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Detection of harmful adulterants in milk supplied to Jabalpur, MP, India

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Adulteration is a rising challenge and a matter of concern in most food products in front of the authorities of concerned fields. The problem with milk contamination exists dominantlyin countries, because we don't have adequate screening and regulating infrastructure to detect point-to-point adulteration. Besides this, the lack of awareness regarding the maintenance of food standards is another big issue that boosts malpractice. Among all the food products, milk is most susceptible to adulteration and can cause serious health issues in consumers. Distribution of Adulterated milk and its consumption poses a bigger threat to consumers, regulators and the milk industry equally in the implementation of food safety standards. There are many detection methods and techniques available globally which are in practice to analyse and differentiate adulterated milk. However, most of them are complexlab-based techniques that limit their application. In this paper, various detection techniques have been used to detect various adulterants present in samples.

Keywords: Milk, Adulterants, Adulteration, Health Hazards, Detection Techniques.

Abstract

Introduction

Milk is considered to be the 'ideal food' because it has high food value. It supplies a balanced diet of nutrients like proteins, fat, carbohydrates, vitamins and minerals, all these necessary components single-handedly. Due to its nutritive value, milk is significant for both infants and adults. The composition of milk varies considerably with a number of factors such as breed of cow, feed, stage of lactation, season of the year etc.

Milk Protein is built up of amino acids which is essential for children and are of two types mainly, caseins and whey proteins. milk contains 4.6–4.7%Lactose popularly known as sugar is a type of carbohydrate in it. Milk contains fat- and water-soluble vitamins with very small fat globules. A number of minerals like calcium, sodium, potassium, and magnesium are also present in milk.

In the urban areas,milk was found to be adulterated mainly with water, detergent, urea and skim milk powder. A part of it for the purposes to keep milk temporarily fresh, some unethical activities are usually adapted to prevent the financial losses due to the spoilage of milk during its transportation and sale. The reasons behind mixing adulterants in milk mostly are:

(i) For increasing its volume,
(ii) Long time preservation,
(iii) Mixing low priced non-milk proteins to falsely increase its protein contents,
(iv) For increasing FAT and solid not fat (SNF) unfairly.

These frauds and adulteration are becoming more common, and the inclusion of low-cost ingredients but sure cause health risks as well.

According to a survey (Executive Summary on National Survey on Milk Adulteration, India 2018) conducted by the Food Safety and Standards Authority of India (FSSAI), as highlighted in India, approximately 68.7% of milk and milk products do not fulfil the acceptable quality criteria.Unfortunately, it is being very easily adulterated throughout the world and significantly worse in developing and underdeveloped countries due to the absence of adequate monitoring and lack of proper law enforcement. It is actually done to make a profit but sometimes it may be due to the lack of proper awareness. Adulteration of milk may be seen due to demand and supply gap, perishable nature of milk, low purchasing capability of customer and lack of its suitable detection tests (Kamthania M, et.al.2014[1]). The common way of mixing adulterants is the addition of water to increase volume of milk and mixing thickening agents like starch, flour, skimmed milk powder, Vegetable oil, sugarcane or urea to compensate the fat, carbohydrate or protein content of diluted milk. Some chemicals such as hydrogen peroxide, carbonates, bicarbonates, antibiotics, caustic soda and detergents etc. detected by Abdul Aziz Soomro, et.al.2014[2]. This is how it decreases the nutritive value of milk. These adulterants, preservatives and drugs in milk cause very serious health related problems.

Typical Adulterants and their health hazards on humans

- **Water –** Water is the most prevalent adulterant in milk (Barham GS, et.al2014[3]). The major percentage of natural milk contains water (87%), but added water in it is a serious concern. This is the easiest way and cheap source for adulteration of milk. But if contaminated water and colour chemicals are added, it is a serious health concern to the milk consumers. In one hand it decreases the nutritious value; on the other hand, chemicals are added to compensateits density and colour after dilution with water.
- **Melamine**–Melamine is a nitrogen-rich compound that has been illegally added particularly milk and milk powder, to increase their apparent protein content. However, when ingested, melamine can react with other compounds in the body, such as cyanuric acid, forming crystals that can accumulate in the kidneys, leading to renal and urinary problems (Cheng Y, et.al.2010[4]). In severe cases, such contamination can result in kidney stones, kidney failure, and even death, particularly in infants who are more vulnerable to such toxins. The 2008 Chinese milk scandal is one of the most notable cases of melamine contamination, which affected thousands of infants and led to numerous illnesses and several deaths.
- **Urea**–Acommon milk adulterant to increase the shelf life is addition of urea to milk (Faraz A, et.al2013[5]). also used to prepare synthetic milk and increase the SNF value and heat stability. Associated Health hazards are acidity, indigestion, ulcers and cancers. Urea is harmful to heart, liver and kidneys (Trivedi UB, et.al.2009[6]) especially for kidneys as the kidneys have to do more work to remove urea from the body (Kandpal SDS. A.,et.al. 2012[7]).
- **Detergents**– Detergents whichcause gastro–intestinal complications are added to emulsify and dissolve the oil in watergiving a frothy solution, the characteristic white colour ofmilk (Singuluri H, et.al 2014[8]).
- **Hydrogen peroxide (H_2O_2)**– Hydrogen Peroxide is added forlong time freshness of milk,but due to toxic nature it damages the gastro intestinal cells which canlead to gastritis and inflammation of the intestine, disturbs the antioxidants in the body this is how disturbing the natural immunity.
- **Starch**–Mixing of Starch is to increase solid-not-fat (SNF) which can cause diarrhoea due to effects of undigested starch in colon, its accumulation in the body may prove very fatal

for diabeticpatients (Singuluri H, et.al 2014[8]). Apart from thestarch, wheat flour, arrowroot, rice flours are also used as adulterants.

- **Sugar**–Sugar is mixed in the milk to increase the solids notfat (SNF) content of milk, to increase the lactometer reading ofmilk, which was already diluted with water.
- **Neutralizers**– NaOH (Caustic soda) is mainly used in synthetic milk to neutralize the acidiceffect. Synthetic milk is another common problem which isprepared by adding urea, caustic soda, refined oil and common detergents. It contains sodium, which acts asslow poison for peoples suffering from hypertension and heart ailments. It also deprives the body from utilizing lysine, an essential amino acid in milk, which is required by growing babies.
- **Chlorine (Sodium Chloride)**–Chlorine is added to compensate the density of the dilutedmilk after addition of water. Chlorinated milk can cause clogging in arteries and develop heart problem. It disturbs the acid base balance (pH of blood) of body.
- **Food colours**–To improve the appearance of milk many food colorants are added which have hazardous effects on health.
- **Milk powder**–It is used as adulterant in fresh milk for economic advantage as subsidy is provided for dried powder milk when a country has milk powder in excess.
- **Skimmed &Low valued Milk**–This is actually the mixing of lower valued milk to the higher valued milk. For example, addition of goat milk with cow milk for greater profit. It has been found that health hazards related to this practice are not well defined, people may have allergy by consuming this adulterated milk. Low priced cow milk is often added in the milk of ewes, goats, buffalos (Haasnoot W S. N., ed.al.2004[9]) and in sheep milk (Pappas CS, ed.al.2008[10]).
- **Preservatives**–To control microorganism spoilage of the milk they mix Boric acid, Formalin, Sodium carbonate (Na2CO3), Sodium bicarbonate (NaHCO3), Salicylic acid, Benzoic acid etc. which can preserve themilk for long time but has poisonous effect which can lead todeath (Tanzina Azad. 2016[11]). It causes abdominal pain, diarrhoea, vomit and other poison relatedsymptoms.

Pesticides are also used to kill the microorganisms present in milk which poses serious health hazards due to its toxicity or carcinogenicity.

Samples Analysed:

Sample ID	Collection Location
H.F cow	Civil Lines
Sachi milk	Sanchi Parlour Wright Town
Home milk 1	Civil Lines
Home milk 2	Gohalpur
Home milk 3	Ratan Nagar, Madan mahal
Home milk 4	Girls Hostel, Ranitaal
Home milk 5	Girls Hostel, Ranitaal
Home milk 6	Prem Mandir Wright Town
Home milk 7	Prem Mandir Wright Town

Result &Detection of milk adulterants

Different milk adulterants in the samples and the method used to detect those adulterants are presented following the table.

S.No.	Adulterant	Procedure	Observation	Limit of Detection (v/v)	References

1.	Water	The presence of water can be detected by putting a drop of milk on a polished slanting surface.	Pure milk drop flow slowly leaving a white trail behind it, whereas milk adulterated with water will flow immediately without leaving a white trail.	_____	(V.S., ed.al.2016[12])

Results -

Sample ID	Water
H.F cow	Absent
Sachi milk	Present
Home milk 1	Absent
Home milk 2	Absent
Home milk 3	Absent
Home milk 4	Absent
Home milk 5	Present
Home milk 6	Absent
Home milk 7	Present

S.No.	Adulterant	Procedure	Observation	Limit of Detection (v/v)	References
2.	**M**elamine	No suitable method is available to check at home. A. Take 5 ml in a test tube and add 0.1 ml 0.5% Bromocresol Purple (BCP) solution.	---- Violet colour indicates the presence of detergent.	-----	(D Maheswara Reddy, ed.al.2017[13]).

Results -

Sample ID	Melamine
H.F cow	Absent
Sachi milk	Present
Home milk 1	Absent
Home milk 2	Absent
Home milk 3	Absent
Home milk 4	Absent
Home milk 5	Absent
Home milk 6	Absent
Home milk 7	Absent

S.No.	Adulterant	Procedure	Observation	Limit of Detection (v/v)	References
3.	Detergents	5 ml of Sample Mixed with 5 ml of Distilled	Dense lather appears, indicate	----------	----------

		Water &by shaken thoroughly.	presence of Detergent.		-

Results -

Sample ID	Detergent
H.F cow	Absent
Sachi milk	Absent
Home milk 1	Absent
Home milk 2	Absent
Home milk 3	Absent
Home milk 4	Present
Home milk 5	Present
Home milk 6	Present
Home milk 7	Present

S.No.	Adulterant	Procedure	Observation	Limit of Detection (v/v)	References
4.	Hydrogen peroxide	Take 1 mL milk sample in a test tube and adding 1 ml of potassium iodide-starch reagent solution by mixing well.	Appearance of blue colour indicates the presence of hydrogen peroxide.	0.004%	(Singhal, ed.al.1980[14])

Results -

Sample ID	Hydrogen peroxide
H.F cow	Absent
Sachi milk	Present
Home milk 1	Absent
Home milk 2	Absent
Home milk 3	Absent
Home milk 4	Present
Home milk 5	Present
Home milk 6	Absent
Home milk 7	Present

S.No.	Adulterant	Procedure	Observation	Limit of Detection (v/v)	References
5.	Starch	Take 3 mL sample in a test tube, boil and cool it to room temperature, by adding 1 drop of 1% iodine solution.	blue colour indicates the presence of starch.	0.02%	(D Maheswara Reddy, ed.al.2017[13])

Results -

Sample ID	Starch
H.F cow	Absent
Sachi milk	Present

Home milk 1	Absent
Home milk 2	Absent
Home milk 3	Absent
Home milk 4	Present
Home milk 5	Present
Home milk 6	Absent
Home milk 7	Absent

S.No.	Adulterant	Procedure	Observation	Limit of Detection (v/v)	References
6.	Sugar	5ml milk sample in a test tube, add 1 mL conc. HCl and 0.1 g resorcinol solution. Place this test tube in water bath for 5 min.	red colour indicates the presence of added sugar.	0.2% (w/v)	(Sharma R., ed.al.2012[15])

Results -

Sample ID	Sugar
H.F cow	Absent
Sachi milk	Present
Home milk 1	Present
Home milk 2	Present
Home milk 3	Present
Home milk 4	Present
Home milk 5	Present
Home milk 6	Present
Home milk 7	Present

S.No.	Adulterant	Procedure	Observation	Limit of Detection (v/v)	References
7.	Neutralizer	Take 5 ml of milk in a test tube and add 5 ml alcohol followed by 4-5 drops of rosalic acid.	If the colour changes to pinkish red, then sodium carbonate /bicarbonates are presents.	----------	(Sharma R., ed.al.2012[16])

Results -

Sample ID	Neutralizer
H.F cow	Absent
Sachi milk	Present
Home milk 1	Absent
Home milk 2	Absent
Home milk 3	Absent
Home milk 4	Absent
Home milk 5	Absent

Home milk 6	Absent
Home milk 7	Absent

S.No.	Adulterant	Procedure	Observation	Limit of Detection (v/v)	References
8.	Food Colour	Add a few drops of hydrochloric acid to milk sample.	Appearance of pink colour indicates azo dyes.	----------	(Lechner E, ed.al.1981[17])

Results -

Sample ID	Chlorine
H.F cow	Absent
Sachi milk	Present
Home milk 1	Absent
Home milk 2	Absent
Home milk 3	Absent
Home milk 4	Absent
Home milk 5	Present
Home milk 6	Absent
Home milk 7	Absent

S.No.	Adulterant	Procedure	Observation	Limit of Detection (v/v)	References
9.	Chlorine	5 ml of milk sample into a test tube and add 1 ml of 0.1 N silver nitrate solution. Mix thoroughly and add 0.5 ml of 10% potassium chromate.	Appearance of yellow colour indicates the presence of added salts while brick red colour indicates the milk free from added salt.	0.02% (w/v)	(Singhal, ed.al.1980[14])

Results -

Sample ID	Foodcolour
H.F cow	Absent
Sachi milk	Present
Home milk 1	Absent
Home milk 2	Absent
Home milk 3	Absent
Home milk 4	Absent
Home milk 5	Absent
Home milk 6	Present
Home milk 7	Present

S.No.	Adulterant	Procedure	Observation	Limit of Detection (v/v)	References

10.	Skimmed Milk	Add nitric acid drop by drop in to the test sample.	Appearance of orange colour indicates the milk is adulterated with skim milk powder.	----------	(DE Souza EMT, ed.al.2000[9])

Results -

Sample ID	Skimmed milk
H.F cow	Absent
Sachi milk	Present
Home milk 1	Absent
Home milk 2	Absent
Home milk 3	Absent
Home milk 4	Present
Home milk 5	Present
Home milk 6	Absent
Home milk 7	Absent

S.No.	Adulterant	Procedure	Observation	Limit of Detection (v/v)	References
11.	Glucose	Take 1 ml of milk sample in a test tube. Add 1 ml of modified Barfoed's reagent and then heat the mixture for 3 min in a boiling water bath. Rapidly cool under tap water.	Appearance of deep blue colour indicates the presence of glucose.	0.1% (w/v)	(Kamthania M, ed.al. 2014[18])

Results -

Sample ID	Glucose
H.F cow	Absent
Sachi milk	Present
Home milk 1	Absent
Home milk 2	Absent
Home milk 3	Absent
Home milk 4	Present
Home milk 5	Present
Home milk 6	Present
Home milk 7	Present

S.No.	Adulterant	Procedure	Observation	Limit of Detection (v/v)	References
1.	Preservative Benzoic & Salicylic Acid	Take 5ml milk sample in a test tube and acidify with sulfuric acid, 0.5% $FeCl_3$ solution is added to it drop by	Appearance of buff colour indicates the presence of benzoic acid whereas that of violet colour indicates salicylic acid	----------	Kamthania M, 2014[18])

		drop Mix it.			

Results -

Sample ID	Preservative
H.F cow	Absent
Sachi milk	Present
Home milk 1	Present
Home milk 2	Present
Home milk 3	Absent
Home milk 4	Absent
Home milk 5	Present
Home milk 6	Absent
Home milk 7	Absent

Conclusion

India is number one in milk production, and it is assumed that milk is a perfect diet for humans and especially for growing children Indians and that's why milk products are used in their diets heavily. Milk adulteration is an actual and dangerous phenomenon and exists worldwide, but developing and underdeveloped countries are more prone to such unethical and harmful practices. The biggest sufferer of these malpractices is the consumer who not only loses his money but also has a threat to his health.

The purpose of adding preservatives to preserve the milk and milk products for long timecauses 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. Financial gain is one of the major reasons for milk adulteration. Knowledge of adulteration of any food is essential for each and every person. Therefore, it is essential to generate awareness among the public about malpractices or negligence in milk production Some of these easy detection methods performed at the consumer level can bring this problem to an end and can save millions of malnourished children in our country.

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