Journal of Natural Science Review

Vol. 4, No. 2, 2026
https://kujnsr.com
e-ISSN: 3006-7804

Prevalence of Milk Adulteration in Retail Dairy Shops of Kabul City and Its Public Health Implications

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ABSTRACT

Milk, an extremely important source of nutrition worldwide, is currently under threat from practices of milk adulteration. The purpose of the study was to determine the prevalence and forms of milk adulteration in dairy shops across the city of Kabul and to estimate their epidemiological implications. A total of 66 raw milk samples were collected from 11 municipal districts and analyzed using lactometer readings, protein titration, and qualitative chemical tests with standard adulterants such as water, urea, starch, and detergent. Findings showed that 81.8% (95% CI: 70.4%–90.2%) of the samples were adulterated, 57.6% (95% CI: 44.8%–69.7%) of the diluted samples were found to be watered down, and 24.2% (95% CI: 14.5%–36.4%) were found to have been added to with other harmful substances. There was a significant difference in the prevalence of adulteration across districts ($\chi^2 = 48.07$, $p < 0.0001$). The paper presents severe nutritional and health hazards associated with milk fraud, including low protein and fat levels and exposure to harmful chemicals. These results emphasize the need to rely on legal backing, conduct constant surveillance, and run publicity campaigns to ensure milk quality and safeguard consumer health in Kabul. This study provides valuable baseline data for policymaking and future food safety research in Afghanistan.

ARTICLE INFO

Article history:

Received: November 3, 2025
Revised: January 29, 2026
Accepted: May 16, 2026
Published: June 30, 2026

Keywords:

Milk adulteration; Food Safety; public health; Water dilution; Chemical adulterants

To cite this article: Sarwary, N. A., Noori, M. A., Sakha, M. Z. (2026). Prevalence of Milk Adulteration in Retail Dairy Shops of Kabul City and Its Public Health Implications. *Journal of Natural Science Review*, 4(2), 564-576. https://doi.org/10.62810/jnsr.v4i2.359

Link to this article: https://kujnsr.com/JNSR/article/view/359

INTRODUCTION

Milk is one of the most nutritious foods, consumed in large quantities and very important in the human diet worldwide. It is a rich source of proteins, especially high-quality ones, essential amino acids, fats, calcium, and vitamins (especially vitamins A, D, B2, and B12) and minerals (phosphorus and potassium) (FAO, 2019; Noori et al., 2024). For children, pregnant women, elderly individuals, and malnourished populations, milk is often the single most important source of animal protein. As a result, the demand for milk and dairy products continues to rise, especially in urbanizing populations in low- and middle-income countries (LMICs) (IFCN Dairy Research Network,2021). Due to widespread adulteration practices, milk safety and quality are increasingly becoming a concern, despite its nutritive value (Kandpal et al., 2012).

Milk and dairy products are essential constituents of the human diet. They are also among the most commonly adulterated food products worldwide, especially in developing nations such as India, Pakistan, Brazil, and China (Kemsawasd et al., 2023; Raturi et al., 2022). Milk adulteration refers to deliberate contamination of milk with foreign, inferior, or even poisonous materials, or to stripping milk of its valuable constituents, in an attempt to gain financially by increasing volume or shelf life, or to mislead consumers (Kandpal et al., 2012). The most common adulterants are water, starch, detergents, urea, formalin, salt, and synthetic milk, the health risks of which are significant, particularly with long-term intake. Such risks are gastrointestinal infections, kidney dysfunction, liver damage, endocrine disorders, and carcinogenic effects in extreme cases (Momtaz et al., 2023).

Formalin, which contains formaldehyde, a human carcinogen of group I, is used to prolong the shelf life of milk, resulting in gastrointestinal damage, shortness of breath, and the risk of cancer (Raturi et al., 2022). The use of detergents to mimic the texture and whiteness of pure milk exposes consumers to substances such as dioxane and sodium lauryl sulfate, which are associated with gastrointestinal irritation, skin disease, and endocrine dysfunction (Kemsawasd et al., 2023). In the same way, as an oxidizing agent, hydrogen peroxide may harm intestinal cells, lead to ulcers and abnormal heart rhythms, and accelerate cell aging. Starch added to make milk thick and enrich SNF can lead to digestive problems, especially among people with diabetes. Synthetic milk with the appearance, flavor, and smell of real milk, but lacking nutritional value, is usually composed of soap, soda, urea, and fats, and has been associated with liver and kidney damage, eye inflammation, and dangers to pregnant women and children (Kemsawasd et al., 2023; Raturi et al., 2022).

The problem of food adulteration is becoming increasingly important worldwide. The World Health Organization (2020) reported that more than 600 million people annually suffer from foodborne diseases associated with contaminated or adulterated foods, and 420,000 of them die. Such fraudulent practices are especially prevalent in milk, since it is a perishable product with high market value. Raw and processed milk is widely adulterated in South Asian countries such as India, Pakistan, Bangladesh, and Nepal, and national food safety agencies have reported this (Food Safety and Standards Authority of India (Amin et al., 2025; *FSSAI, 2018).*

In India, one of the world's largest milk-producing countries, national surveys have consistently reported high levels of milk adulteration. A 2011 study found that 68.4% of samples failed to meet food safety standards, with common adulterants such as urea (60%) and formalin (32%)(Kemsawasd et al., 2023). Similarly, the Food Safety and Standards Authority of India (FSSAI) reported in 2018 that 68.7% of raw milk samples collected from urban and rural areas were non-compliant due to contamination with water and other chemicals, including detergents, ammonium sulfate, and hydrogen peroxide (Food Safety and Standards Authority of India (FSSAI, 2018) A significant proportion of the milk samples in Lahore, Faisalabad, and Karachi were contaminated with water, starch, or chemicals to resemble the texture and whiteness of pure milk (Amin et al., 2025).

There have been several reports of extremely high levels of milk adulteration across South and Central Asia, detected that 40 percent of raw milk samples in Karachi, Pakistan, were contaminated, mainly at the point of sale, with urea, starch, and formalin. Similarly, Panahzadeh et al. (2016) also found formalin (16.4%) and hydrogen peroxide (11.5%) contamination in milk samples collected in Qazvin, Iran, with adulteration concentrated during warmer months, which would be of particular concern to Kabul but was not studied in the present study. The study conducted by Nawaz et al. (2022) in Mardan, Pakistan, revealed considerable water adulteration, decreases in protein and fat levels, and changes in SNF levels.

Rapid, low-cost detection methods, particularly lactometer-based specific gravity testing and protein titration, have been validated by multiple researchers as reliable tools for detecting milk adulteration. As Nawaz et al., (2022) emphasized, "In settings with limited laboratory infrastructure, such field-based tests offer a practical and scalable solution for routine monitoring of milk quality. In the same way, an Iranian researcher demonstrated that, with the use of simple methods, sensitivity and specificity can be achieved to detect common adulterants, such as water, urea, and detergents (Panahzadeh et al., 2016).These approaches not only reduce reliance on costly laboratory testing but also enable national governments and manufacturers to conduct quality checks more regularly and effectively.

The milk supply chain can be contaminated at many levels of the chain- at the stage of collection by farmers, during transportation, processing, and sale. In most situations, vendors add water to increase volume and profits. Although it can be assumed that the dilution of milk with water would be less dangerous than the use of chemical adulterants, the process of dilution lowers the nutritional quality of milk, especially its protein and fat amounts. Further, the diluting water is either impure or untreated, which adds another health danger (Chege & Ndungu, 2016). There are more serious adulterants, such as detergents, added to enhance frothiness or whiteness, which mimic the appearance of pure milk. They are toxic chemicals that may cause vomiting, diarrhea, organ damage, and health issues in the long run (Mudgil & Barak, 2013). The other issue is the addition of urea, a compound rich in nitrogen that is supposed to enhance the perceived protein level in milk. The kidneys and liver are very susceptible to such severe damage by urea, especially among vulnerable groups like infants and pregnant women (Kandpal et al., 2012). Artificial thickening with starch is also applied to diluted milk, and formalin is used to increase shelf life by slowing microbial growth, even though it is known to be a carcinogen (Chauhan et al.,2019)

In response to these risks, global organizations such as the Codex Alimentarius Commission, WHO, and FAO have also encouraged member countries to establish robust legal systems and food-testing laboratories and to continuously monitor high-risk products such as milk (Codex Alimentarius Commission, 2021). In this regard, Afghanistan has to immediately begin conducting empirical studies and implementing institutional response measures to ensure the safety of milk, protect consumers, and enhance consumer confidence in the food chain.

Afghanistan is a rich country with a predominantly agricultural economy, and livestock production and dairy consumption are old traditions. Nevertheless, like other developing countries, Afghanistan lacks a strong, centralized food safety surveillance system (Noori et al., 2024). The capital city of Kabul, which has more than 7 million residents, is urbanizing rapidly, and its population is becoming more dependent on informal markets and increasingly demanding food. It is an informal dairy supply chain, usually unregulated and lacking cold-chain logistics, which opens the door to unethical business practices in milk distribution. However, empirical information on the level of adulteration in the retail milk market in Kabul is quite lacking.

Scientific research on milk quality in Afghanistan has been minimal to date. There are scattered reports from health officials and the media that adulteration is widespread in dairy shops and among street vendors, especially in the summer months when milk can turn bad. But with no studies done in the labs and no structured data gathering, it is hard to measure the extent and trend of such adulteration. Such a data gap exposes consumers to health hazards and hinders the establishment of effective food safety policies. This study aims to;

- Fill this critical knowledge gap by assessing the quality of raw milk sold in retail dairy shops across Kabul city.

METHODS AND MATERIALS

This study was conducted in Kabul city, the capital of Afghanistan, which consists of 22 administrative districts. For feasibility, 11 districts were purposively selected, based on factors such as population density, milk consumption rates, and accessibility. Kabul's dairy supply chain is largely informal, and most retail shops operate without regulated cold-chain systems.

Sample Collection

A purposive, nonprobability sampling approach was adopted to target areas presumed to have a higher risk of adulteration. A total of 66 raw milk samples (six per district) were collected directly from retail dairy shops during early morning hours. Samples were obtained in sterile, food-grade plastic containers, labeled with district codes, and transported to the Food Technology and Hygiene Laboratory at Kabul University in iceboxes at 4–8 °C. All analyses were performed within three hours of collection. Each sample was tested in triplicate, and mean values were calculated to enhance data accuracy. The purposive sampling method was chosen because there is no national sampling frame of retail milk outlets in Kabul and to cover the various districts with different socioeconomic and hygiene statuses.

Preliminary Quality Assessment

All the samples were initially screened to determine their quality. An abnormal sample with abnormal specific gravity and protein content was collected for further chemical analysis to identify prevalent milk adulterants. Only the samples with a normal specific gravity range (1.028–1.034) and protein concentration were not further tested for adulteration.

Adulteration Detection Tests

Determination of Specific Gravity

Milk specific gravity was measured using a lactometer according to AOAC (2005) guidelines. Samples were poured into a 100 mL glass cylinder, and the lactometer reading was taken at the lower meniscus. Temperature was recorded immediately, and corrections were made by subtracting 0.2 units for each degree Celsius above or below 15.5 °C. The corrected lactometer reading (CLR) was then used to calculate specific gravity as follows:

Specific gravity=CLR/1000+1

Protein content (Formol titration)

Protein content was measured using the formalin titration method as described by Kalimoldina et al. (2021). First, 10 mL of milk was mixed with 0.4 mL of saturated potassium oxalate and 0.5 mL of 0.5% phenolphthalein. The mixture was titrated with 0.1N NaOH until a pink color appeared. Then, 2 mL of 40% formalin was added, neutralizing the solution and causing the pink color to disappear, followed by re-titration until the pink color reappeared. The difference between the NaOH volumes used after neutralization (re-titration) was calculated and multiplied by 1.74 to determine the protein percentage.

Starch test (Iodine reaction)

A drop of iodine solution was added to milk. The appearance of blue-black color confirmed the presence of starch (Navale & Gupta, 2016).

Urea test

Detected using para-dimethylaminobenzaldehyde reagent, where the development of a yellow color indicated the presence of urea (Shalileh et al., 2023).

Detergent test

10 mL of hot water was mixed with the milk sample, followed by a few drops of phenolphthalein indicator; the appearance of a pink or red color indicated the presence of detergent adulteration (Yadav et al., 2023).

All procedures followed guidelines adapted from the Food Safety and Standards Authority of India (FSSAI). The assays were performed in triplicate, and reagent blanks and positive controls were used to assess the reliability and reproducibility of the test.

Statistical Analysis

To statistically analyze the data, we used descriptive statistics to calculate the frequencies and percentages of pure and adulterated milk samples across the different districts of Kabul. The frequency of various forms of adulteration, including water dilution and other adulterants, was also determined.

To assess the statistical significance of differences in milk adulteration prevalence across districts, we used a Chi-square test of independence. Additionally, the 95% confidence intervals (CIs) for the proportions of adulterated and pure milk samples were calculated using the exact Clopper–Pearson method, which provides accurate interval estimates for binomial data, particularly when sample sizes are small or proportions are extreme. The analysis was performed using GraphPad Prism version 9.0, and statistical significance was set at 5% ($p < 0.05$).

Microsoft Excel 2016 was used to organize the raw data, compute percentages, and generate visual representations of the results, including bar and pie charts. The descriptive and inferential analyses were performed according to the guidelines for prevalence studies in food safety, as suggested by (Thrusfield et al., 2018)

FINDINGS

Overall, 54 samples (81.8%, 95% CI: 70.4%–90.2%) were adulterated, while 12 samples (18.2%, 95% CI: 9.8%–29.6%) were pure. In particular, 38 samples (57.6%, 95% CI: 44.8%–69.7%) were identified as adulterated by the addition of water, and 16 samples (24.2%, 95% CI: 14.5%–36.4%) contained other adulterants (starch and urea). This implies that the milk was adulterated in 81.8 percent of the samples, indicating a high rate of milk fraud in the Kabul market (Table 1). This high level of adulteration is dangerous to human health, as it poses a risk of consuming harmful chemicals and of low nutritional value.

Table 1. *Frequency and Percentage of Milk Sample Types*

Type of milk sample	Number of samples	Percentage (%)
Water adulteration	38	57.6
Adulteration with other substances	16	24.2
Pure milk	12	18.2
Total	66	100

To evaluate whether the prevalence of milk adulteration varied significantly across districts, a Chi-square test of independence was performed on the dataset. The Chi-square value of the test was 48.07 with 10 degrees of freedom (df), and the p-value was less than 0.0001 ($p<0.0001$). Therefore, the difference in the distribution of adulterated versus pure milk samples between the districts was highly significant. This affirms that the geographical location is a factor to consider when assessing milk quality in Kabul.

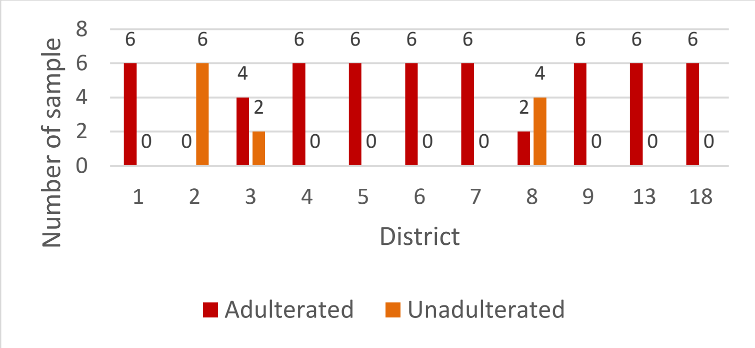

Figure 1. *Proportional Distribution of Pure and Adulterated Milk Samples in Kabul Dairy Shops*

There was a varying distribution of adulterated milk samples across the districts. The samples collected in districts 1, 4, 5, 6, 7, 9, 13, and 18 were all adulterated (100%). District 2, on the contrary, did not exhibit any cases of milk adulteration, and the six samples were clean. Intermediate adulteration was observed in districts 3 and 8, with 66.7% and 33.3% of the samples, respectively. Such fluctuations imply that local supply chains, vendor activity, and regulatory oversight vary by district (Table 2; Figure 1).

Table 2. *Distribution of milk adulteration status across districts in Kabul*

District	Number of samples	Adulterated	Unadulterated
1	6	6	0
2	6	0	6
3	6	4	2
4	6	6	0
5	6	6	0
6	6	6	0
7	6	6	0
8	6	2	4
9	6	6	0
13	6	6	0
18	6	6	0
Total	66	54	12

Regarding the types of adulteration, dilution with water was the most prevalent method, accounting for over half of the samples (57.6%). The remaining 24.2% of samples contained additional adulterants beyond water (Figure 2), including substances harmful to consumers or that degrade milk's nutritional value. The presence of these substances further complicates the public health risks posed by adulterated milk.

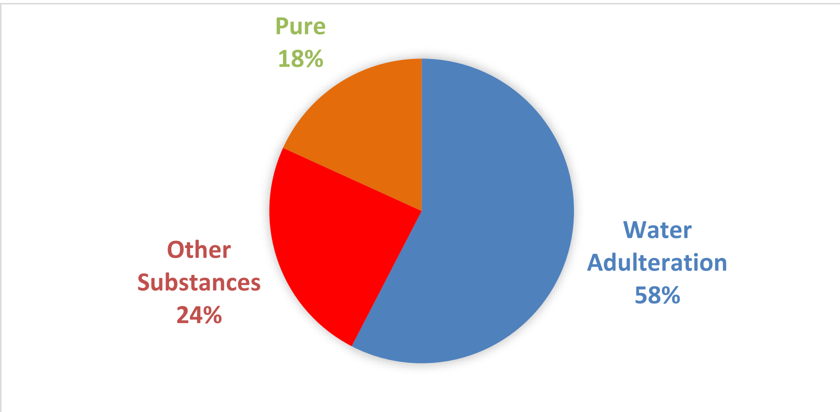

Figure 2. *Percentage of Pure and Adulterated Milk Samples in Kabul City*

In general, the results point to a serious problem in the dairy industry in Kabul, where more than 80 percent of milk samples fail to meet quality standards due to adulteration. This undermines consumer safety as well as trust in local dairy products. The significant difference between the districts indicates the need to introduce a narrower range of regulatory measures and to increase quality control, depending on local context. These findings highlight the need for continuous surveillance and sensitization to help eliminate milk fraud and safeguard consumers' lives.

DISCUSSION

The results of this research indicate a worrying level of milk adulteration in Kabul, with 81.8 percent of analyzed raw milk samples found to be adulterated. Of these, 57.6 percent were adulterated with water and 24.2 percent with other adulterants, indicating a high risk to food safety and revealing systematic failures in the dairy supply chain, regulatory oversight, and enforcement of public health in the city.

The prevalence of adulteration observed in the present study is lower than that reported by Habibi (2019) who found that 97.85% of milk samples collected from the Kabul market were adulterated, while only 2.14% were free from adulteration. Habibi detected several chemical adulterants, including sulfates (89.28%), formalin (64.28%), anionic detergents (7.14%), starch (3.5%), and sodium chloride (3.5%). Although both studies were conducted in Kabul City, the differences in adulteration prevalence may be explained by variations in the study period, sampling strategy, sample type, sample size, and analytical methods. Habibi's study included both locally produced and imported liquid milk available in Kabul markets, whereas the present study focused exclusively on raw milk collected from retail dairy shops in Kabul. Despite these methodological differences, both studies consistently demonstrate that milk adulteration remains a serious food safety issue in Kabul.

The findings of the present study are partly consistent with those of Noori et al. (2024), who evaluated the physicochemical quality of imported milk brands in Kabul. They reported significantly lower protein levels in some imported milk brands, along with significant variations in total solids, titratable acidity, pH, and specific gravity compared with standard values. Although their study did not directly investigate chemical adulterants or retail raw milk, these physicochemical deviations indicate compromised milk quality and support the present findings that milk quality remains a concern in Kabul.

The patterns are consistent with those in similar regional studies. Abbas et al. (2024) found a 40 percent adulteration rate in Karachi, Pakistan, which is much lower than that in Kabul (81.8 percent). However, they also found that adulterants included urea, detergents, starch, and formalin. The two works highlight that adulteration primarily occurs at selling points and during transport, indicating poor retail-level quality management. Formalin (16.4%) and hydrogen peroxide (11.5%) contamination was also reported by Panahzadeh et al. (2016) in Qazvin, Iran, together with salt and water adulteration.

Similarly, in Hyderabad, Pakistan, a study by (Shaikh et al., 2013) found 100% water adulteration, with an average extraneous water content of 21.18%. This finding supports Kabul's observed practices and reflects broader regional trends during high-demand periods, such as in summer months. Moreover, the increased freezin g point and decreased viscosity in adulterated milk were consistent indicators of water dilution, as confirmed in both Hyderabad and Kabul samples. In Bangladesh Chanda et al (2012) Found widespread adulteration at milk entry points in Barisal District, including water, cane sugar (26%), starch (12%), and powdered milk (14%). These practices were aimed at increasing milk volume and mimicking authentic milk characteristics, paralleling Kabul's use of adulterants such as detergent and urea for the same purpose. Additionally, sodium bicarbonate (20%) and formalin (10%) were detected in that study, again matching Kabul's chemical profile.

There were also large geographic variations in Kabul ($\chi^2 = 48.07$, df = 10, $p < 0.0001$), with District 2 being the only district in which all samples were shown to be pure, whereas some districts showed no adulteration. This implies that there are local variations in supply chain integrity, enforcement, and vendor practices, indicating a need to implement targeted interventions rather than general policies. The identified adulterants pose serious health risks. Vitamin and mineral content is lost during water dilution and can compromise nutritional value. Adulterants in chemicals such as urea and detergents pose risks, including kidney damage and gastrointestinal tract irritation (Azad & Ahmed, 2016).The simple rapid diagnostic tests (protein titration and lactometer-based specific gravity measurement) used in this study were both sensitive and specific in distinguishing between water dilution and more sophisticated adulterations, which are important in resource-constrained settings such as Kabul.

To support these findings, Nawaz et al. (2022) tested milk samples from Mardan district, Pakistan, which also raised concerns about physico-chemical quality and adulteration. Their research also identified reduced fat (to 4.04 percent) and protein content (to 3.34 percent) in some samples, indicating dilution and potential fat skimming, consistent with the Kabul results. The water content varied between 14.73% and 15.85%, which showed adulteration with excessive water- a fact that was re-confirmed in the two studies. The components of solid non-fat (SNF), which are essential to growth, were reduced, providing stronger support for SNF as an indicator of quality.

The adulteration detection was further supported by milk density and electrical conductivity measurements. Both studies demonstrated that adding water decreases density and modifies conductivity, and that salts may also raise conductivity. Such practical tests are easy to administer and provide affordable instruments for milk quality testing.

The implications of these findings extend beyond immediate health risks. Persistent exposure to adulterated milk undermines consumer trust, violates food safety rights, and compromises the nutritional security of vulnerable groups. In line with Codex Alimentarius and WHO recommendations, Afghanistan urgently needs a multi-tiered response combining strict enforcement, vendor education, and public awareness campaigns. Moreover, establishing mobile testing units and expanding laboratory capacity could facilitate more frequent and decentralized monitoring. In summary, this study not only quantifies the magnitude of milk adulteration in Kabul but also identifies key adulteration practices, geographical hotspots, and feasible detection methods for low-resource contexts. By providing baseline data for policymakers and public health authorities, it lays the foundation for targeted interventions to safeguard milk quality and public health in Afghanistan.

CONCLUSION

This study indicates that milk contamination in Kabul city is a significant health issue, and 81.8 percent of samples failed to meet minimum quality standards. This extensive dilution in water and adulteration with deleterious chemical additives, such as urea and detergents, pose major health hazards to milk safety and direct health risks to consumers. The high geographic variability of adulteration highlights deficiencies in supply chain integrity, vendor practices, and regulatory enforcement.

It requires a multidimensional and urgent solution. Local and national food safety authorities should implement strict surveillance systems with mobile and fixed laboratories capable of on-site testing. Sensitization programs to educate consumers, vendors, and small-scale producers are necessary to raise awareness of the dangers of adulterated milk and encourage safer methods. Moreover, punishing repeat offenders can help prevent unethical practices in the milk distribution chain.

The implementation of low-cost, easily practical diagnostic methods, such as specific gravity and formol titration, demonstrates that quality control can be effectively achieved even in resource-poor environments like Kabul. Such instruments enable official bodies and research institutions to conduct regular monitoring and must become part of national food safety systems.

In conclusion, the issue of milk adulteration needs to be addressed not only to enhance food quality but also as a safeguard of people's health, consumer rights, and confidence in the Afghan food chain. A lifelong partnership among government agencies, research institutions, and community stakeholders is critical to providing safe and nutritious milk. Future research should expand geographic scope, include microbial assessments, and consider seasonal effects to build a comprehensive understanding of milk safety and adulteration trends nationwide.

Authors Contributions

The authors declare that no external funding was received for this research. Nasir Ahmad Sarwary was involved in all aspects of the study, including the study design, and played a significant role in the planning. Mohammad Asif Noori assisted with writing and manuscript verification. Mohammad Zaher Sakha assisted in reviewing the manuscript. None of the contributors had any funding or sponsor involvement in relation to the study design, data collection, analysis, interpretation, report writing, or decision to submit the article for publication.

Acknowledgements

The authors declare that they have no acknowledgments to make.

Funding Information

The authors did not receive funding.

Conflict of Interest Statement

The authors declare that there are no competing interests related to this publication.

Data Availability Statement

Data will be made available if needed.

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