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Milk Adulteration: Types, Health Implications, Detection Methods and Regulatory Control in India

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Milk is a highly beneficial drink for human health, containing various nutrients including builders, proteins, energy components, carbohydrates and lipids. It also contains functional elements like vitamins, enzymes and dissolved salts like phosphate, nitrates and chlorides. Milk is obtained from the complete milking of healthy milch animals, excluding those obtained within 15 days before and 5 days after calving.

India has seen significant growth in milk production and consumption over the past nine years, becoming the world's largest milk producer. The production has increased by over 61% from 137.7 million tonnes in 2013-14 to 230.06 million tonnes in 2022-23. The per-capita availability of milk has also increased, from 303 gram/day in 2013-14 to 459 gram/day in 2022-23. The top five major milk producing states are Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat and Andhra Pradesh.

Adulteration is the addition of substances to a product, making it unfit for consumption. India, the largest milk producer and consumer, frequently employs adulteration to meet increasing demand. This includes intentional and incidental contamination during preparation, storage and transportation. Adulterated food can have adverse health effects due to the toxic nature of substituting compounds or lack of nutritional value. Common adulterants in milk include water, urea, starch, oils, SMP, sugar and detergent. As the population grows the demand for adulterated food will increase.

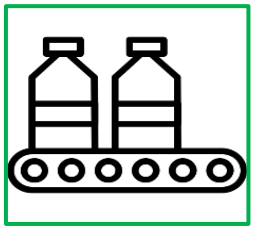
Adulteration and Their Purpose

The production and utilization supply gap are increasing, leading to producers and sellers exploiting people's needs by adding water to milk to increase profits and reduce production costs. This strategy is often used by small-scale or traditional milk producers and sellers, who operate dairy units without strict regulation and inadequate hygienic and sanitation standards. Adulteration is often carried out to mask spoilage signs, such as hydrogen peroxide, formalin and sodium bicarbonate.

- **Water:** This is the most common, simplest and oldest method of adulteration. Adulteration is a common method of milk dilution, where milk components are reduced and chemicals added to normalize density and colour. This increases volume, but decreases nutritional value and quality control parameters.

Detection of adulteration using lactometers or freezing points can reveal changes in quality.

- **Detergent:** Detergent is a compound used to achieve milk's natural characteristics, making it thicker and emulsifying vegetable oil. It is mainly added to synthetic milk, which is white and produced by mixing urea, detergent, vegetable oil, neutralizers, sugar and water.
- **Urea:** Urea is a natural component of milk that can be used as an adulterating agent when water is added to it. It acts as a preservative, increases solid non-fat and non-protein nitrogen and suppresses milk fermentation. The concentration of urea in milk varies depending on the protein content in the feed ration. The maximum permissible limit for urea in milk is 70 mg/100 ml. Mixing water and urea is common to preserve the density of tainted milk.
- **Starch:** Functional maize starch is a new addition to the milk industry, replacing modified starches with better stability and suitable for heating or shearing processes. Rice proteins are used as milk supplements for lactose intolerance consumers.
- **Preservatives:**

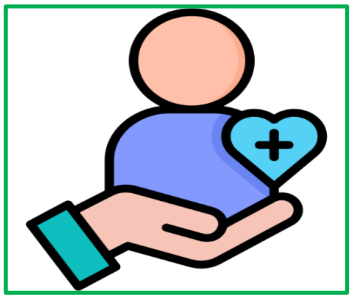


a) **Neutralizers:** Neutralizers like sodium bicarbonate, hydrated lime, sodium hydroxide and sodium carbonate are added to milk to cover acidity and sour taste, despite legal restrictions.

b) **Formaldehyde:** Formaldehyde is a toxic, carcinogenic substance used to preserve milk for extended periods, but its high dose can cause liver and kidney damage, making it a dangerous substance.

c) **Vegetable Oil:** Milk fat is crucial for food economics, nutrition and properties. It consists of 70% saturated and 30% unsaturated fatty acids. Factors like diet, lactation and health affect fatty acid composition. Dairy cow nutrition is key. Vegetable oils like olive and palm oil can alter fat droplet content, affecting dairy product's microstructure and textural behaviour.

d) **Synthetic milk:** Synthetic milk is an imitation of milk, containing vegetable oil, urea and emulsifiers. It has similar properties to natural milk but differs in pH, colour and storage, with synthetic milk becoming pale yellow over time.



Side Effect of Adulteration

Consuming adulterated milk can lead to health issues, including organ disorders and failures. Common milk adulterants can cause heart, kidney, liver and other organ disorders. Consumers pay more for lower-quality, lower-quantity food.

A. Human Health

Adulterants	Side Effect on Health
Water	Diluting milk: malnutrition, Impure water: intestinal problems
Urea	Digestive issues such as stomach cramps, bloating and diarrhea Kidney failure, harmful to heart, lever.
Detergent	Gasto- intestinal and kidney problems Phosphates can cause nausea, diarrhea and skin irritations.
Formalin	Poisons effects lead to death, Corrosion of intestine, Ulcer and inflammatory disease. Including nausea, vomiting, gastric irritation etc.
Starch	Diarrhea, Fatal to diabetic patients

i. **Digestive issues:** Adulterated milk may contain harmful substances that can cause gastrointestinal issues like diarrhea, nausea, vomiting and abdominal pain.

ii. **Food borne illness:** Salmonella and *E-coli* bacteria can cause food poisoning in adulterated milk, causing symptoms like fever, cramps and diarrhea, which can be severe and potentially life-threatening.

iii. **Allergic reactions:** Milk adulterants can cause allergic reactions in susceptible individuals, including skin rashes, hives, respiratory distress and in severe cases, anaphylactic shocks.

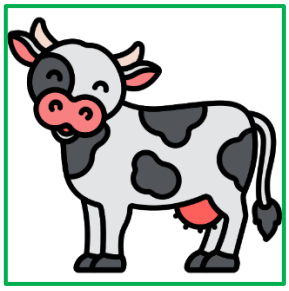
iv. **Nutritional deficiency:** Adulterated milk lacks essential nutrients and vitamins, leading to nutritional deficiencies, particularly in growing children.

B. Animal Health

i. **Harm to dairy animals:** Excessive use of growth hormones or antibiotics in adulteration practices can negatively impact the reproductive health and well-being of dairy animals.

ii. **Residue build-up:** Excessive use of antibiotics in dairy farming can lead to antibiotic residue build-up in milk which can have health implication for consumers when ingested.

iii. **Physical stress:** Excessive milk production in animals through artificial growth hormones or antibiotics can cause physical stress, leading to lameness, joint issues and reduced longevity.



Chemical Tests for Milk Adulteration

Table: Chemical Tests for Milk Adulteration

Adulterant	Test	Inference
Sugar	Take 3 ml milk in TT + 2ml Con. HCL + 50mg resorcinol then heat the test tube	Red colour or cherry-red colour
Pulverized Soap	Take milk sample + 10ml hot water + 2-3 drops Phenolphthalein indicator	Pink colour
SMP	Take milk sample + add few drops of nitric acid dropwise	Yellow colour
Vanaspati Oil	Take 5ml milk + 10 drops of HCL + 1 teaspoon Sugar, then heat	Red colour
Salicylic Acid	Take milk in TT + few drops of H_2SO_4 + 0.5% $FeCl_3$ in it.	Violet or Purple colour
Benzoic Acid	Take 5ml milk in TT + Sulphuric acid drops wise + 0.5% Ferric chloride in it.	Buff (yellow to brownish) colour
Urea	Take 5ml milk in TT + 5ml Dimethyl Amino Benzaldehyde (DMAB), place TT in hot water bath for few min.	Yellow colour
Detergent	Take 5ml milk in TT + 0.1 ml Bromo-Cresol Purple (BCP) sol.	Violet or Purple colour
Starch	Take 3ml milk in TT then it is heated to boil over flame and cool at RT + Drop of 1% Iodine sol. and mixed.	Blue colour
Synthetic milk	Take 5ml milk in TT + 0.2ml urease, shake well + 0.1ml Bromo-Thymol Blue (BTB) sol.	Dark blue colour
Buffalo milk in Cow milk	Put drop of milk on glass slide + drop of Hansa test serum and mix with glass rod	Curdy particles
Formalin	Take 10 ml in TT + 5 ml conc. H_2SO_4 with traces of Ferric chloride added slowly along the side of TT	Violet or Blue colour ring at junction
Nitrates (Pond water)	Take 10ml milk in beaker + 10ml Mercuric chloride then filtrate through What man paper. Take 1ml filtrate in TT + 4ml Diphenyl Amine Sulphate.	Blue colour

Prevention

Prevention of milk adulteration is necessary for variety of reasons, primarily for public health, consumer's protection, economic fairness etc. here are some preventions.

i. Regulation and Enforcement

Government should establish strict regulation and standards for milk quality and safety. Regular inspections and rigorous enforcement of these regulations are essential to detect adulteration. Offenders should face severe penalties. Government should establish strict regulation and standards for milk quality and safety. Regular inspections and rigorous enforcement of these regulations are essential to detect adulteration. Offenders should face severe penalties.

ii. Quality Certification

Encourage dairy producers and vendors to obtain quality certification from government authorities, such as ISO22000 and FSSAI certification. Also encourage them to produce and provide high quality milk to the consumers.

iii. Transparency

Promote transparency in the dairy supply chain. Traceability system can help consumers and authorities to track the source of milk and identify any irregularities.

iv. Public Awareness

Educate consumers about different type of milk adulteration and how to identify signs of adulteration. Encourage consumers to buy high quality milk from reputable sources.

v. Strict Punishment

Impose strict legal consequences for those found guilty of milk adulteration. Heavy fines, imprisonment and the revocation of licenses can act as strong deterrents.

vi. Whistle Blower Protection

Encourage individuals to report suspected cases of milk adulteration without fear of retaliation. Establish mechanism to protect whistle-blower.

vii. Farm Inspections

Regularly inspect dairy farms to ensure proper animal husbandry practices, including the use of antibiotics and growth hormones are within limits.

viii. Supply Chain Audits

Conduct periodic audits of the entire milk supply chain, including transport, storage and processing facilities to identify potential vulnerabilities to adulteration.

ix. Technological Solutions

Employ technique such as block chain to create transparent and tamper proof records of milk production, transportation and processing. This can enhance traceability and accountability.

Acts Against Adulteration

In India we had many acts/ orders to control the quality of food items. Some are as follows:

- **Prevention of Food Adulteration Act (PFA):**

The Prevention of Food Adulteration Act was passed in 1954 and came into force on 1 June 1955.

Objectives - The Prevention of Food Adulteration Act, 1954 was enacted to protect consumers against adulterated and unsafe food. The main objective of the Act was to ensure that food sold to consumers is pure, wholesome and free from adulterants. The Act laid down provisions related to sampling procedures, analysis of food, definition of offences and punishments.

Provision - Prohibited the import of certain food articles without license and required manufacturers, distributors and sellers to provide warranty regarding the quality of food under PFA rules.

- **Food Safety and Standard Authority of India (FSSAI), 2006:**

Objective - To overcome the multiplicity of food laws such as PFA, MMPO, Fruit Products Order, etc., the Government of India enacted the Food Safety and Standards Act (FSS Act), 2006. The Act aims to establish a single reference point for all matters related to food safety

and standards. It regulates the manufacture, storage, distribution, sale and import of food products by strengthening enforcement mechanisms. The Act ensures the availability of safe and wholesome food for human consumption and provides graded penalties instead of harsh criminal punishment in most cases.

Functions - The Food Safety and Standards Authority of India is responsible for framing food standards and guidelines, prescribing limits for food additives, contaminants, heavy metals, antibiotics and residues, developing an information network for rapid dissemination of food safety information and promoting consumer awareness regarding food safety and food standards.

- **Food safety and standards (food product standards and food additives) regulations, 2011:**

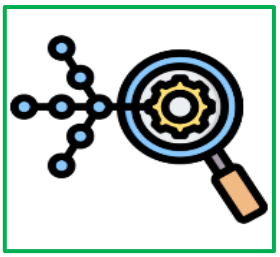
These regulations, issued by FSSAI in 2011, prescribe standards for various food products, including milk and milk products. They specify permissible limits for food additives and define the quality parameters that food products must meet. In milk, these regulations indirectly help control adulteration by defining composition and quality standards.

- **Food safety and standards (contaminants, toxins and residues) regulations, 2011:**

These regulations lay down maximum permissible limits for contaminants, toxins and residues in food, including pesticides, veterinary drug residues, antibiotics, heavy metals and mycotoxins. Adulteration of milk with such harmful substances is strictly regulated under these provisions.

Conclusion

Milk adulteration in India is a pressing issue exacerbated by rising demand, economic pressures on producers and inadequate monitoring along the supply chain. Common adulterants such as water, urea, detergent, starch, preservatives, vegetable oils and synthetic compounds compromise the nutritional value of milk and endanger public health, particularly for vulnerable populations like children, the elderly and those with weakened immune systems. This review outlines the prevalent adulterants, their uses and the associated health risks. It highlights simple, cost-effective chemical tests for the detection of these adulterants, usable in both field settings and laboratories, which are essential for regular monitoring and consumer protection regarding milk quality. Addressing milk adulteration necessitates a comprehensive strategy that includes robust regulatory enforcement, adherence to the Food Safety and Standards Act of 2006, public education, improved supply chain transparency and modern technological tools for traceability. Enhancing food safety regulations and educating both producers and consumers is crucial to providing safe and nutritious milk, thus protecting public health, maintaining consumer confidence and fostering sustainable growth in India's dairy sector.



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