Journal of Natural Science Review

Vol. 2, No. 1, 2024, 57-67
http://kujnsr.com
e-ISSN: 3006-7804

Evaluation of the Physicochemical Properties of Different Imported Milk Brands Offered in Afghanistan Markets

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ABSTRACT

Milk is an enriched food that humans widely consume. It is the source of many nutrients like protein, fat, carbohydrates, vitamins, and minerals. The content of high-quality milk should match that of natural milk and national and international standards. In the current study, the quality of selected imported milk brands (Pak1, Pak2, Pak3, Pak4, and Ir1) and local cow milk in the markets of Kabul City was evaluated. For this purpose, the levels of protein, fat, total solid, solid not fat, acidity, pH, and specific gravity were measured. Data analysis was conducted using the Kruskal-Wallis test in GraphPad Prism software. Our findings showed that the protein level in imported brands was significantly lower than the standard of cow milk ($p<0.01$). Among imported brands, the protein level in Ir1 and Pak4 was higher than other brands and the standard ($p<0.05$). The level of fat in Pak2 and Pak3 was higher than the standard and other brands ($p<0.05$), the level of total solid in Ir1 was lower than the standard ($p<0.05$), and the level of solid not fat in Pak2 and Pak3 was lower than the standard ($p<0.05$). Our results showed that local cow milk has a higher quality than imported milk brands, and among the brands, Pak4 has a higher quality than other brands, where its quality is almost the same as the composition of local cow milk.

ARTICLE INFO

Article history

Received: March 04, 2024
Revised: March 20, 2024
Accepted: March 28, 2024

Keywords

Milk, Physicochemical Properties, Fat, Protein, Specific Gravity

To cite this article: Noori, M. A., Sarwary, N. A., & Farkhary, S. I. (2024). Evaluation of the Physicochemical Properties of Different Imported Milk Brands Offered in Afghanistan Markets. *Journal of Natural Science Review, 2*(1), 57-67. https://doi.org/10.62810/jnsr.v2i1.41

To link to this article: https://kujnsr.com/JNSR/article/view/41

Introduction

Dairy products encompass a wide range of food items derived from milk, each offering unique nutritional benefits. Milk, the primary source of most dairy products, provides essential nutrients such as protein, calcium, and vitamins, making it a cornerstone of many diets worldwide (Nicholson et al., 2013). Cheese, another popular dairy product, undergoes

fermentation and aging processes that enhance flavor and texture while preserving valuable nutrients (Fox et al., 2017). Yogurt, produced through the fermentation of milk by lactic acid bacteria, not only retains the nutritional properties of milk but also contains probiotics, beneficial bacteria that promote digestive health (Marco et al., 2017). Butter, cream, and other dairy-based spreads contribute to the richness and flavor of various dishes, though they should be consumed in moderation due to their higher fat content (Norn, 2015). Despite concerns about lactose intolerance and dairy allergies, dairy products remain a valuable source of essential nutrients for many individuals, highlighting their importance in promoting overall health and well-being.

Dairy products are ideal, nutrient-dense, and well-balanced diets; milk is a crucial part of a balanced diet (Pereira, 2014). Caseins, whey proteins, milk polar lipids (MPL), conjugated linoleic acids (CLA), α-linolenic acid (ALA), lactose, palmitic acid (16:0), and other elements, including calcium, phosphorus, magnesium, and vitamin D are among the twenty-two essential nutrients found in the milk (Zhang et al., 2021; Derek, 2023).

Milk, a staple beverage enjoyed worldwide, is crucial to human nutrition due to its rich and diverse array of essential nutrients (Nicholson et al., 2013). As a primary source of high-quality protein, cow milk aids tissue repair and muscle development while supporting immune function (Haug et al., 2007). Its calcium content promotes bone health and density, particularly vital during periods of growth in childhood and adolescence (Heaney & Weaver, 2003). Fortified with vitamins such as vitamin D, milk facilitates calcium absorption and contributes to overall bone strength (Wagner et al., 2008). Moreover, milk provides a mix of fats, including essential fatty acids, for energy and metabolic processes (Bauman & Griinari, 2003). Alongside carbohydrates and micronutrients like phosphorus and potassium, cow milk offers a balanced nutritional profile essential for optimal health and well-being (Thorning et al., 2016). Its widespread availability and affordability contribute to its continued popularity among consumers across diverse demographics. Additionally, advancements in dairy processing techniques and the introduction of various milk-based products have expanded milk's appeal and consumption patterns, further solidifying its place as a dietary staple in many cultures worldwide (Bansal & Bansal, 2015; Fox et al., 2017).

Consumers are interested in pathogen-free milk that is hygienic, safe, and nutritious. High-quality milk should taste good, have a low bacterial count, be free of harmful compounds and pollutants, have a typical chemical composition, and have low titratable acidity. Therefore, a quality assessment of milk is necessary (Fahmid et al., 2016).

Milk adulteration, a concerning issue globally, involves the intentional addition of substances to milk for economic gain, compromising its quality and safety (Sharma et al., 2012). Common adulterants include water, which dilutes the milk and increases volume, thereby deceiving consumers and reducing the nutritional value per unit (Sharma et al., 2012). Additionally, producers may add cheaper ingredients like vegetable oils or powdered milk to stretch their supplies or mimic the appearance of higher-quality milk, ultimately compromising its nutritional integrity (Sharma et al., 2012; Bansal & Bansal, 2015).

Mislabeling of milk origin or quality is another form of adulteration, where conventional milk may be falsely labeled as organic or sourced from specific regions known for premium dairy production (Sharma et al., 2012; Bansal & Bansal, 2015). Adulteration with contaminants such as antibiotics, pesticides, or microbial pathogens poses serious health risks to consumers, highlighting the importance of regulatory oversight and quality control measures in the dairy industry (Sharma et al., 2012; Bansal & Bansal, 2015).

Milk adulteration is common in some developing countries, such as Pakistan, India, China, and others (Pal, 2017). One important tool for physiochemical analysis is to monitor the quality of milk and other dairy products. Food adulteration primarily happens for commercial benefit and poor sanitation, transportation, preservation, and marketing. As a result, consumers are deceived and sick. Therefore, it is essential to make consumers aware of common frauds (Tesfay et al., 2015).

Milk quality and composition in cattle are influenced by genetic factors (heritability) and non-genetic factors (nutrition, season, etc.), impacting fat, protein, lactose, and solid content (Tirfie, 2023).

Almost all of Afghanistan's dairy cattle are Watani, Kunari, Kandahari, and Sistani, which are endogenous and cannot produce enough milk, unlike population density in the urban cities of Afghanistan, which is increasing day by day and demand for milk and dairy products is high (Naeimi and Almas, 2021). Recently, hybridization has also been promoted, and the mentioned generations have been bred by famous generations such as Holstein Friesian and Brown Swiss. These hybrids have been used for milk production (Rahimi et al., 2019; Ahmad et al., 2023).

The Afghan livestock population comprises 22 million sheep, 10 million goats, and 3.7 million cattle (DCA, 2018). In contrast, imported dairy products were estimated at 2.6 MT and valued at USD 1.6 million. A significant portion of rural and urban demand is met by domestic production, with 90% of urban demand met by imported milk (MAIL, 2020); however, the quality of these imported milk products has not been qualitatively evaluated, whether it is based on international standards or not.

The main objective of this study is to evaluate the quality of selected imported milk that exists in Kabul city markets and compare them with local cow milk.

Materials & Method

Research design

This is an experimental research in which the physicochemical parameters of milk samples were determined after sampling in a laboratory. The samples were collected on three separate dates to represent various batches.

Chemicals and reagents

Potassium oxalate (BDH®, England), phenolphthalein solution (0.5%) (BDH®, England),

NaOH (0.1N) (BDH®, England), formalin (40%) (Prime®, Pakistan), sulfuric acid (MERCK®, Germany) and amyl alcohol (MERCK®, Germany) were purchased from a medical drug store in Kabul. All chemicals or regents were laboratory grade.

Sample Collection

Samples were collected from five imported milk brands, Pakistani (Pak1, Pak2, Pak3, Pak4) and Iranian (Ir1), and six retail cow milk Samples (CM). The samples were collected in three different months of 2021 (January, May, and September). Physicochemical parameters were examined from a total of five tetra packs of each brand (imported milk brands, n = 30), and samples from six retail cow milk (n = 6) were purchased from markets and retail shops (Milk samples were collected upon delivery by farmers to the retail shops) in Kabul city. All the samples were tight and free from any leakage during collection. Cow's milk samples were collected in glass tubes and put in an icebox to prevent contamination and protect them from sun damage. The samples were immediately transferred to the laboratory.

Determination of Protein

Protein percentage was determined by formalin titration test as described by (Kalimoldina et al., 2021). The first 10 mL of milk was added to an Erlenmeyer flask. Then, 0.4 ml of saturated aqueous potassium oxalate and 0.5 ml of phenolphthalein solution (0.5%) were added and mixed with the milk by the vortex. After 2 minutes, the mixture was titrated by NaOH (0.1N) until a pink color was obtained. After that, 2 mL of formalin (40%) was added for neutralization, which disappeared, and pink and white colors reappeared. Therefore, titration continued with NaOH (0.1N) until a pink color of equal intensity was obtained.

The volume of NaOH used for titration in both phases (before and after neutralization) has been noted. The noted number of used NaOH was subtracted (titrated NaOH before neutralizing and titrated NaOH after neutralizing), then multiplied by 1.74 according to the formula factor for cows` milk described in the Kjeldahl method (Kala et al. 2018).

$$\text{Protein percentage} = a\text{-}b\ (1.74) \qquad \text{Formula (1)}$$

Determination of Fat

Gerber's method was used to determine milk fat percentage. First, a volume of 10 ml of sulfuric acid (density 1.815 g/ml at 20 °C) was pipetted into a butyrometer. After that, 11 ml of milk sample was added to the butyrometer and mixed well by vortex. This was followed by adding 1 ml of amyl alcohol to the butyrometer; then, the butyrometer closed with a lock stopper. The mixture was shaken and inverted several times until the sulfuric acid thoroughly digested the milk. Finally, the butyrometer was centrifuged in a Gerber centrifuge for five minutes (1100 rpm/min). Then, the butyrometer was placed in a water bath at 65 °C for five minutes. The test result, the butyrometer reading number, was recorded as described by other researchers (Kala et al. 2018; COSMT 2001).

Determination of Total Solid Percentage

Milk total solids were determined by the Richmond formula as described by (Patel et al.

2018).

$$TS\ \% = \frac{\text{CLR}}{4} + 1.25\text{F} + 0.65 \qquad \text{Formula (2)}$$

CLR= corrected lactometer reading; F= fat

Determination of Solid, not Fat Percentage

The solid not fat (SNF) was determined by the Getachew formula as described by the (2003) formula:

$$SNF\ \% = \text{TS}\% + \text{F}\% \qquad \text{Formula (3)}$$

TS= total solid; F= fat

Measurement of acidity

The titratable acidity of the milk sample was determined by acid-base titration according to the (AOAC (2005). For such purpose, 9 ml of milk was pipetted into a beaker, and then five drops of phenolphthalein (1%) were added. After that, the milk samples were titrated with NaOH (0.1N) solution until a faint pink color appeared. The titratable acidity, expressed as lactic acid (%), was finally calculated using the following formula:

$$Acidity\ \% = \frac{0.009\ (0.1\text{N NaOH ml})}{\text{Weight of milk sample (ml)}} * 100 \qquad \text{Formula (4)}$$

Determination of pH

The milk samples' pH was determined using a digital pH meter (HM-25G, DKK.TOA Corporation, Japan). The pH meter was first calibrated using pH 6.86 and 4.01 buffers each time before the pH milk samples were taken.

Determination of Specific Gravity

A lactometer determined the specific gravity of the milk samples according to the AOAC (2005). A glass cylinder (100 ml capacity) was filled with milk samples, and a lactometer was inserted into the milk until it floated freely. Then, the lactometer reading at the lower meniscus was recorded, and the sample temperature was immediately recorded through the thermometer. For each degree of temperature above 15.5 °C, 0.2 number was subtracted from the lactometer reading; for each degree below 15.5 °C, 0.2 number was subtracted from the lactometer reading. After that, the lactometer reading was corrected (CLR) and calculated with the following formula:

$$Specific\ Gravity = \frac{\text{CLR}}{1000} + 1 \qquad \text{Formula (5)}$$

CLR= Corrected lactometer reading

Statistical Analysis

To evaluate the statistical difference of variables (protein, fat, TS, SNF, acidity, pH, and specific gravity) between milk brands, retail cow milk, and standards, the Kruskal-Wallis test, followed by Dunn's multiple comparison tests, was used. The statistical analysis used

GraphPad Prism (version 5.0.0 for Windows, GraphPad Software, San Diego, California, USA) and Microsoft Excel 2013 (version 15.0.5 for Windows).

Results

The amount of protein was significantly different among all experimental groups (Kruskal-Wallis test, $p<0.001$, Fig. 1(I)). The level of protein was markedly lower in Pak1 and Pak3 than the regular cow milk protein standard (Dunn's multiple comparison test, every day vs. standard: $p<0.01$, Pak3 vs. standard: $p<0.01$); however, there was no significant difference between the standard and other groups. The amount of fat was significantly different among experimental groups (Kruskal-Wallis test, $p<0.001$, Fig. 1(II)); however, the difference was not significant between the standard and all other groups (Dunn's multiple comparison tests, Pak1, Pak2, Pak3, Pak4, Ir1, and CM vs. Standard: $p> 0.05$).

The amount of total solid was significantly different among experimental groups (Kruskal-Wallis test, $p<0.001$, Fig. 1(III)). Still, the post hoc test shows that only the total solid of Ir1 was significantly lower than the standard (Dunn's multiple comparison tests, $p<0.05$). The amount of solid not fat was significantly different among experimental groups (Kruskal-Wallis test, $p<0.001$, Fig. 1(IV)). Still, all groups were not significantly different from the standard (Dunn's multiple comparison tests, $p<0.05$).

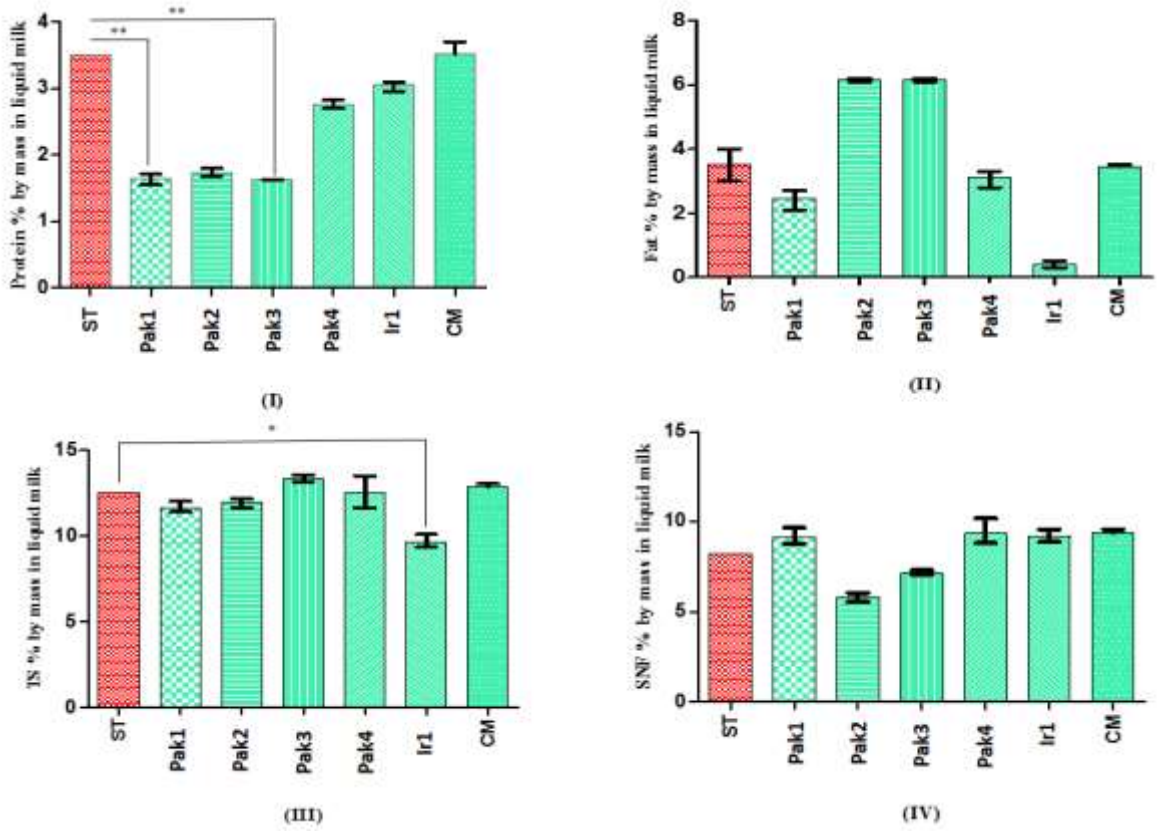

Figure 1. Proximate composition of imported milk brands, cow milk, and standard: (I) Protein content percentage in liquid milk; (II) Fat content percentage in liquid milk; (III) Total solid percentage in liquid milk; (IV) Solid not fat percentage in liquid milk.

The level of titratable acidity was significantly different among all experimental groups (Kruskal-Wallis test, p<0.001, Table 1). A post hoc test shows that only the Acidity of Pak1 was significantly higher than the standard (Dunn's multiple comparison test, p<0.05), but other groups were not significantly different.

The level of pH and specific gravity were significantly different among all groups (Kruskal-Wallis test, pH: p<0.001, Specific gravity: p<0.001, Table 1), but there was no significant difference between standard and other groups (Dunn's multiple comparison test, p > 0.05).

Table 1. *Comparison of physicochemical parameters of imported brands and cow milk samples with the standards.*

Parameter	Standard	Pak1	Pak2	Pak3	Pak4	Ir1	CM
Protein (%)	3.5	1.64±0.05**	1.74±0.05	1.62±0.00**	2.76±0.05	3.05±0.05	3.52±0.43
Fat (%)	3-4	2.47±0.26	6.17±0.05	6.17±0.05	3.12±0.21	0.417±0.10	3.46±0.14
TS (%)	12.5	11.6±0.23	12.0±0.17	13.3±0.17	12.5±0.71	9.62±0.32*	12.9±0.43
SNF (%)	8.25	9.16±0.35	5.83±0.16	7.16±0.13	9.36±0.56	9.20±0.32	9.40±0.48
pH	6.6-6.8	7.05±0.02	6.75±0.15	6.79±0.07	6.71±0.02	6.56±0.03	6.71±0.13
TA (%)	0.14-0.16	0.88±0.06*	0.12±0.05	0.078±0.00	0.18±0.00	0.17±0.00	0.19±0.03
SG g/ml	1.028-1.033	1.031±0.00	1.015±0.00	1.020±0.00	1.032±0.00	1.034±0.00	1.032±0.00

Note: TS = total solid; SNF = solids, not fat; TA = titratable acidity; SG = specific gravity; means ± SD; **(p<0.01); *(p<0.05)

Discussion

Generally, this research evaluates the quality of imported milk brands and retail cow milk by determining the amount of protein, fat, total solid, solid, not fat, specific gravity, pH, and acidity. The results showed that the protein content of the Pakistani brands Pak1 and Pak3 is significantly lower than that of the standard. Only the acidity of Pak1 is higher than the standard. Iranian Ir1 milk is no different from the standard in all its characteristics, but only the amount of total solid is significantly lower than the standard. The characteristics of retail cow milk and Pak4 were similar to those of standard. The amount of protein in Moheghi's (2017) findings is closely comparable to our findings in the cases of retail cow milk, Ir1, and Pak4. Unlike the amount iPak1, Pak2 and Pak3 differ from those in Moheghi's study (2017). The low amount of milk protein in Pak1 and Pak3 might be due to the adulteration of milk with water or the addition of cheaper substances (Fahmid et al., 2016). This can lead to nutritional deficiencies, compromised health benefits, and consumer economic losses (Scholz et al., 2020).

According to the standard (Wozniak et al., 2022), cow milk has approximately 3–4% fat content. In this study, the average fat amount in Ir1 was meager, and the Pak2 and Pak3 were higher (Table 1). The average amount of milk fat in the examined brands was different, although there was no statistically significant difference. This could be due to various factors like sample size and variability. The content of milk fat depends on breed, specificity of an individual animal, health and age, season, stage of lactation, nutritional status, and feed (dos Santos Pereira et al., 2020). In addition, the low milk fat percentage may be attributed to

adulteration by the addition of water and/or partial skimming, and the high milk fat percentage may be attributed to adulteration by the addition of vegetable fat in the milk (Shinawy et al., 2018; Poonia et al., 2016).

According to the European Union, the standard for total solid in whole cow milk should not be less than 12.5% (Gemechu et al., 2007; Ketema et al., 2018). The data showed that the total solid percentage in Ir1 was estimated to be lower when compared with the total solid standard of regular cow milk (Table 1). The low amount of total solid may be due to adulteration of milk with water, also referring to how skimming of milk was done (Fahmid et al., 2016). Also, the difference could be due to the breed type, feeding, and management practices, which impact the milk composition (Tesfay et al., 2015).

Regular milk of high quality has an apparent acidity of 0.14–0.16% as lactic acid (O "Connor, 1995). A high value of Pak1 TA in our study could indicate poor quality and an unhygienic condition of milk (Shaikh et al., 2015; Fahmid et al., 2016).

Our findings' pH level and specific gravity are consistent with those of Moheghi (2017) and standard (Gemechu et al., 2016; O'Connor, 1995). The high pH values in milk are probably due to mastitis milk, adding preservatives, and adulteration (Gemechu, 2015). The pH with low values indicates an acidity increase in milk due to bacterial multiplication (O'Connor, 1995). Also, temperature affects pH values since milk is a complex buffer system, and variations in temperature cause many changes (Ekpa & Onuh, 2018). Processing operations such as homogenization and sterilization have negligible effect on specific gravity (Ekpa & Onuh, 2018). The addition of water or other substances changes the specific gravity. Lower values of specific gravity in milk indicate the dilution of milk with water and skimming practices (Tesfay et al., 2015; Fahmid et al., 2016). The higher value of specific gravity indicates skimming of fat, adding solids such as flour or sugar to milk, and removing butterfat, increasing milk's specific gravity (Gemechu, 2015).

Conclusion

Overall, the findings of this research show that the quality characteristics of some imported milk brands do not meet the standards of regular milk and may cause health and nutritional problems. It is suggested that the quality of imported milk be controlled before being released to the market. Since retail cow milk is similar to international standards in terms of quality, it is recommended as one of the good milk sources.

Acknowledgments

We are grateful to Assistant Professor M. Yousuf Farahmand for their assistance, and we are also thankful to the Food Technology and Hygiene Department staff who assisted us in this research.

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