

Food Safety Perspective: Assessing Milk Quality, Safety, Adulteration, and Supply Chain Dynamics in Khyber-Pakhtunkhwa, Pakistan.

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ABSTRACT

This study was carried out by the (Khyber Pakhtunkhwa Food Safety and Halal Food Authority) to examine the quality of raw milk available in the markets from across 26 districts of Khyber Pakhtunkhwa (KP) province. Total 583 milk samples were collected from medium and large shops in the province, while 87 samples were obtained from the milk tankers supplying milk from other stations other than the KP. Out of 583 samples, 418 were found to be adulterated with more than 8% water, and 224 had fat content below the standard of 3.5%, with various other adulterants including glucose in 106 samples, formaldehyde in 17 samples, sucrose in 92 samples, salts in 24 samples, maltodextrin in 34 samples, and melamine in one sample. 488 samples had lower than standard solid-not-fat (SNF) levels. Besides, 17 samples were identified as chemically constituted milk, and only 42 samples met minimum standards. Out of the 87 samples tested from the milk tankers, 79 samples failed to meet the quality standards, 67 samples were found to have added water, 7 samples had a fat content of less than 3.5%, 17 samples were found with added glucose, 15 samples were found with added sucrose, 5 samples tested positive for formaldehyde addition, 76 samples had low SNF (Solid-Not-Fat) levels. It can be summarized from the results that quality of raw milk in the province is not up to the standards and posing public health issue in the region due to adulteration and needs drastic reforms in improving supply chain management, enforcement mechanism and awareness.

Keywords : Milk Quality, Supply chain, Safety, Milk adulteration, Chemical Adulteration.

INTRODUCTION

Milk is considered to be a complete food and a great source of the essential nutrients needed for proper growth and other functions of the body. The white, nourishing liquid food is released by the mammary glands of mammals. 18 out of 22 essential nutrients are found in milk, along with a variety of bioactive peptides and fatty acids like caseins, whey proteins, milk polar lipids (MPL), conjugated linoleic acids (CLA), α -linolenic acid (ALA), lactose, palmitic acid (16:0), and other minor ingredients like calcium, phosphorous, magnesium, and vitamin D that are crucial for human health and metabolism (Zhang et al., 2021 Cavaliere et al., 2023).

Small-scale rural farmers account for a considerable amount

of milk production in Pakistan, which is one of the top 5 milk producing countries in the world. Milk is produced in rural areas about 80% of the time, peri-urban areas 15% and urban areas 5%. Milk output in the 1960s and 1970s averaged 6.6 million metric tons and 8.1 million metric tons, respectively. In three decades, this has quadrupled from 12 million MT in 1985–1986 to 48 million MT in 2018–19 and 55 million MT by FY23 (Dairy sector update, 2024).

Over the previous ten years, Pakistan's average milk output has stayed at roughly 50 million tons (MNFSR). with Sindh and Punjab provinces producing the most, then KPK and Baluchistan. Of Pakistan's total milk production, Punjab is predicted to produce 63%, Sindh to produce 23%, KPK to produce 12%, and Baluchistan to produce 2% (Economic Survey of Pakistan 2022-23, 2018-19). The current production of the Khyber-Pakhtunkhwa Province does not meet the demand of the province. Due to the importance of milk in human life, the gap between supply and demand, higher prices, perishable nature and the lack of proper enforcement mechanism it is one of the most vulnerable food products to adulteration (Reddy 2017).

However, the practice of adulterating milk continuously lowers its quality and may introduce dangerous compounds into the dairy supply chain, putting consumers' health at risk. Many cases of adulterated milk have been reported worldwide. Potential adulterants in milk and milk products include extraneous water, foreign proteins, whey proteins, melamine, and urea, as well as vegetable or animal fats and thickening agents like starch, flour, glucose, urea, and salt (Dhiman et al., 2020).

Milk is also given additional preservatives, such as formalin and some antibiotics, to lengthen its shelf life. The nutritional value of milk is reduced by this addition. These medications, preservatives, and adulterants in milk lead to extremely dangerous health issues (Ali et al., 2011).

The Khyber Pakhtunkhwa Food safety and Halal Food Authority is working under the Food Safety Act 2014. This Authority is striving for the provision of safe, healthy, nutritious and halal food in the province. The current study was carried out in order to determine the quality safety and supply chain management of milk produced locally and of that supplied from other provinces of the country.

MATERIALS AND METHODS

Sample collection and survey

Milk samples were collected from medium and large milk shops across 26 districts in Khyber Pakhtunkhwa Province. The samples were properly collected following standardized procedures. Sterilized bottles were used for collection of the samples, properly coded to ensure identification, confidentiality and integrity of the samples. Cold chain was

maintained during transportation to prevent the milk sample from microbiological deterioration (Nicolaou N, et al., 2008). Ice boxes were procured for the drive which had the capacity to store the milk sample at 2-4 °C. The samples were received in the Hayat Abad Food Testing Laboratory, Peshawar.

Similarly, milk samples were collected from tankers transporting milk into the province. The collection was conducted at various key entry points identified for the out-province supply, including Motorway M-1, Swat Expressway, Kohat Road, Peshawar, Gandhi Chowk Dera Ismail Khan.

Sampling points, sources and selling capacity

Milk is supplied to the markets within the province from local sources and due to the high demand of milk and low production in the province a bulk quantity is supplied from out province sources. A proper survey was conducted on the prescribed proforma regarding source of milk and selling capacity of the shops. Details about number of local suppliers, out province suppliers, details of the milk supplied in liters from the local and out province sources were acquired.

METHODOLOGY

The samples were analyzed through the MilkoScan™ FT3 for the analysis of milk composition, added water and detection of adulterants including sugars, artificial sweeteners and other chemicals. MilkoScan™ FT3 an automatic, high-resolution spectrophotometer, based on Fourier transform infrared (FTIR), used for the rapid determination of components of milk. 80 ml of milk sample was used for each analysis (AOAC Official Method 972.16). All the samples were analyzed in triplicates. Results of the samples were generated within 24 hours of sample collection. For interpretation and compilation these results were provided to Research and Development Khyber Pakhtunkhwa Food safety and Halal Food Authority. The results were compiled on the basis of composition of the milk and adulteration in the milk. A total of 37 parameters were considered for quality of the milk.

The analysis revealed varying levels of water addition and other forms of adulteration as per standards of Pakistan Standards and Quality Control (PSQCA).

RESULTS AND DISCUSSION

Samples taken from the markets

Water Adulteration

The most common adulterant found was water. Addition of water and ice is common which affects the physical quality of milk. Samples having 1-8% of only water adulteration have been given a grace due to the prevailing hot and humid weather during collection and analysis of the samples, despite that out of the total (583) samples a higher proportion of the

samples (418) were found to be adulterated significantly with above 8% of water, which is 71.69% of the total samples.

Out of the total (583) samples (123) samples were having 9-15% of water adulteration, (170) samples were having 16-25% of water adulteration, while (125) samples were having above 25% of water adulteration. This indicates that the quality of milk has been significantly compromised with water adulteration in majority of the samples. Water is added in order to achieve greater volume but depending upon the source of water it not only can reduce the nutritional value of the milk but also can poses a major food safety challenge as the water added from ponds and lakes and other sources may be contaminated with pathogens, agriculture chemicals and other heavy metals. The addition of this contaminated water to the milk can cause cholera, bacillary dysentery, hepatitis, typhoid, paratyphoid and salmonellosis etc. [Paul M], {Aleiw B}

Low fat content

Evidently number (224) out of the total (583) samples were having low fat content. Samples with less than 3.5% fat has been considered low fat as per PSQCA standard for cow milk. Samples with low fat are 38% of the total samples. In Khyber Pakhtunkhwa Province milk per liter price is fixed on the basis of % fat. Higher is the % fat of the milk higher is the price per liter (District Administration). Low fat content milk deceives the customer and increase the perceived value of the product.

Added sugars

Considerable number (106) out of the total (583) samples had added glucose, which is 18.18% of the total. While (92) out of the total (583) samples were having added sucrose which is 15.78% of the total samples. These sugars are often added to improve the taste and texture of diluted milk. sugar like sucrose is added to the milk to increase the carbohydrate content of the milk and used to increase the density of milk (Chauhan et al., 2019). This can deceive consumers and increase the perceived value of the product. Cane sugar or sucrose is added in the milk to reconstitute its compositional requirement followed by adulteration of extraneous water in the milk (Ragae, S. and Abdel-Aal, E.S.M., (2006). Added sugars can adversely effect those having health issues like diabetes.

Added salt

Out of the total (583) samples (24) number of samples were having added salt which is 4.1% of the total. Salt is added to milk as an adulterant to mask the taste of dilution and increase the milk's density, making it appear fresher and higher in quality.

Added maltodextrin

Out of the total (583) samples (34) number of samples were

having added Maltodextrin. Maltodextrin gives milk a richer, creamier texture by increasing its volume and thickness. Customers find the milk more enticing and healthful as a result. Milk can be made more volumetric by adding water, but this is not economically desirable. Instead, starch is added to the milk to preserve its density and solid components. Diarrhea is brought on by undigested starch irritating the stomach. (Azad T et al., 2016).

Added formaldehyde

Out of the total (583) samples (17) number of samples were having added formalin in the milk which is 2.91% of the total. Formaldehyde is added to milk as an adulterant to prolong its shelf life by preventing bacterial growth. Formaldehyde is a preservative that can be toxic, according to the World Health Organization, the estimated daily intake of formaldehyde in adults should be in the range of 1.5–14 mg/day (WHO., 2001). However, if consumed in excess, formaldehyde adversely affects the gastrointestinal tract, kidney, liver and lungs and may lead to cancer (Wilber et al., 1999). Formaldehyde ingestion irritates the mucous membranes and causes inflammatory changes in the liver and kidneys.

Added sorbitol

A noticeable number (28) out of the total (583) samples were having added sucrose which is 4.8% of the total samples. Sorbitol is an artificial sweetener added to milk as an adulterant to increase the milk's sweetness and density, simulating higher-quality milk. This can deceive consumers and increase the perceived value of the product.

Low SNF

488 samples out of the 583 had low SNF which is 83.7 % of the total samples. The amount of SNF (solid, not fat) components in milk is decreased when water is added, especially protein, which is one of the vital nutrients needed for healthy growth and development. Consequently, the amount of SNF can dictate how much water is added to milk (Santos, P. M., et al., 2013). From the results it is obvious that the overall the milk quality is compromised with added water.

Chemically constituted milk

A noticeable number (17) out of the total (583) were found to be chemically constituted as the amount of formaldehyde, hydroxyproline, sodium bicarbonate, glucose and sucrose was higher in these samples (one sample having higher melamine). Moreover, the fat content in one sample was unusually high (20 fat). This number is 2.91% of the total samples.

Estimated Quantity of the milk samples and total number of failed samples

Total estimated quantity of the 583 samples taken from medium and large shops was estimated to be (323,962 liters), out of which 541 samples failed to meet the quality standards and estimated quantity of these samples was (306,762 liters). Only 42 samples met minimum criteria, highlighting serious concerns regarding milk adulteration and quality. Milk samples taken from local sources of milk were 345 and total estimated quantity of the milk was 85,702 liters, out of which 320 samples failed to meet the minimum criteria. Milk samples tested from out province sources milk were 135 and the total estimated quantity of the milk was 177,850 liters, out of which 127 samples failed to meet minimum standard. Similarly, milk samples taken from unknown sources of the milk were 103 and total estimated quantity of the milk was 43,210 liters, out of which 94 samples failed to meet minimum standard.

Results of the samples collected from milk tankers

Out of the total 87 samples collected, a significant number showed signs of adulteration or did not meet the required quality standards, (67) samples were found to have added water above 8% which is 77% of the total samples, 7 samples of the total samples had a fat content of less than 3.5% which is 8% of the total samples, 17 samples were found with added glucose, 15 samples were found with added sucrose, 5 samples tested positive for formaldehyde addition. 76 samples had low SNF (Solid-Not-Fat) levels.

Total Failed Samples

Out of the 87 samples tested from the milk tankers, 79 samples failed to meet the quality standards, highlighting serious concerns regarding milk supply to the province from out sources.

Statistical analysis

All experiments were repeated in triplicate. The results of the basic composition of milk and other adulterants analyses were compared by ANOVA using the Excel 2016 software program (Microsoft, CA, USA). The statistical significance was determined at $p < 0.05$.

CONCLUSIONS AND RECOMMENDATIONS

The KP Food Safety and Halal Food Authority's study on milk analysis sheds light on a significant public health concern in the area. The study's vast geographic scope within the province of Khyber Pakhtunkhwa suggests that milk adulteration is a problem that affects both urban and rural areas. Widespread adulteration of milk with water, sweeteners, and toxic compounds puts consumer health at serious risk and

erodes confidence in the dairy industry. Stricter regulation and enforcement, better supply chain management, and extensive education efforts to increase public knowledge of the risks associated with milk adulteration are just a few of the many strategies needed to address this issue. The current study will help to devise a policy at provincial and national level to reduce the menace of adulteration in milk.

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