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Physicochemical Properties and Health Implications of Cow's Milk from Armenian Manufacturers

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ABSTRACT

This study evaluates the physicochemical properties of milk samples from six different Armenian manufacturers to assess their quality and suitability for dairy product production. The milk samples were analyzed for key parameters including pH, fat content, solid non-fat (SNF), density, protein, lactose, salts, and freezing point. Results revealed slight variations in pH, fat, and protein content, with goat milk showing the highest protein, lactose, and SNF levels, and a lower freezing point compared to other milk types. Temperature, fat content, and protein concentration were identified as significant factors influencing milk quality, with implications for dairy product formulation. This research provides valuable insights into the nutritional profiles of Armenian milk and can inform the development of targeted dairy products based on these physicochemical characteristics.

Introduction

Milk is a fundamental agricultural product consumed globally, prized for its nutritional benefits, including proteins, fats, vitamins, and minerals (Górska-Warsewicz, et al., 2019, Fox, et al., 2021, Antunes, et al., 2022). As one of the most widely consumed liquids in the world, milk has been integral to human diets for centuries, providing essential nutrients and promoting growth and development, particularly in young children. The quality of milk plays a pivotal role not only in human health but also in the dairy industry, as it influences its use in producing various dairy products, such as cheese, butter, and yogurt (Rozenberg, et al., 2016). The physicochemical properties of milk—including pH, fat content, solid non-fat (SNF), density, and protein levels—have profound effects on its sensory characteristics, nutritional profile, and shelf life (Huppertz, et al., 2024). These properties also contribute to the texture, taste, and stability of milk-based products, which are often highly valued by consumers. Furthermore, additional factors such as temperature, water content, lactose concentration, salts, and freezing point contribute to determining milk quality and its suitability for different dairy products (Wu, et al., 2024).

Milk composition is influenced by several factors,

including breed, diet, and geographical location (Ahuja, et al., 2022). Variations in these factors lead to differences in the physicochemical properties of milk produced by different manufacturers. For instance, the type of feed, environmental conditions, and even seasonal changes can lead to significant fluctuations in the milk's composition. Such variations ultimately affect the overall quality of the milk and, by extension, the quality of the dairy products made from it (Lind, 2007). While numerous studies have investigated the milk composition of various animal species, including cows, goats, and sheep (Ferro, et al., 2017), there is limited research on comparing milk samples from different producers within a specific region. This gap is especially noticeable in Armenia, where a detailed and comprehensive study on the physicochemical properties of milk from local producers is still lacking.

Understanding the variations in the physicochemical properties of milk from different Armenian manufacturers is vital for both consumers and producers. For consumers, this knowledge can inform their choices based on factors like taste, nutritional value, and product consistency. For producers, it can help optimize milk production to meet specific demands for quality and quantity. In addition, local milk variations can have an impact on the production of specific dairy products, which are integral to Armenia's agricultural economy. In countries with rich dairy traditions, like Armenia, optimizing the quality of milk is essential for producing a diverse range of products that meet both local and international market needs.

Previous studies have demonstrated that factors such as fat content, protein concentration, and pH significantly influence milk quality and the resulting dairy products (Cheng, et al., 2019). However, comprehensive research specifically addressing these factors in the context of Armenian dairy production remains sparse. Moreover, the relationship between these physicochemical parameters and the production of particular dairy products—such as cheese, yogurt, and cream—has yet to be fully explored. Fat content plays a crucial role in determining the texture, mouthfeel, and flavor of products like cheese, cream, and butter, whereas protein concentration is essential for curd formation and contributes to the nutritional content of dairy products (Silva, et al., 2021). Therefore, investigating the physicochemical properties of milk from different Armenian producers is of utmost importance, as it will provide insight into the functional characteristics of milk and its suitability for various dairy products.

In this study, the physicochemical properties of milk from several Armenian manufacturers will be analyzed, with a focus on key parameters such as pH, fat content, SNF, protein levels, and density. By exploring these properties and identifying variations between different producers, this research aims to contribute to a deeper understanding of milk quality in Armenia. Ultimately, this study seeks to inform dairy production practices and contribute to the broader knowledge of how regional factors affect milk composition and dairy product quality.

Materials and methods

Milk samples were collected from six different Armenian manufacturers, selected based on the diversity of dairy production practices within the region. The sampling process considered both the production date and storage conditions of the milk to ensure consistency and minimize any external factors that could affect the milk's physicochemical properties.

The physical properties and biochemical components of cow's milk were measured using the Lactoscan Milkanalyzer (Farm Eco, Bulgaria), commonly used for the analysis of milk quality and composition (Bork, et al., 2015).

The following parameters were analyzed to evaluate the differences and similarities in the composition across milk samples: pH, temperature (°C) (Lan, et al., 2024), fat (%), Solid Non-Fat (SNF) (%) (Assen and Abegaz, 2024), density (kg/m³) (Fox, et al., 2021), proteins (%), lactose (%), salts (%) (Woźniak, et al., 2022) and Freezing Point (°C) (Kumar, 2024) .

To assess the differences between milk samples from different manufacturers, a t - and Mann-Whitney U tests were conducted.

Results and Discussions

This study evaluates the physicochemical characteristics of six samples of milk: "Ani milk," "Marianna pasteurized milk," "Marianna ultra-pasteurized milk," "Chanakh milk," "Yeremyan milk," and "Goat milk." The analysis focuses on key parameters, including pH, temperature, fat content, SNF, density, water content, protein, lactose, salts, and freezing point, as detailed in Table 1.

Table. Physicochemical properties of milk samples from different Armenian manufacturers*

Milk Type	pH	Temperature (°C)	Fat (%)	SNF (%)	Density (kg/m³)	Proteins (%)	Lactose (%)	Salts (%)	Freezing Point (°C)
Ani Milk	6.67	20.7	2.9	8.52	29.73	3.12	4.07	0.69	-0.534
Marianna Pasteurized Milk	6.64	19.2	2.99	9.46	33.21	3.46	5.19	0.77	-0.604
Marianna Ultra-Pasteurized Milk	6.64	19.2	2.99	9.46	33.21	3.46	5.19	0.77	-0.604
Chanakh Milk	6.78	19.9	2.94	9.01	31.56	3.3	4.94	0.73	-0.572
Yeremyan Milk	6.87	18	2.85	9.24	32.53	3.39	5.07	0.75	-0.588

*Composed by the authors.

pH Levels. The pH values of the milk samples range from 6.62 (Goat milk) to 6.87 (Yeremyan milk), indicating a slightly acidic nature. A lower pH indicates higher acidity, which can have an impact on the milk's preservation, shelf life, and its microbial stability (Rahman & Rahman, 2020). Yeremyan milk shows the highest pH, which may reflect its different processing techniques compared to other samples. Studies have shown that pH levels play a crucial role in the overall quality of milk and dairy products (Fox, et al., 2021).

Temperature. The temperatures range from 18.0°C (Yeremyan milk) to 20.7°C (Ani milk). Temperature plays a significant role in controlling the growth of bacteria and maintaining the milk's freshness. Lower temperatures contribute to a reduction in microbial activity, thereby increasing the shelf life of milk (Li, et al., 2023). The variations in milk temperature may be attributed to the conditions under which the samples were stored or processed (Toghdory, et al., 2022).

Fat Content. Fat content ranges from 2.84% (Goat milk) to 2.99 % (Marianna pasteurized and ultra-pasteurized milk). Fat is a crucial component that affects milk's texture, flavor, and nutritional value. Higher fat content enhances the sensory properties, making milk creamier and richer in taste (Bakke, et al., 2015). These variations can also be linked to the milk's processing methods, as pasteurization can influence the fat content without significantly altering it (Bakke, et al., 2015).

Solid Not Fat. SNF values range from 8.52 % (Ani milk) to 9.49 % (Goat milk), with Marianna milk (both pasteurized and ultra-pasteurized) showing the highest SNF value of 9.46 %. SNF is a measure of the total solids excluding fat and water, and it plays an essential role in determining the milk's nutritional value. A higher SNF indicates a higher concentration of proteins, lactose, and minerals, contributing to milk's higher overall nutritional profile (Olsen, et al., 2023).

Density. The density of the milk samples varies between 29.73 kg/m³ (Ani milk) and 33.48 kg/m³ (Goat milk). Density is influenced by the fat content and the concentration of solids in the milk. Goat milk's higher density can be attributed to its richer composition in proteins and minerals. Density is an important parameter that influences the processing behavior of milk, such as its suitability for producing various dairy products (Magan, et al., 2021).

Proteins. Protein content in the samples ranges from 3.12% (Ani milk) to 3.48 % (Goat milk). Proteins are essential for milk's nutritional value and affect its functional properties in dairy products such as cheese and yogurt (Fox, et al., 2021). The higher protein content in goat milk suggests it may offer superior nutritional benefits, which is in line with other studies on goat milk's higher protein profile compared to cow's milk (ALKaisy, et al., 2023).

Lactose. Lactose content in the samples ranges from 4.07% (Ani milk) to 5.21% (Goat milk). Lactose is the primary carbohydrate in milk and contributes to its energy value. The higher lactose concentration in Goat milk is consistent with the overall richer composition of the milk, however, lactose content may cause issues for individuals with lactose intolerance (Lind, 2007).

Salts. Salt content in the milk samples varies from 0.69 % (Ani milk) to 0.77 % (Goat milk). Salts, primarily in the form of minerals such as calcium and magnesium, are critical for milk's nutritional properties and contribute to its flavor and preservation (Woźniak et al., 2022). The higher salt content in goat milk may reflect its richer mineral profile.

Freezing Point. The freezing point of the milk samples ranges from -0.534°C (Ani milk) to -0.606°C (Goat milk). A lower freezing point correlates with higher total solid concentrations, particularly lactose and minerals. Freezing point depression is often used to measure milk's overall quality and the concentration of dissolved solids, indicating that Goat milk has a higher concentration of solids (Kumar, 2024).

Milk's physicochemical properties, such as fat, protein, lactose, and mineral content, play a significant role in influencing its nutritional value and its applicability in managing various health conditions. Understanding the specific milk composition is crucial for the formulation of dietary interventions aimed at preventing or managing diseases. The milk samples in this study, with varying concentrations of fat, proteins, lactose, and other components, offer a valuable dataset for assessing the potential dietary impacts of milk on different health conditions.

Familial Mediterranean Fever (FMF) is a genetic disorder that is highly prevalent in Armenia (Pepoyan, et al., 2022a, 2024). During the disease, various therapeutic approaches are recommended, including the use of probiotics (Pepoyan, et al., 2023, Balayan, et al., 2023, Tsaturyan et al., 2024, Pepoyan, 2024), such as dairy-based probiotics like yogurts.

Impact of Milk on Cardiovascular Health and FMF

The fat content in milk is of particular interest when considering its role not only in cardiovascular health but also in its potential influence on FMF. Elevated saturated fat levels, commonly found in full-fat milk, have been associated with an increased risk of heart disease due to their role in raising low-density lipoprotein (LDL) cholesterol (Siri-Tarino, et al., 2010). The fat content in the samples ranged from 2.84 % to 2.99 %, which aligns with the fat concentrations typically found in commercially available cow's milk. Studies have shown that milk fat, especially in whole milk, may contribute to cardiovascular risk factors; however, emerging research suggests that dairy fat might not have as negative an effect on heart disease as previously thought (Givens, et al., 2009). Specifically, milk with a lower fat content may be more suitable for individuals managing hypertension or high cholesterol levels.

When it comes to FMF, the impact of milk is less clear. Some studies suggest that the high-fat content found in dairy products may trigger FMF attacks due to its potential to increase inflammation. For instance, in the study by Yenokyan, et al. (2012), it was found that a high-fat diet was associated with an increased risk of FMF attacks, implying that milk and other high-fat dairy products could contribute to exacerbations of the disease (Yenokyan, et al., 2012). However, other studies, such as the one conducted by Mansueto (2022), did not find a significant link between the consumption of cow's milk or breastfeeding and FMF severity, suggesting that milk may not be a primary trigger for FMF symptoms in some individuals (Mansueto, et al., 2022).

Furthermore, FMF patients who were on a strict low-fat or anti-inflammatory diet, including limited dairy intake, have shown improved responses to treatments like colchicine (Mansueto, et al., 2022). In these patients, reducing fat intake, which includes cutting back on dairy, appears to reduce inflammation and potentially ease disease flare-ups. However, the direct relationship between milk consumption and FMF remains under-researched, and further studies are needed to conclusively determine whether specific components in milk—such as lactose, proteins, or fat—contribute to FMF symptom exacerbation.

In conclusion, while the impact of milk on cardiovascular health is relatively well-documented, its role in FMF is more ambiguous. Some evidence suggests that high-fat dairy may contribute to inflammatory responses that trigger FMF attacks, but further research is necessary to understand how milk, especially low-fat varieties, interacts with the underlying mechanisms of FMF. For now, patients with FMF might benefit from monitoring their milk intake, particularly full-fat dairy products, and opting for lower-fat alternatives when managing their disease.

In this study, Yeremyan Milk and Goat Milk exhibited slightly higher fat contents, which may suggest a richer texture but also may be less favorable for individuals aiming to limit saturated fat intake for cardiovascular health.

Milk in Diabetic Diets

The carbohydrate content, primarily in the form of lactose, also influences milk's suitability for individuals with diabetes. Milk's natural lactose, which ranges from 4.07 % to 5.21 % in the current samples, is a sugar that can impact blood glucose levels. Despite this, dairy products like milk have a relatively low glycemic index (GI), meaning they do not cause significant spikes in blood sugar (Shkembi, et al., 2023). Goat milk, with a higher lactose content (5.21 %), may be beneficial for individuals with diabetes in moderation, as it is often considered easier to digest than cow's milk due to its unique protein structure. This could potentially enhance its suitability for managing

blood glucose levels without causing abrupt increases in insulin levels. Additionally, proteins present in milk, which ranged from 3.12 % (Ani Milk) to 3.48 % (Goat Milk) in the study, play a significant role in slowing down the absorption of carbohydrates, thereby helping in blood sugar regulation. Higher protein content may benefit those with type 2 diabetes by improving satiety and reducing postprandial glucose levels (Minari, et al., 2023).

Bone Health and Mineral Deficiencies

Milk is a key dietary source of calcium, which is essential for bone health. The salt content in milk, which includes minerals such as calcium and magnesium, plays a significant role in bone mineralization and preventing conditions like osteoporosis. In this study, the salt content ranged from 0.69 % (Ani Milk) to 0.77 % (Goat Milk). Calcium, a major component of milk's mineral content, is particularly beneficial for preventing bone diseases such as osteoporosis, which is a concern for postmenopausal women and the elderly. Furthermore, higher salt concentrations, such as in Goat Milk, may contribute to an increased mineral profile, which could enhance the bioavailability of calcium, aiding in better bone health management. On the other hand, individuals with kidney disease or hypertension may need to limit salt intake, in which case milk with lower mineral content (such as Ani Milk) may be more suitable (Fox, et al., 2021).

Lactose Intolerance and Dairy Sensitivity

Lactose intolerance is a common condition where individuals have difficulty digesting lactose due to insufficient lactase enzyme activity. This can lead to gastrointestinal discomfort when consuming dairy products (Lind, 2007). The lactose content in the milk samples in this study varies, with Goat Milk showing the highest concentration at 5.21 %, followed by Yeremyan Milk at 5.07 %. For individuals with lactose intolerance, goat milk may still be better tolerated compared to cow's milk due to the difference in milk protein structure and fat composition. Goat milk's smaller fat globules and higher protein content can make it more digestible for lactose-intolerant individuals (Liao, et al., 2024). This may allow consumers with sensitivity to cow's milk to benefit from the nutritional advantages of dairy without the typical discomfort associated with lactose digestion.

Role of Milk in Weight Management and Satiety

The protein and fat content of milk also affect feelings of fullness and overall calorie intake, which has implications for weight management. Proteins in milk play an important role in promoting satiety, which may help in controlling calorie intake (Givens, et al., 2009). In this study, Goat Milk, with its higher protein and fat content, might be more satiating compared to Ani Milk, which has relatively lower protein and fat concentrations. Therefore, incorporating higher-protein milk types may help in reducing overall food intake and may be beneficial for individuals trying to manage their weight. Additionally, the fat content in milk can influence the absorption of fat-soluble vitamins, such as Vitamin A and D, which are important for metabolic health and immune function (Itkonen, et al., 2019).

Milk's Effect on Gut Health and Probiotic Potential

The fermentation potential of milk is also relevant for individuals looking to incorporate probiotic-rich foods into their diet. The SNF content, which includes proteins and lactose, is a key determinant of milk's ability to undergo fermentation (Li, et al., 2023). Higher SNF content, such as in Goat Milk (9.49 %) and Marianna Pasteurized Milk (9.46 %), may be more suitable for the production of probiotic dairy products such as yogurt, which are beneficial for gut health. Probiotic-rich (Pepoyan, et al., 2022b) dairy products support the balance of gut microbiota, which can influence immune function, digestion, and even mental health.

Conclusion

This study demonstrates significant variability in the physicochemical properties of milk from different Armenian manufacturers, with notable differences in fat, protein, lactose, solid non-fat (SNF), density, and other parameters. Although these differences are relatively small, they may still play a role in managing specific health conditions, such as cardiovascular diseases, osteoporosis, and lactose intolerance. The analysis of these milk samples reveals that goat milk stands out due to its higher protein, lactose, and SNF content, as well as its lower freezing point and higher density, making it a nutritionally richer option. These characteristics make goat milk a potential candidate for targeted dairy products, especially for consumers with specific dietary needs or health conditions.

The findings have important implications for the dairy industry, particularly in the formulation of milk-based products designed to address health concerns. For instance, individuals with cardiovascular disease may benefit from milk products with lower fat content, while those with osteoporosis or lactose intolerance could benefit from higher protein or lactose-free alternatives. Additionally, the higher SNF content in goat milk, which includes more protein and minerals, may provide additional

nutritional benefits, particularly in managing bone health or supporting muscle maintenance.

Furthermore, processing methods such as pasteurization do not significantly alter the overall nutritional profile of milk but may influence parameters like fat content and microbial stability. The insights provided by this study can assist dairy producers in tailoring their products to meet the nutritional needs of various populations, including those managing chronic conditions like diabetes and osteoporosis. By understanding these physicochemical differences, dairy producers can optimize their product offerings to align with consumer health requirements and contribute to better health outcomes.

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Declarations of interest

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