Detection of Food Adulterants

Review Article

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Abstract **-** Food Adulteration is a growing concern for countries. Food Adulteration is adulterating food articles with different low-quality and cheap quality products to gain profit. It has become a widespread malpractice usually performed in developing and underdeveloped countries. It is performed in India on a large scale for financial profit. Adulteration of foods like milk and milk products, honey, edible oil, and other products. Food forensics is a branch of science that detects and identifies adulteration in food items using scientific methods or techniques for the court of law. Here in this paper, various ways for the detection of adulterants in food articles like milk, honey, and edible oil are discussed using homemade tests, chemical/laboratory examination, and physical examination in a tabular form. This detection is rapid and budget-friendly, which can further be used by laypeople. These detection methods will help to separate adulterated food from non-adulterated food. It will also spread awareness among locals and aims for the betterment of the food industry.

I. INTRODUCTION

Food adulteration is a huge global concern, and underdeveloped countries are particularly vulnerable due to a lack of monitoring and policies. However, this is a widespread occurrence that has been overlooked in many countries. Unfortunately, it has caused numerous health issues in various countries, including food poisoning. According to Azad and Ahmed (2016), this is also one of the most common phenomena that has gone unnoticed in many nations. The intentional reduction of food quality by the addition or substitution of inferior ingredients or the removal of some essential components is known as food adulteration. It is important to consider not only the intentional addition, substitution, or removal of equipment that negatively impacts natural resources and food quality, but also any unintentional contamination that may occur during development, storage, harvesting, processing, transportation, and distribution.[1]
Unfortunately, it has caused numerous health issues in various countries, including food poisoning. Food adulteration has resulted in a variety of health problems, including food poisoning and other serious illnesses. The most basic need for survival is food. Admixture and substitution are synonyms that aid in the definition of the term adulteration. Food adulteration is the process of reducing the quality of food by either purposefully or inadvertently replacing it with a subpar foreign particle or by removing a value-added food substitute from the main food item. A chemical that is or may be used to render food hazardous, inferior, mislabeled, or include extraneous material is referred to as an "adulterant" under the Food Safety and Standards Act of India (FSSA).[2]

The issue of food adulteration has long existed, particularly where there is a conflict between a food item's physical availability and consumer demand. If there is a disparity between the price that the supply chain customer (at a supplier/customer interface) or the end user is willing to pay for the product and the cost of production, say of meats or meat-based items, this further gets influenced.[3]
India now leads the world in milk production, which increased by 88.9% from 20.8 million tonnes in 1970–1971 to 187.75 million tonnes in 2017–2018. The top milk-producing states in the Indian subcontinent are Uttar Pradesh, Rajasthan, and Madhya Pradesh. Unorganized milk production typically takes place in an unsanitary setting, which lowers the milk's overall quality and nutritional value. In addition to milk, the Indian dairy and milk processing industries also profit from value-added goods such as butter, paneer, curd, ghee, whey, flavored milk, ultra-high temperature milk, cheese, and yogurt.[4]
Food that has been tampered with is dangerous since it will be toxic and may create health problems by depriving the body of nutrients that are essential for healthy growth and development. While quantitative detections of adulterants in milk are more complicated, qualitative detections can be accomplished with ease using a chemical reaction. The presence of adulterants in milk is a prerequisite for some crucial quantitative detection methods.[1]

Honey bees make honey from plant nectar, plant secretions, or plant-sucking insect excretions on plant parts. The bees gather these materials, transform them by combining them with their own substances, deposit, dehydrate, store, and then leave in the honeycomb to ripen and mature (Codex, 2001). 80–85% of carbohydrates, 15–17% of water, 0.3% of proteins, 0.2% of ashes, trace amounts of vitamins and amino acids, and other substances in trace amounts make up honey. The product's local and worldwide market prospects are being negatively impacted by honey adulteration, which can also lead to consumers' health and nutritional issues (Gary et al., 2000). Adulterated honey is difficult to detect. According to Puscas et al. (2013), the identification and quality criteria of honey are thought to be helpful in identifying these potential adulterations as well as in verifying the hygienic conditions for honey modification and storage.[5]

Humans need edible oils and fats for proper nutrition, and they complement a regular diet (Pitts et al., 2007). However, it is regrettable that adulteration of high-priced oil with low-priced oil is a significant problem due to their increased demand in the domestic and foreign markets (Yadav, 2018). Due to its widespread use and minimal consequences, adulteration is not seen, despite the fact that it has long been in society. The main cause of adulteration is treachery, increasing their income by raising its volume and shortage of unintentional quality assessment on questionable products. Additionally, certain self-centered companies engage in adulteration in order to increase their profit margin (Ayza and Yilma, 2014). Food is frequently contaminated to satisfy the demands of the world's growing population and to feed the vast majority of people, as the population is expanding at an alarming rate. The majority of wealthy nations worldwide have greater rates of food adulteration. Of these, it has become a major issue over the past 20 years and poses a major risk to the health of practically every population (Majed et al., 2016). Past instances of oil adulteration made it clear that palm stearin and olein, two fractions of palm oil, had been combined with or added to palm oil to produce a product of unclear and inconsistent quality. Ghee is frequently adulterated by mixing it with hydrogenated oils and animal fats. To make the other fats appear like ghee, artificial flavors along with colors are added in it (Choudhary et al., 2020). It is also possible to define cheaper, contaminated oil as though it were some oils of higher (pure) quality (Ebong et al., 2014). The tiny database that establishes suitable purity criteria for genuine food oils and fats has historically made it difficult to detect such deception. It has been noted in a number of instances that edible soybean oil tainted with linseed oil (Manandhar et al., 1986), virgin olive oil tainted with cotton oil, and castor oil, karanja oil, mineral oil, and artificial coloring are extensively used to adulterate edible oils (Navya et al., 2017), as well as vegetable oil and sunflower oils (Kesen, 2019). Adulteration of fats and oils is currently a major issue on a global scale, necessitating the development of quick detection techniques (Kou et al., 2018). Customers struggle greatly to select a single food item because of deceptive advertising, inappropriate media focus, and food adulteration. The end-user is harmed and suffers as a result of these misconducts (Gupta and Panchal, 2009). The purity of edible oils along with fats has been evaluated using a variety of techniques.[6]

This project describes many approaches for detecting adulterants in food ingredients using chemical methods. Food forensics is a scientific subject that focuses on evaluating authenticity, detecting adulteration, and resolving any other legal issues associated with food products. In this research, we will apply various approaches to identify the adulterants present in various food items. We primarily focus on qualitative assessment and determine if the food substance (milk, for example) is contaminated or not. This study will assist the inquiry in running smoothly and productively. This work will eventually help food forensics evolve and realize its potential for the Court of Law.

Common Adulterants in Milk

According to Moore et al. (2012), milk powder is the second most likely food item to be at risk of adulteration after olive oil. Economically motivated adulteration, which includes the addition of vegetable protein, milk from different species, whey, and watering, does not pose a serious health risk, but some adulterants are too dangerous to ignore. Among the main adulterants in milk that have a serious negative impact on health are urea, formalin, detergents, ammonium sulfate, boric acid, caustic soda, benzoic acid, salicylic acid, hydrogen peroxide, sugars, melamine, and ammonium sulfate.[7]

Common Adulterants in Honey

The addition of sugar is the biggest authenticity issue (Bogdanov & Gallman, 2007). Honey is contaminated with cheaper and conveniently available sweeteners, e.g., glucose syrup, cane sugar, and corn syrup, etc. [8].

There are two types of adulteration in honey: Direct and Indirect. The sweeteners adulterant materials like sugar syrup, sugar, mollases, coca cola, and melted candy are detected in honey.

Common Adulterants in Edible Oil

Higher-priced and less accessible oils are more likely to be contaminated. Due to the expensive cost of virgin olive oil, it is tempting to substitute it with oils with comparable fatty acid and sterol profile.[9] There are different adulterants mixed in the edible oils, such as Prohibited colours, Cotton seed, Argemone oil, Castor oil, Palm oil, Vanaspati, Mineral oil, Super Soyabean oil, etc, in oils like Sunflower oil, Mustard oil, Ghee, etc.

Food Forensics: Food forensics is a scientific subject that focuses on evaluating authenticity, detecting adulteration, and resolving any other legal issues associated with food products. The act of introducing a few substances known as adulterants into food is known as food adulteration. Food adulteration has become a serious concern in food forensics.
When forensic techniques are used to determine authenticity and discover food fraud and adulteration, as well as any other legal difficulties inherited in the food product, the term "food forensics" is used. While concentrating on the collection of methods and approaches most suited to detect counterfeiting and producing activities from a court perspective, it is primarily out of step with the field of food quality, authenticity, and safety research. The majority of the analytical methodologists now used in other forensic fields, such as analyzing crime scenes, identifying doping in sports, etc., are also applicable to food authentication or would be of interest.[10]

II. Literature Review

2.1 **Mohanty et al. (2020)** researched milk adulteration, a global issue that poses health hazards. It is accomplished by conducting qualitative analysis. Poor customer purchasing power and a mismatch between supply and demand are the primary causes of adulteration. To prevent unethical behavior, collaboration among the scientific community, public administration, market intelligence, and regulatory authorities is necessary. Awareness campaigns and proper information for identifying adulterated milk will help limit and prevent this rising malpractice. They had focused on the quick detection of detergents, starch, water, synthetic milk, rice, and wheat flour. Also employed instrumentation techniques in detecting adulterants.[1]

2.2 **Bansal S et al. (2015)** described the adulterants, different types of adulteration, and their detection methods. Physical detection, chemical or biochemical detection, and molecular detection are the three methods of detection that have been described. Physical property analysis and structural analysis are examples of physical detection techniques. Chemical techniques such as those based on immunology, spectroscopy, electrophoresis, and chromatography. molecular, like PCR. They have been used to make the detection.[2]

2.3 **Manning L et al. (2014)** This study's goal was to examine the methods now in use for EMA monitoring and detection, as well as their relative advantages and disadvantages, and to provide fresh ideas and regulations to improve future capacities to combat adulteration in a globalized food environment. With a focus on calibrating expert confidence, which supports horizon scanning, risk assessment, and predictive processes and informs requirements to ensure effective reactions and detections are undertaken, The conceptual framework created for this study was centered on the process of anticipating, responding to, and identifying food that has been illegally and economically tampered with.[3]

2.4 **Gandhi K et al. (2020)** The book examined the chemical quality assurance of milk products. It shows the examination of milk both qualitatively and quantitatively. To identify and test food adulterants, a variety of milk samples are gathered. Outlines the sample plan for different milk products that are going to be subjected to chemical analysis. Elucidate the comprehensive methods for assessing the quality of milk products, processed milk, and raw milk. Talk about the procedures for verifying the precision of glassware, reagent standardization, and the details of the chemicals utilized in the dairy sector.[4]

2.5 **Damto T (2021)** studied the detection of adulterants in honey and how to identify them; it concentrated on both lab-based and home-based methods for detecting adulterated honey, and it proposed easy and straightforward different local ways to separate samples of adulterated honey from those of pure honey. Examined the main documented status of honey adulteration and identification methods across ecological

beekeeping regions to recommend quick and easy local ways to separate pure honey samples from adulterated ones.[5]

2.6 **Huq et al. (2021)** examined how to identify adulterants in edible oils, including ghee, milk fat, mustard oil, sunflower oil, olive oil, and others, using qualitative evaluations. The state of fats and oils today has also been covered. It is a review paper that was created by analyzing many studies and drawing conclusions.[6]

2.7 **Azad T et al. (2016)** researched milk products and popular methods for detecting milk adulterants such as salt, sugar, flour, and others. The study is based on qualitative assessments and colorimetric assays. A thorough analysis of milk adulterants is provided in this study, along with various qualitative and quantitative detection techniques. This study is structured to be "adulterant-based" rather than "technique-based," with quantitative detection methods restricted to a small number of main milk adulterants and qualitative detection for the majority of frequent adulterants.[7]

2.8 **Jaafar M B et al. (2020)** The study examined the issue of honey adulteration and how to identify it utilizing techniques such as fiber optic sensor-based sugar content detection. Detection of contaminated honey using optical microfibers. Fiber optic sensing is a straightforward and affordable method that people can easily employ to identify tainted honey, as explained in this review article. The concepts of honey adulteration and detection techniques have been covered in this work.[8]

2.9 **Tura A G et al. (2020)** This review covered a variety of detection techniques, including the NIR system, gas chromatography, thin layer chromatography, isotopic techniques, and quick test procedures. Also consists of Microscopic analysis and calorimetric detection. It is also mentioned that a microscope can be used to identify the pollen in honey, which provides information on the plants that bees have been gathering from. It provides a thorough analysis of the tools used to identify common honey adulterants.[11]

2.10 **Pooja B et al. (2021)** investigated the identification of adulterants in edible oils and the use of spectroscopic methods for this purpose. Adulterants in edible oils are detected using chromatographic methods, FTR, mass spectroscopy, Raman spectroscopy, and NMR techniques.[12]

2.11 **Detect Adulteration with Rapid Test (2024)** The Indian government's (FSSAI) pamphlet, Detect Adulteration with Rapid Test (DART), discusses domestic and quick detection techniques. The assay is typically colorimetric and relies on qualitative examination of food items that have been tampered with, such as milk, oil, salt, spices, etc.[13]

2.12 **Abhirami S et al. (2015)** researched different food articles and their laboratory-based detection techniques. Different food articles like honey, milk, Edible oil, spices, ice cream, curd, ghee, khoa, wheat, paneer, salt, sugar, jaggery, green peas, watermelon, and many more. There is a deep study on their adulterants, detection methods, along their results.[14]

2.13 **Chugh R et al. (2022)** researched the adulterants contained in milk. Twenty-five different milk samples were collected from several dairy farms and traders in the Delhi NCR region, India. The chemical test was done for the eight adulterants present on the gathered samples, and the results are being recorded in tabular form. The samples contained several forms of adulterants. A qualitative technique was used to detect adulterants in different milk samples like starch, pulverized soap, vanaspati, skimmed milk powder (SMP), sugar, synthetic milk, benzoic acid, and salicylic acid.[15]

PROBLEM IDENTIFICATION

Reviewed different research articles. Few of them have mentioned spectroscopic techniques such as Infrared spectroscopy, NMR, etc, which can detect and quantify the adulterant, but are all costly techniques. It takes a longer time to detect the adulterant. Few of them have researched only one food article. Most of the articles have not mentioned even 3-4 food articles and their detection methods.

The techniques mentioned in their paper are costly, and it is not possible for a common man to detect adulteration rapidly on a low budget.

Different types of food adulterants were detected in this paper by using physical rapid techniques and laboratory-based chemical techniques. Some of the techniques are performed by household methods or by easily available chemicals.

This can be an effective approach to spreading awareness among the common people in India about Food Adulteration.

IV. METHODOLOGY

Different research papers were studied and taken into consideration. It is an Inductive approach for preparing this review article. It is an explorative review paper. Secondary data has been collected and given the main priority, which forms the base of this paper. Deep interpretation of the given secondary data was carried out. The data is being taken by studying different research and review papers for the proper analysis.

Those papers are taken into consideration which are relevant to my topic 'Detection of food adulterants' and only those papers were reviewed. Detection methods of different food articles like milk, edible oil, and honey are taken. Common household detection or physical and chemical detection methods were given main priority. These adulterants and their detection methods were collected and arranged in a table for easy interpretation.

V. RESULTS AND DISCUSSION

Concern over the rate of food adulteration is growing. The majority of food items, including milk, honey, edible oil, etc., are tainted. Table 1 discusses the use of physical examination to detect dietary adulterants in various foods. For this article, milk, edible oil, and honey are the main considerations.

Table 1: Adulterants of different food items and their physical detection methods

S. No	Food items	Adulterants	Physical Detection (if any)	PURE	IMPURE	Reference
1	Raw Milk		Sediment Test Using Sediment Tester	BIS Greater than 0.5	BIS Less than 0.5	Gandhi K et al. (2020)
			Clot on Boiling Test (COB)	Absent Can be used for Pasteurisation		Gandhi K et al. (2020)
2	Milk	Water	Put the drop of milk on polished slanting surface	Will flow down leaving a tail	Will flow down without leaving a tail	FSSAI (2012)
		Detergent	Shaking	No formation of lather	Forms dense lather	FSSAI (2012)
		Sugar and Invert Sugar	Diabetic Stripe dunk into milk for 30sec	No change	Colour Change of stripe	Mohanty et al. (2020)
3	Honey	Sugar	Add 1 spoon honey in a glass of water	No dispersion of honey	Dispersion	Tura A G et al. (2020)

			Take a Cotton wick dipped in honey and burn it	Will burn	Will not burn.(if burnt, will show crackling sound)	FSSAI (2012)
			Thumb Test Drop honey on thumb	Will stay intact	Will Spills away	Damto T (2021)
			Flame Test	Absent	Smoky flame or crackling sound	Damto T (2021)
			Shelf life Test	100% Crystal formation	Will be less	Damto T (2021)
4	Coconut Oil		Refrigeration	Coconut oil solidifies	Separate layer formed	fssai (2012)
		TOCP	Yellow Butter	No colour change	Red Colour change	fssai (2012)
5	Sunflower oil	Castor oil	Adding of 10 mL petroleum to oil sample	No turbidity observed	Turbidity observed	Huq et al. (2021)

Detection methods can be used to reveal unscrupulous activities and also to eliminate the threat of adulteration.[1] Some of the rapid detection methods using chemical methods of common adulterants of milk such as sucrose, pond water, vanaspati, formalin, salt, hydrogen peroxide, etc. been indexed in Table 2. To keep up with the rapidly increasing demand for milk, several substituents and chemicals were added. Water and detergent are two low-value ingredients that continuously contaminate raw milk. The main causes of milk adulteration could possibly be a number of additional factors.[15]

Table 2: Adulterants in Milk and their Chemical detection methods

S. No.	Adulterants in Milk	Chemical Detection Methods	Pure	Impure	Reference
1	Sucrose / Cane sugar	0.5% resorcinol solution and boil it	White Colour	Rose red colour	Gandhi K et al. (2020)
2	Vanaspati	Add Hydrochloric acid	Colour will not change to red	Colour change to red	Mohanty et al. (2020)
3	Pond Water	1-2 drops of 2% solution of diphenylamine (2%, w/v, in sulfuric acid) along sides	Will not change to blue	Blue along the sides	Gandhi K et al. (2020)
4	Formalin	Add Sulphuric Acid	Absence of violet blue ring	Presence of violet blue ring	Mohanty et al. (2020)
5	Salt	Add Nitrate solution and Potassium Chromate	Chocolate brown colour	Yellow Colour	Gandhi K et al. (2020)
6	Hydrogen Peroxide	2% para-phenylenediamine solution	Absence of blue colour	Presence of blue colour	Mohanty et al. (2020)
7	Starch and other cereal flours	Boil the sample and then cool it. Add Iodine Solution	Absence of blue colour	Appearance of Blue Colour	Gandhi K et al. (2020)
8	Boric acid	Add HCl to the sample Dip a turmeric strip into it	Absence of red colour	Presence of red colour	Azad T et al. (2016)

It is customary to respect economic view points by substituting cheaper oil with more costly ones. Because of their higher cost and restricted availability, certain oils are more likely to be tampered with.[16] Adulteration results in low quality, inexpensive oil. One way to commit adulteration is to substitute a cheap oil for an expensive one. For instance, in order to increase profits, olive oil is adulterated with vegetable oils that comprises mustard, rapeseed etc. which poses a serious issue.[17] Some of the common adulterants chemical detection methods in different oils are mentioned in Table 3.

Table 3: Adulterants in Edible oil and their chemical detection methods

S No	Food Article	Adulterants in honey	Chemical Detection Methods	Pure	Impure	Reference
1	Edible Oil	Prohibited Colours	Adding and shaking the sample with HCL.		A layer of colour will be observed after adding	FSSAI (2012)
		Rancidity	ammonium molybdate reagent		The appearance of white colour turbidity	FSSAI (2012)

2	Mustard Oil	Super soybean oil	HCl based kit Different colours will be observed			Huq et.al (2021)
		Cotton seed oil	By observing a red coloration after heating with amyl alcohol.	No red colour formation	Red colour will be observed	FSSAI (2012)
		Argemone Oil	Add Nitric Acid	No red colour formation	Red colour formation	Huq et.al (2021)
3	Soyabean Oil	Palm Oil	Gentle shake with nitric acid based kit	Separate layer of colour will not be observed	Separate layer of colour will be observed	FSSAI (2012)
4	Sunflower Oil	Castor Oil	addition of 10 mL petroleum to the sample oil	No white turbidity	White turbidity	Abhirami and Radha (2015)
		Argemone Oil	Nitric Acid	No layer of red brown colour	A layer of red-brown colour	FSSAI (2012)
		Palm oil , castor oil and Paraffin	Colorimeter			Abhirami and Radha (2015)
		Mineral Oil	Heating with alcoholic potash	Absence of turbidity	Presence of turbidity	FSSAI (2012)
5	Ghee	Rancid stuff(old ghee)	Addition of ether and HCl solution	No pink red colour observed	a pink-red colour layer at the bottom	FSSAI (2012)
		Synthetic colouring matter	acidic or alkaline solution	No pink or yellow colour observed	The appearance of pink or yellow colour	FSSAI (2012)
6	Ghee/Butter	Mashed potatoes, sweet potatoes and other starches	Drops of Iodine	No blue colour observed	Observing a blue colour.	FSSAI (2012)
		Vanaspati/ margarine	Adding HCl	No Crimson colour layer is observed	Crimson colour layer is observed	FSSAI (2012)
7	Vegetable oil/Gingerly oil	Argemone oil	Adding Nitric acid	No Yellow, orange or crimson colour layer	Yellow, orange or crimson colour layer is observed	Abhirami and Radha (2015)
		Mineral oil	Addition of alcoholic potash	No Appearanc	Appearance of turbidity	Abhirami and Radha (2015)

			and 10 mL of water.	e of turbidity		
8	Coconut Oil	Cyanide	addition of alcoholic potash, ferrus sulphate and ferric chloride consecutively.	No presence of blue colour in sample.	Presence of blue colour in the sample.	FSSAI (2012)

There are two main varieties of fake honey: artificial (imitation) honey and adulterated (adulteration) honey. Honey that has had its overall composition altered through methods such as feeding bees sugar syrups during the production phase, mixing honeys with various characteristics, or adding syrups to honey after production is all considered adulterated honey. Honeys that are made entirely of sugar syrups without the use of bees are referred to as artificial (imitation) honey. [18] Different types of adulterants and ways of detection are mentioned in Tables 4 and 5.

Table 4: Adulterants in Honey and Their Detection Methods

S. No.	Adulterants in Honey	Way of Detection	Reference
1	Sugar	Viscosity test/ Smelling/Sticky in palpation	Damto T (2021)
2	Banana	Soily by Observation	Damto T (2021)
3	Flower	Viscosity check, Oily Presence	Damto T (2021)
4	Banana with Sugar	Smelling continues flow	Damto T (2021)

Table 5: Adulterants in honey and their Chemical detection methods

S No.	Chemical Detection Methods	Pure Honey	Impure Honey	Reference
1	Fiehe's Test: Add solvent ether to honey. Shake well and decant the ether layer in Petri dish. Evaporate completely by blowing the ether layer. Add resorcinol	Absence of cherry red colour	Appearance of cherry red colour	Abhirami and Radha (2015)
2	Aniline Chloride Test: Take honey in dish. Add Aniline Chloride solution and stir	No orange-red colour	Orange-red colour	Abhirami and Radha (2015)

VI. CONCLUSION

Food adulteration is the most widespread malpractice in India; it is an illegal practice carried out for profit. To entice consumers, various sorts of food articles are contaminated with low-quality, low-cost ingredients. These contaminated food items are sold at higher prices in order to maximize profit margins. Food adulterants must be detected because they can have a significant impact on one's health. These adulterants can pose various and serious health risks. This review article analysed goods such as milk, edible oil, and honey, which are popular home products. It also specified many methods for detecting adulterants, including physical and chemical analysis. These methods are rapid and budget-friendly.

Today, many people in India are unaware of food adulteration methods and their detection techniques. Even if they are aware of it, they don't raise their voice against it. This carelessness of the consumers encourages the sellers to sell cheap and low-quality products in the market and gain profit. The awareness is necessary for the locals to help them achieve a good and healthy lifestyle without adulterated food items.

VII. SCOPE OF FURTHER WORK

Detection of food adulterants can also be done by using spectroscopic methods like Infrared spectroscopy, NMR, and many more. Qualitative, along with quantitative, detection of adulterants in food items can be done. Identification of a particular substance can also be done. Different New techniques can also be used to detect food adulterants in a given sample.

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