A Study on Milk Adulteration and methods of detection of various Chemical Adulterants qualitatively

Riya Chugh¹, Gurmeet Kaur*¹

¹Chemistry Department (UIS), Chandigarh University, Gharuan, Mohali - 140413

Email ID: riya.r62@cumail.in, gurmeet.uis@cumail.in

ABSTRACT: The food Adulteration now becomes a worldwide issue as the emergent nations are at very high risk associated with this Adulteration. The milk is an important part of our daily life and is consumed on the daily basis but, now a days milk is being adulterated by several chemicals due to lack of monitoring, unhygienic conditions and for financial gain. Unfortunately, various chemical Adulterants can pose danger health risks that lead to many lethal diseases including heart problems, diarrhoea, CNS disorders, irritation and gastrointestinal disorders. Various common Adulterants like benzoic acid, urea, water, skimmed milk powder, sugar, detergent were detected in the pure milk samples which concludes that the milk samples doesn’t meet the expected quality accepted as standard. Many studies have been carried out on milk Adulteration and detection techniques. This Present work gives a clear view of the quality of milk. This article gives a comprehensive review of the common Adulterants added in milk along with the various methods of detection qualitatively.

1. Introduction

Milk is a pale white nutrient rich liquid food produced by mammals. It is a major source of nutrition and provides essential nutrients to maintain the growth of body. Since ancient time in India, It is a significant and valuable part of our diet as it is readily digested and absorbed. Humans have been preserving the milk for centuries. Milk is made of water, fat, protein, lactose and some minerals. This milk is used as a source of food for the infant humans and animals who are unable to eat at that time. It provides various essential nutrients like protein, vitamins, carbohydrates, fat and minerals. Milk alone contains these all-important nutrients than any other single food; this is the main reason for milk to be called as complete food. The lactation milk contains many antibodies like IgA which contains many antibodies which helps in fighting from disease in the infants [1]. It is easily obtained by various milk-producing animals like cow, buffalo and goat etc.

India’s share in world milk production stands at 17 % as it produces 90% of the total volume of buffalo milk in world and is on second rank for worldwide production of cow’s milk i.e. 54 million metric tons followed by USA.

Being the largest milk exporter of milk and skimmed milk yet it is needed for country like India to import some milk varieties [2,3].

The process of production and exportation of milk is done via a proper supply chain that creates network between different companies, which helps in the distribution of the sample. More than six billion of the world consumes milk and its products [4].

The milk constitutes many particles containing lactose, water, fat, protein, milk sugar and salt mineral. Trace amount of various phospholipids, vitamins, enzymes are there in the milk.

Rajasthan, Maharashatra, Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, Karnataka and Andhra Pradesh are some of the states having highest production rate. The following map shows the three
major states having highest production of milk (figure 1). The survey shows the contribution of different states of India to the growth of milk production [5].

![Image of milk production contribution by states]

**Figure 1.** Contribution of States in the production of milk

However, the quality of milk is being exploited continuously since era due to its Adulteration in the market. Adulteration is done by adding various cheaper Adulterants that increases the quantity of the milk and to make more profit. The major and common adulterant of milk is water, which consequently decreases its nutritive value and also become a source of water- borne diseases if added water is contaminated.

In order to know more about the milk Adulterants and its effects on human health, a research has been done determine the quality of raw milk in Delhi-NCR.

1.1 Adulteration

The Deterioration of Milk is a socio economic issue especially in the developing nations the act of addition of various substances to the food products in order to increase its quantity results in the looses of its actual quality of the food items and to makes it unfit for consumption. The adulterated food product fails to meet the legal standards [6].

The most common chemical Adulterant which are added in the milk includes starch, Chlorine, Sodium carbonate, Formalin, Ammonium Sulphate. These chemicals like urea, starch, flour, detergent etc. are added in the milk to increase profit margin [7].

To meet the paucity of milk the artificial milk is then processed by adding urea, refined oil, Sodium hydroxide, and some ordinary detergent which has adverse and toxic effects [8–11,11,12]. The consumption of adulterated milk causes various critical health regarding problems like heat diseases, cardiovascular diseases, skin diseases etc. Hence, it has become a great concern to the food safety.

The major food Adulteration occurs with widely publicized Adulteration of milk and milk products. Adulterated milk is the one in which the milk quality is intentionally degraded by mixing substandard toxic substances or chemicals to increase the profit.

Generally, the major adulterant in the milk is water in high percentage and it is a very serious concern. When milk is adulterated with water there is a decrease in the quantity of ions present in the milk and electrical conductivity also get changed [11,13–18].

The contaminated water if added in the milk, it will cause severe health problems especially to infants [11,19–22].

To reduce the increased demand, the Contamination of milk has progressively prevalent in India. Most of the times, the Adulteration is intentionally done to make high profits, but sometimes may be
due to lack of proper detections. The chemicals and various substituents added to the milk to meet the rapid demand of milk. Constantly the natural milk is contaminated with low value ingredient like water and detergent. Several other reasons may also be the major issues for milk Adulteration.

Milk used by the common people is such adulterated that it has become very less nutritive and may cause several serious diseases like gastrointestinal illness, heart problems, cancer, irritation in eyes, kidney problems, etc. The common Chemical which are intentionally or unintentionally added to milk are glycogen, urea, chlorine, soda ash, formaldehyde, detergent, caustic soda, skimmed milk powder, flour, vegetable oils etc.

In order to know more about the milk Adulterants and its effects on human health, a research has been done to determine the quality of raw milk in Delhi-NCR. FSSAI in 2011 conducted a survey on milk Adulteration in some selected urban and rural areas, found that the most common adulterant of milk is water.

2. SOME COMMON FOOD ACTS

The Act ensure that the milk used is safe for drinking and consumption purpose. The data contains all the information about various offensive content present in the sample. Various food acts which are applicable to preserve and package milk and milk products in India are Vegetable and Oil Products Order (1947), Prevention of food Adulteration act (1954), The Fruit Products order (1955), Meat Food Products Order (1973), Edible Oil Packaging Order (1988), Milk and Milk Products Order (1992), Food Safety and Standards Authority of India (2006).

3. LITERATURE REVIEW

In the Department of Public Health and Epidemiology, College of veterinary science, Proddatur town, Kadapa, Andhra Pradesh a study was reported, Fifty samples of raw milk were found to be adulterated with highest percentage of salt and sugar that is 54% and 40% respectively and did not confirmed to the legal standards of FSSAI [23].

Nirwal et al. (2013) collected 100 samples from different localities of Dehradun. Out of which only two milk samples were found to be pure and rest was adulterated with high amount of glucose i.e. 80%, of the skimmed contains 58% of milk powder, 51% of salt and 35% of urea. 32% of the result of milk samples was found to be safe for consumption and follow the act and the rest of the 68% failed to follow the law. Study concluded that the most common adulterant added in milk is water that not only reduces the nutritional value but also spread various water-borne illnesses.

Testing of milk Adulteration was done on 50 samples obtained in sterilized screw capped glass bottles to avoid external contamination were from Godaulia and Pandeypur of Uttar Pradesh (Varanasi) India. The extent of Adulteration in these milk samples with NaCl, neutralizers and NH$_2$CONH$_2$ were 80%, 28% and 60% respectively. The preservative used increases the shelf life of the milk. Same testing was done in Tandojam, Hyderabad with 20 samples among which 40% of the milk sample were found to be adulterated followed by 30% with starch and 25% with urea. The Adulterants had strong potential to degrade the qualities and physico-chemical characteristics of milk [19].

A 2007 report in the journal of American Heart Association found that consumption of vanaspati elevates cholesterol level in the body causing diabetes and coronary ailments. A national survey conducted shows that nearly 70% of nations the milk is adulterated with neutralizers and detergent, but water again is the major contaminant found in milk [24].

According to study of Adulteration in Hyderabad, total 50 samples were collected for determination and extent of Adulteration. It was found that sucrose and SMP were present in 22% and 88%
respectively. The amount of Urea, neutralizers and salt (NaCl) were found to be 26%, 80%, and 82% of the milk samples. Some other chemical Adulterants like Formalin, detergent and hydrogen peroxide were present in 32%,32%, and 44% is obtained (figure.2). All the mentioned Adulterants found in the milk samples proved about the milk that it did not conform any legal standards and might cause critical health hazards [19].

Figure 2. Percentage of chemical Adulterants in milk.

According to the national survey in India by FSSAI in 2011 in concluded that after detergent water is found to be the most commonly used adulterant in the milk. Further in 2012, it concluded in a survey that 68% were found to be adulterated and 88% was there in Uttrakhand [19]. Research on milk Adulteration done in Koti, Hyderabad concluded that out of ten samples of milk, six samples were highly adulterated with water and starch and one was adulterated with detergent (figure. 3) [25].

Figure 3. Adulterated milk with detergent

India’s milk production is 18.5% of the world population. According to FAO the increase in worlds milk production is 3.1% while as that of India is 18.5% in the year 2014-15. Though India ranks 1st in milk production still it is importing milk products and on the other hand exporting less quantity of milk and milk products to the neighbouring countries [26]. From China 300 samples were collected from 3 localities in Sudan. Ninety five percent of the samples were found to contain water and 35.5% contained starch. As per the studies carried out in Hyderabad, Pakistan and its vicinity it was found that most of the milk simples contained most common Adulterants practiced out by market milkman. Out of 100 unprocessed milk samples, no sample was found to be wholesome/unadulterated. Beniwal and Akhetar paul (1999) reported the Adulteration of water to be 70% while almost 94% samples of milk adulterated with water was recorded by Lateef et al. (2009). Other Adulterants like formalin, starch, skimmed milk powder and NaCl were 34%, 13%, 8%, and 5% respectively [27].
Karabi et al. have conducted a study that shows constant phase element sensor for the detection of microorganisms and bacteria in milk. The growth of bacteria and microbes changes the ionic properties of the medium, which results in changing the conductivity value of the milk. [28].

In 2011, it was found that 260 million dairy produced 730 million tonnes of milk. But in today’s world, 600 million tonnes of milk was produces by 264 million dairy cow every year and goat milk is the number one consumed milk in the world. Six billion of consumer of milk and its product are there worldwide.

Dr. Sitaram dixit, chairman, CGSI Maharashtra, reported that milk Adulteration has increased by 5% in the year 2018 as per the research conducted, the 340 low-graded or loose milk packets were tested, out of which 76 samples, which made up for 22% were standardised, while the remaining 264 packets that were made for 78% were found to be adulterated.

Pawan Agarwal, CEO, FSSAI conducted a detailed survey on the presence of Aflatoxin M1 a kind of fungus, gets mixed in the milk through feed and fodder, majorly found in packaged milk products in top three states including Delhi, Tamil Nadu, Kerala, total 368 samples (out of 6,432) that is 5.7% in the country were found to be adulterated by the Aflatoxin M1 [29]The (table 1) shows the common Adulterants present in the milk.

**Table 1.** Some Places where Major Adulterants were detected in Milk Samples.

| S No. | Area                  | No. of Samples | Major Adulterants         | References |
|-------|-----------------------|----------------|----------------------------|------------|
| 1.    | Kadapa, Andhra Pradesh| 50             | Salt, sugar                | [23]       |
| 2.    | Dehradun              | 100            | Glucose, skimmed milk powder | [22]       |
| 3.    | Pandeypur, Varanasi   | 50             | Sodium chloride, urea      | [22]       |
| 4.    | Tandojam, Hyderabad   | 20             | Starch, urea               | [11]       |
| 5.    | Hyderabad, Andhra Pradesh| 50         | Urea, salt                 | [19]       |
| 6.    | Koti, Hyderabad       | 10             | Water, Starch              | [19]       |
| 7.    | China                 | 300            | Water, starch              | [27]       |
| 8.    | Hyderabad, Pakistan   | 100            | Water, formalin            | [28, 29]   |

4. METHODOLOGY

4.1 Procurement of milk samples

The present study was conducted in Manav Rachna University, Faridabad, Haryana. In total twenty-five samples were collected from local vendors, dairies and farms from different areas and brands that come under Delhi-NCR. The raw samples were collected into clean dry sterilized bottles to prevent
any type of contamination. The testing was done for given eight Adulterants i.e. Starch, Pulverised soap, Vanaspati, SMP (Skimmed Milk Powder), sugar, synthetic milk, Benzoic acid and Salicylic acid.

Table 2. Number of milk samples collected from different areas.

| S No. | Milk Samples | Area                  | Milk Brand         |
|-------|--------------|-----------------------|--------------------|
| 1.    | A            | N.I.T - 5             | Dairy              |
| 2.    | B            | Jawahar Colony        | Dairy              |
| 3.    | C            | Dabua Colony          | Amul Toned         |
| 4.    | D            | Okhla                 | Dairy              |
| 5.    | E            | Dabua Colony          | Dairy              |
| 6.    | F            | N.I.T – 5             | Mother Dairy Toned |
| 7.    | G            | S.G.M Nagar           | Dairy              |
| 8.    | H            | N.I.T - 5 , Block C   | Dairy              |
| 9.    | I            | N.I.T – 4             | Dairy              |
| 10.   | J            | Badarpur Border       | Dairy              |
| 11.   | K            | Manav Rachna          | Milk Powder        |
| 12.   | L            | N.I.T – 2             | Dairy              |
| 13.   | M            | Manav Rachna          | Mother Dairy Toned |
| 14.   | N            | Sec-20b               | Dairy              |
| 15.   | O            | Okhla                 | Amul               |
| 16.   | P            | Sec-20b               | Dairy              |
| 17.   | Q            | Sec-15                | Amul               |
| 18.   | R            | N.I.T-3               | Dairy              |
| 19.   | S            | Okhla                 | Vita               |
| 20.   | T            | Sec-21c               | Paras              |
| 21.   | U            | Sec-16                | Mother Dairy       |
| 22.   | V            | N.I.T-2               | Ananda             |
| 23.   | W            | S.G.M Nagar           | Dairy              |
| 24.   | X            | Gandhi Colony         | Country Delight    |
| 25.   | Y            | Sec-16                | Parag              |

5. ANALYSIS OF MILK SAMPLES

5.1 Sugar - Take 3ml of milk sample in the test tubes. Add 2ml of concentrated HCL and 50 mg of resorcinol, then heat the test tubes and solution turns red, which shows the existence of sugar in milk sample (figure.4).
5.2. Pulverized soap - In the given milk samples add 10ml of hot water with 2-3 drops of phenolphthalein as an indicator. The presence of soap in the milk is analysed by the appearance of pink colour (figure 5).

5.3. Skim milk powder - Take some milk in test tubes, add few drops of Nitric acid drop wise, the yellow colour if appears the milk is unadulterated (figure 6).

5.4. Benzoic acid - 5ml milk was taken in test tubes, and to it sulphuric acid was added drop wise and 0.5% ferric chloride in it. The buff colour of the milk shows the presence of benzoic acid (figure 7).
5. Salicylic acid - Take some amount of milk sample in test tubes, add few drops of H$_2$SO$_4$ and 0.5% FeCl$_3$ in it. The colour changes to violet that indicates that salicylic acid is present in the given milk sample.

5.6. Vanaspati - In a test tube, Take 5 ml of milk sample and add 10 drops of HCL with 1 teaspoon of sugar is added. If the colour of the milk changes to red, it shows the presence of ghee (figure.8).

5.7. Synthetic milk - Take some milk in test tube and heat the test tube. The yellow colour indicates that the milk sample is adulterated (figure.9).
5.8. Starch - Take 3ml milk in test tubes and was kept for incubation for 5 minutes in boiling water. Then, cool it and add (1%) iodine solution, mix well. Black colour appeared which confirms the presence of starch.

6. RESULTS AND DISCUSSIONS

The most harmful Adulterants found in the milk are Water, Benzoic acid and Sugar.

The presence of sugar in the milk is observed generally, as it is a common source of natural sweetness in the milk. Some Adulterants like Hydrogen peroxide, urea and various other neutralizers also used as cheap preservatives that assist to enhance the shelf life of milk. Among all the Adulterants, water and benzoic acid both were found to be the common and major Adulterants present in the milk that degrades the nutritional value of milk and may cause various critical water-borne diseases.

All the 25 samples were tested for common Adulterants like sugar, vanaspati, starch etc. as depicted in the (table3). After the determination of milk samples benzoic acid, synthetic milk, sugar and skimmed milk powder were found to be major Adulterants. A, B, G, I are milk samples from different localities were highly adulterated with SMP, sugar and benzoic acid whereas the milk samples named as E, F and L were commonly adulterated with sugar, synthetic milk and benzoic acid.

Table 3: Twenty-five different brands of Milk were samples tested with presence of different Adulterants.

| Sno. | Adulterants   | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y |
|------|---------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1    | Starch        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 2    | Pulverized Soap | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3    | Skim Milk Powder | - | - | - | - | - | - | - | - | + | - | - | - | - | - | - | - | - | + | - | - | - | - | - | - | - | - |
| 4    | Sugar         | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 5    | Synthetic Milk | - | - | - | - | - | + | + | + | + | + | + | + | + | - | - | - | + | - | - | - | - | - | - | - | - | - |
| 6    | Benzoic Acid  | + | + | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - | + | + | + | + | + | + | + | + | + |
| 7    | Salicylic Acid | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 8    | Vanaspati     | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
7. CONCLUSION

The various chemical substances that are added in milk due to financial gain. But, it is mostly done due to carelessness and lack of hygienic condition of processing and storing and is mainly occurs in both developing and backward countries both. The consumers are often become victim of diseases consuming the Adulterated milk. This present work shows that Benzoic acid, water, synthetic milk and sugar were the most common Adulterants present in all the milk samples taken. Salicylic acid and vanaspati ghee found to be Non-existent whereas, benzoic acid and sugar both found in highest amount as the adulterant. The purpose of adding benzoic acid is to preserve the milk and milk products for long time, which causes various adverse effects on human health. According to the research conducted, most of the collected milk samples are Contaminated with different chemical Adulterants which were added during the production or processing of milk. Whether intentionally and unintentionally in order to deal with maximum production of milk and to generate more money these harmful and poor quality chemicals added in milk. In India, as milk is the common and complete food for the human beings, this analysis is carried out to bring awareness to public about the malpractices in milk production and their health hazards.

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