FOOD SCIENCE AND TECHNOLOGY

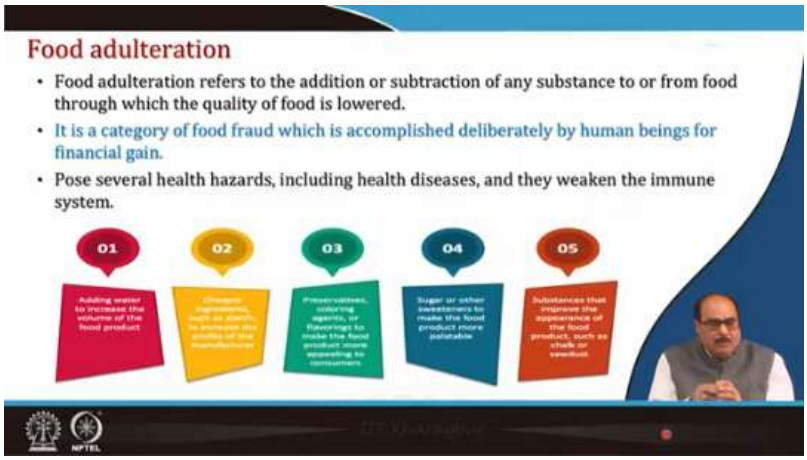
Lecture38

Lecture 38: Food Adulteration

Hello everyone, Namaste.

Now we are in lecture number 38 of this course, and in this lecture today, we will talk about food adulteration in the next 30 minutes or so.

We will discuss what food adulteration is, what the various types of adulterants in food are, and their detrimental effects on detecting food adulteration. Finally, in the last part, we will also talk briefly about food adulteration detection techniques.

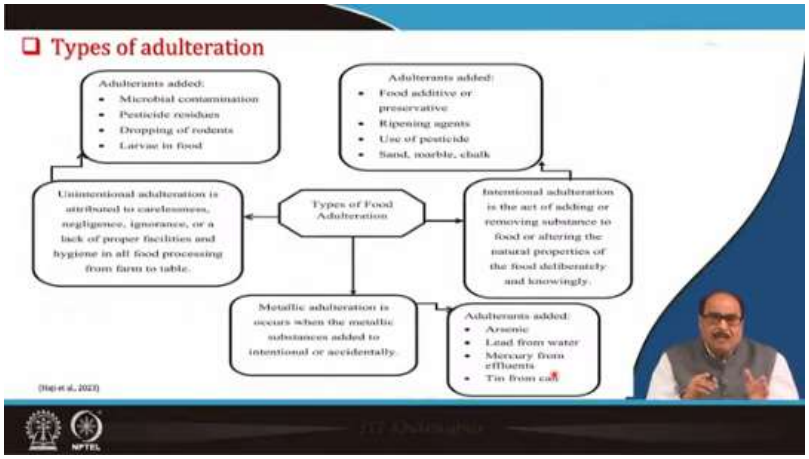


So, let us see what food adulteration is. Food adulteration refers to the addition or subtraction of any substance to or from food, through which the quality of food is lowered. That is very important. It may be that any inferior-quality material is added to the food, or any vital component of the food may be removed or subtracted from it, and the purpose here is to gain more financial profit. It is a category of, you can say, food fraud, which is accomplished deliberately by human beings for financial gains. These pose several health hazards, including diseases that weaken the immune system. If you continuously consume adulterated foods, your weakened immune system will be affected, and you will suffer from various diseases, etcetera. So, there are even familiar food adulterations, like adding water to milk, adding cheaper ingredients such as starch, etcetera, to increase profit, and adding non-permitted, cheap-quality preservatives or other additives like sugars or other sweeteners to make the food product more palatable. Or even substances that improve the appearance of the food products, such as chalk or sawdust, etcetera. But you see, adding chalk or sawdust may increase the whiteness, but obviously, this is food fraud.

So, as per the Food and Drug Administration, food adulteration can be defined as any food that has been added with any foreign material injurious to health; it can be considered adulterated. If any food has been added with the same material of inferior quality, that is, in the food, there is a component, but if the same element from outside has been added to increase its content and that is of inferior quality, you can consider this as adulteration.

Product quality can be adulterated if it does not meet the standards. Any addition of foreign materials to alter the appearance or consumer appeal of the original product is also adulteration. Then, food is added with any substance to manipulate the product's weight or density or remove any important or characteristic compound. So, if any of these or two of these are happening in the product as per the FDA, it can be acknowledged to be adulterated.

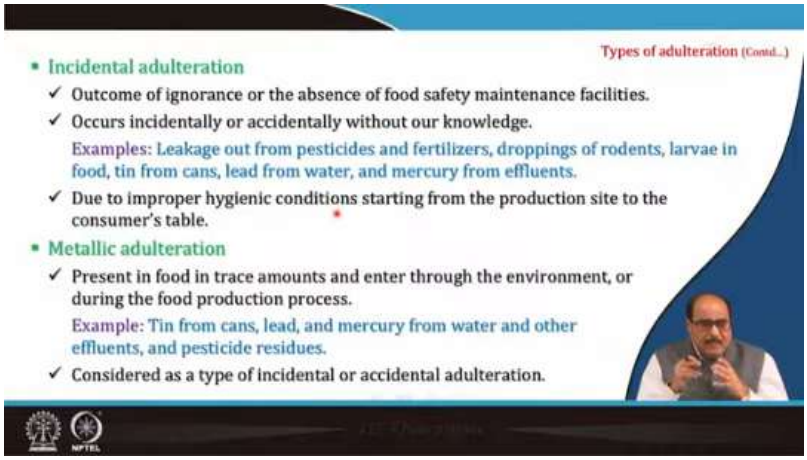
So, causes of food adulteration. I already told you earlier that economics is one of the critical factors in having more financial profit. So, the more common reasons for carrying on adulteration are complex supply chains that extend to many countries across the globe. The rise in demand for imported ingredients among consumers and gaps in the food safety and quality laws in different countries serve as loopholes for EMA. So, because of all this, people may go for adulteration if they increase the quantity of food to increase the distribution of nutrition. It may be a business strategy or lack of awareness by the general public to attain more profit. So, these might be the prominent causes of food adulteration.



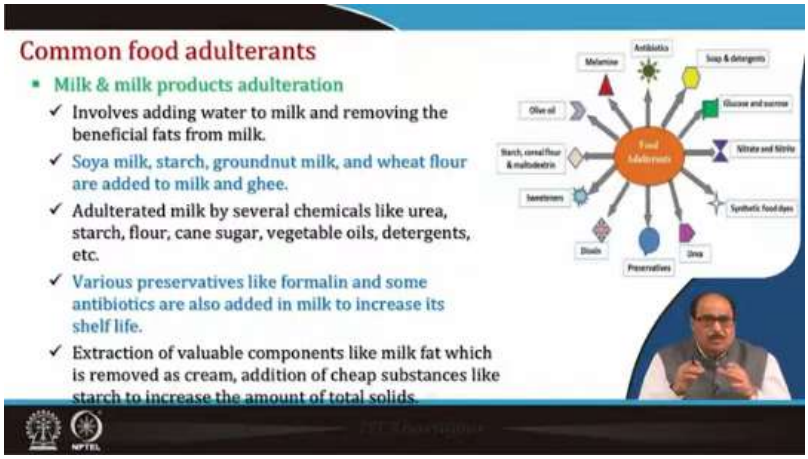
There are different types of adulteration, like unintentional adulteration, which is attributed to carelessness, negligence, ignorance or a lack of proper facilities and hygiene in all food processing from farm to table. It may be that it is unintentional that it may come by chance that there is microbial contamination, pesticide residues, and dropping of rodents or larvae present in the food. So, if they are present in the food, it will also be adulteration, but it is unintentional. Then there may be intentional adulteration, that is, the act of adding or removing substance to food or altering the natural properties of the food deliberately and knowingly. Some examples may include adding food additives or preservatives, ripening agents, use of pesticides, sand, marble, chalk, etcetera. Then, there is also metallic adulteration. Metallic adulteration occurs when metallic substances are intentionally or accidentally added to food. For example, arsenic or lead from water may enter the food, mercury from effluents, or even tin can enter the food from tin cans, etcetera. Still, if that occurs, it may also be adulteration. So, here, I will elaborate a little bit on intentional adulteration. As I told you earlier, it is purposefully performed for financial gain for food products. Also, it is termed food fraud, which includes inferior substances with similar physical properties to the food they are added to, and it can be any physical or biological.

For example, the products you can find in milk and milk products include melamine, urea, detergent, water addition, skim milk, vegetable oil, synthetic milk, and annatto. Sometimes, they starch or starch; once they remove the fat or add water, they add starch or other inferior-quality flours, etcetera, to make up the specific gravity of milk. Similarly, in ice cream, starch, rice powder, or wheat flour is added. In tea leaves, black or Bengal gram, dal husk with colouring is used. Then, in coffee: chicory, roasted barley powder, tamarind seeds, etc. In pulses, Sudan dye, lard, melamine, metallic yellow, and Kesari dal are the common adulterants in arhar dal and other pulses. Then, papaya seeds are added to black pepper in common salt, white powdered stone, or chalk. Vegetable oils: Add cheaper seed oils. In wheat, rice, maise, jowar, and bajra, there may be dust, stone, straw, wheat seeds, and many other types. So this is, in fact, a menace, you can say, and people, to get more profit, etc., they use all these cheap means.

Then, incidental adulteration, as I also told you earlier, is the outcome of ignorance or the absence of food safety maintenance facilities. It occurs incidentally or accidentally without the knowledge of the producer. For example, leakage from pesticides and fertilisers, dropping of rodents may be found, larvae in food, or tin from the can lead from water or mercury from effluents that are, it come from the water which is treated for the food ingredient processing that is used, and this may even be effluent you are using. So, it may be contaminated with mercury or other such metals. Then, adulteration may occur due to improper hygienic conditions, starting from the production site to the consumer's table.

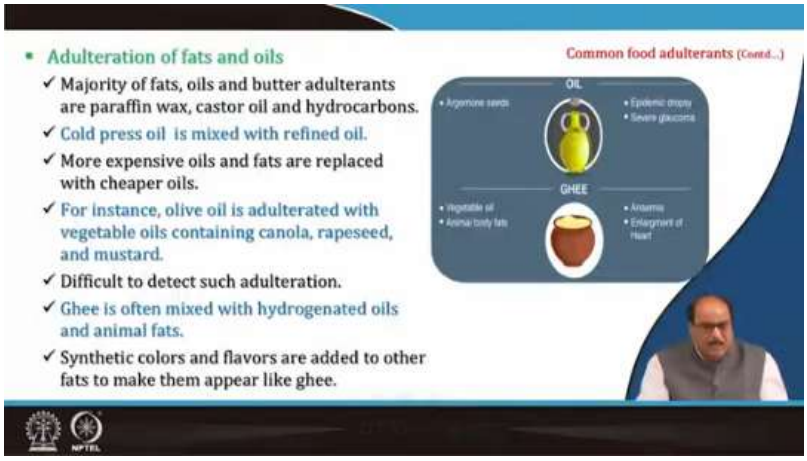


So, all these come under incidental adulteration. Then, metallic adulteration is present in the food in trace amounts. They enter the environment during food production or from within the value chain. For example, a tin may dissolve excessively into canned food. Lead can come from mercury in the water and other effluents, pesticide residues, etcetera. So, this metallic adulteration is considered a incidental or accidental adulteration.



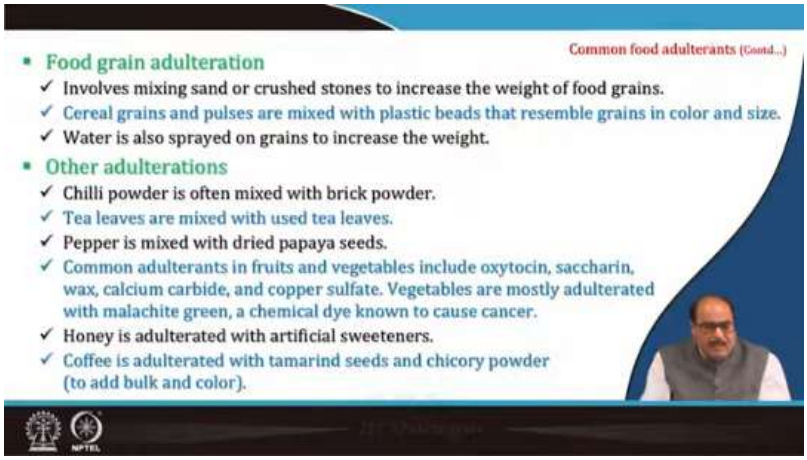
So, we will elaborate a little bit on common adulterants in food. First, we will talk about milk and milk products. Adulterating milk and milk products mainly involves adding water and removing the beneficial fats from the milk. Even soya milk, starch, groundnut milk, wheat flour, etcetera, are added to milk and ghee. Adulterated milk contains several chemicals like urea, starch, flour, cane sugar, vegetable oils, detergents, and more. The milk is adulterated with enough substances. Various preservatives like formalin and some antibiotics may also be added to the milk to increase its shelf life. Extraction of valuable components like milk fat, which is removed as cream. So, selling milk with lower quality

fat or even to make up for those losses, they sometimes add cheap substances like starch to increase the number of total solids, etcetera. So, these may be some common.

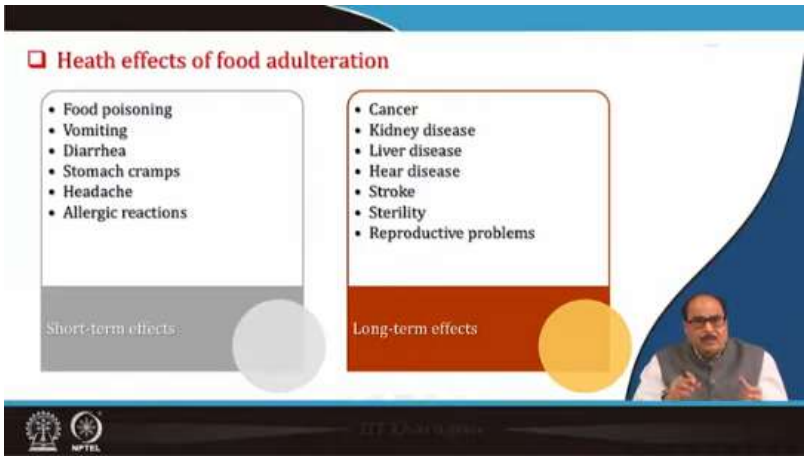


Then, adulteration in the fats and oils. Maybe most fats, oils, and butter adulterants are paraffin, wax, castor oil, and hydrocarbons, meaning cheap-quality triglycerides and cheap-quality oils may be added to the good-quality products. Cold-pressed oil is mixed with refined oil. Cheaper oils replace more expensive oils and fats. For example, olive oil is adulterated with vegetable oils containing canola, rapeseed, mustard, etc. Then, this is, of course, as it is often challenging to detect such adulteration. Ghee is often mixed with hydrogenated oils, as well as animal fats. Synthetic colours and flavours may also sometimes be added to other fats to make up or to make them appear like ghee, etcetera. So, that is there in the fats and oils.

Then, in the food grain, adulteration involves mixing sand or crushed stones to increase the weight of the food grain. Cereal grains and pulses are combined with plastic beads that resemble grains in colour and size. Water is also sprayed on grains to increase their weight. Other adulterations may include chili powder, which is often mixed with brick powder. Tea leaves are mixed with used tea leaves, and pepper is mixed with dried papaya seeds.

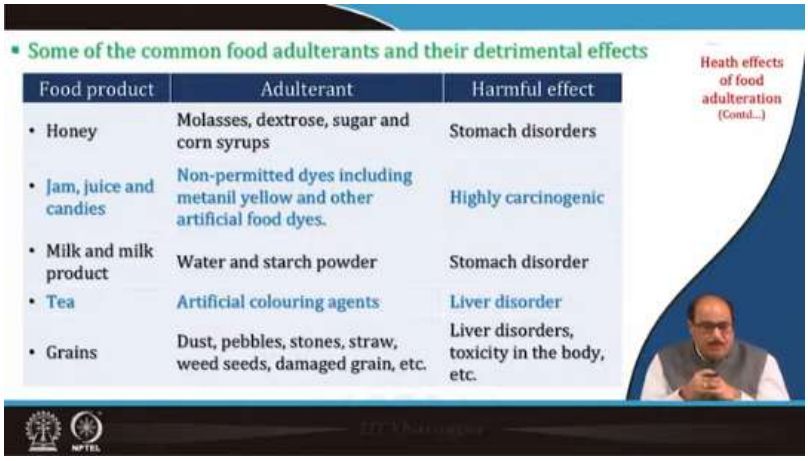


Common adulterants in fruits and vegetables include oxytocin, saccharin, wax, curcumin carbide, calcium carbide, and sulfate. Vegetables are mostly adulterated with malachite green, which is a chemical dye known to cause cancer. Honey is adulterated with artificial sweeteners. Coffee is adulterated with tamarind seeds, chicory powder, etc., to add bulk and color.

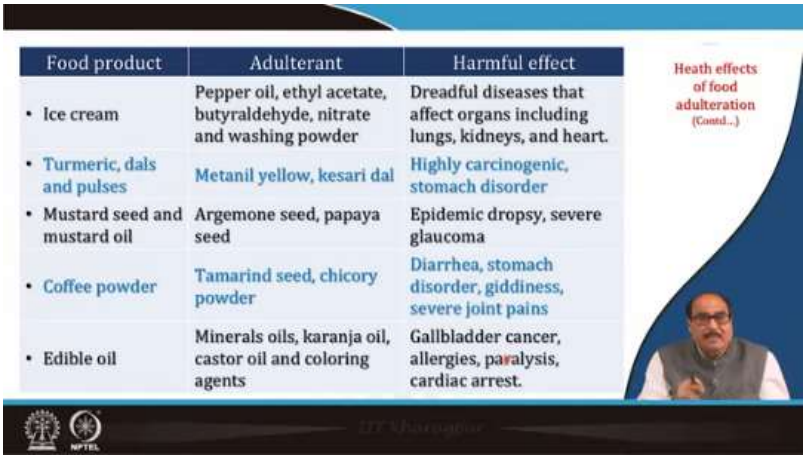


So, this is a heinous crime, adulteration of food, and you can see that it affects the health of the consumer very severely and adversely. So, it has short-term effects like food poisoning, vomiting, diarrhoea, and stomach cramps. Headaches and allergic reactions can occur immediately afterwards, depending on the type of food and the adulterant used. You can have short-term effects. Sometimes, it may also have long-term effects if you continuously consume adulterated foods. There will be long-term effects, like cancer. Consumers may be affected by cancer. There will be kidney disease, liver disease, heart

disease, stroke, sterility, or even other reproductive problems. Consumers must be aware of all these food frauds and menaces to take proper precautionary measures.

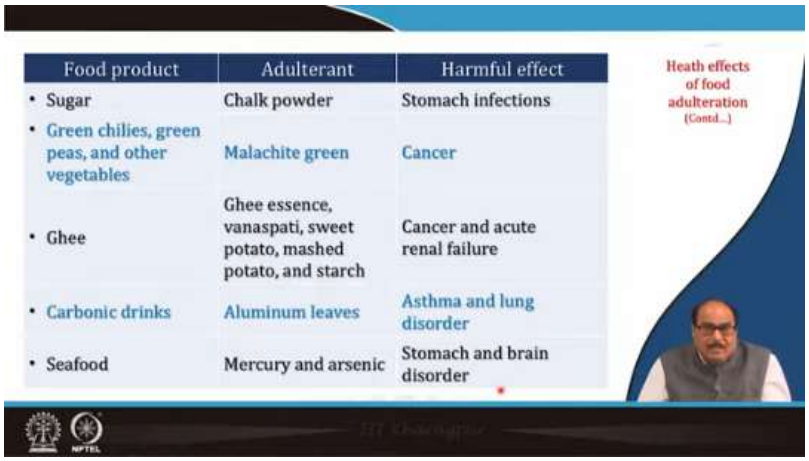


So, I will elaborate on some typical food adulterants and their detrimental effects. Honey adulterated with molasses, dextrose, sugar, corn syrup, etc., results in stomach disorders. Jams, jellies, juices, candies, etc., which are adulterated with non-permitted dyes, including metanil yellow and other artificial food dyes, are highly carcinogenic. Milk and milk products with added starch, water, and starch powders result in stomach disorders. Artificial colouring agents are used for adulteration in tea, which might cause liver disorders. In grains, there will be dust, pebbles, stones, straw, weeds, damaged grain, etcetera, which may result in liver disorders, toxicity in the body, etcetera.



Ice cream is adulterated with paper oil, ethyl acetate, butyryl aldehyde, nitrite, washing powder, etcetera. Dreadful diseases that affect organs, including lungs, kidneys, heart, etcetera. Turmeric, dal, and pulses are adulterated with methanol yellow and khesari dal.

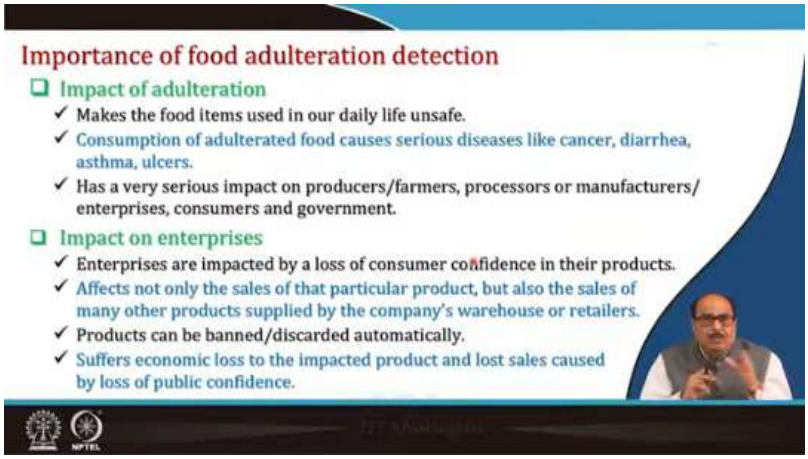
So, these, again, are highly carcinogenic, and they result in stomach disorders. Mustard seeds and oil are adulterated with argemone seeds, papaya seeds, etcetera: epidemic dropsy, severe glaucoma. Coffee powder is adulterated with tamarind seeds, chicory powder, etcetera; it causes diarrhoea, stomach disorders, giddiness, severe joint pain, and so on. Even edible oil, when adulterated with mineral oils, Karanja oil, castor oil, and other colouring agents, etcetera, can cause gallbladder cancer, allergies, paralysis, and even cardiac arrest.



Food product	Adulterant	Harmful effect
• Sugar	Chalk powder	Stomach infections
• Green chilies, green peas, and other vegetables	Malachite green	Cancer
• Ghee	Ghee essence, vanaspati, sweet potato, mashed potato, and starch	Cancer and acute renal failure
• Carbonic drinks	Aluminum leaves	Asthma and lung disorder
• Seafood	Mercury and arsenic	Stomach and brain disorder

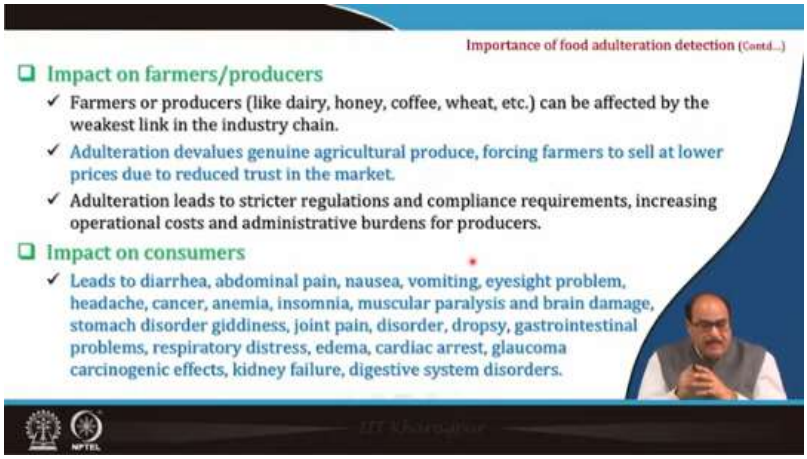
Sugar they are adulterated with chalk powder. So, it again causes stomach infections. Green chillies, green peas, and other vegetables are adulterated with malachite green, which causes cancer. Ghee adulterated with ghee essence, vanaspati, sweet potato, mashed potato, starch, etcetera causes cancer and may lead to acute renal failure. Carbonated drinks are sometimes adulterated with aluminium leaves, which causes asthma and lung disorders. Seafood contains mercury and arsenic, which may result in stomach and brain disorders.

So, we discussed what adulteration is, what the common types are, and how they affect consumers' health. So, there is a need for consumer awareness and food adulteration detection. So, the importance of food adulteration detection lies in making the food items used in adulteration. If you talk about it, it may make the food unsafe. Consumption of adulterated food causes serious diseases, as you have seen earlier, like cancer, diarrhea, asthma, ulcers, etcetera, and it has a severe impact on producers,

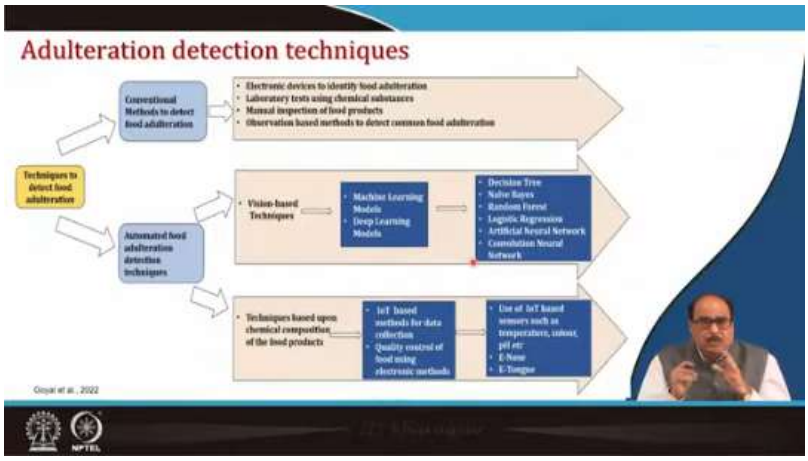


farmers, processors, manufacturers, enterprises, consumers, and the government. So, every section or stakeholder involved in this is affected in one way or another by the adulteration process. The impact of adulteration on enterprises is that enterprises are impacted by a loss of consumer confidence in their products. If it is known that this X product produced by Y manufacturing agency or Y enterprise is adulterated, then consumers will not like to take that. So, it has an impact. It affects not only the sales of that particular product but also the sales of many other products supplied by that company, the warehouse, or retailers. Even products can be banned or discarded automatically. It may suffer economic loss; the enterprise may suffer economic loss due to impacted products and lost sales caused by the loss of public confidence.

Then, adulteration impacts the farmers as well as producers. Farmers are producers of dairy, honey, coffee, wheat, etc., of these producers. They can be affected by the weakest link in the industry chain. Adulteration devalues genuine agricultural produce, forcing farmers to sell at lower prices due to reduced trust in the market. Adulteration leads to stricter regulations and compliance requirements, increasing producers' operational costs and administrative burdens. So, and finally, the impact of adulteration on consumers. I told you it leads to various health diseases and disorders, etcetera; it affects health; it leads to diarrhea, abdominal pain, nausea, vomiting, eyesight problems, headache, cancer, anaemia, and a lot of other issues.

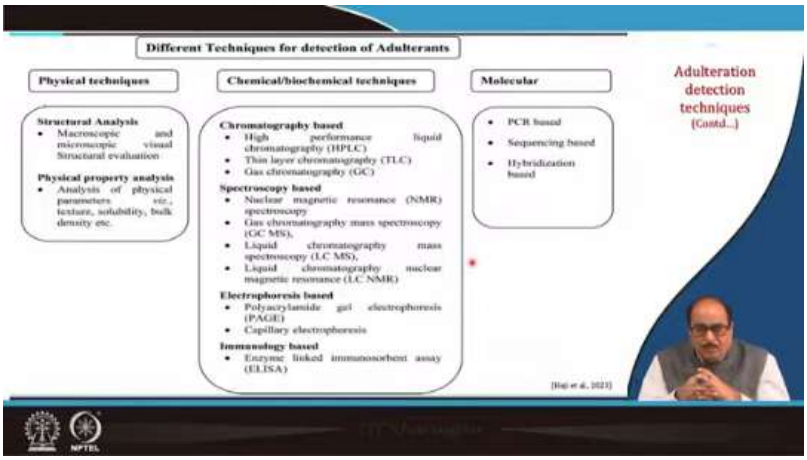


Any problem like disorders, joint pain, gastrointestinal issues, edema, cardiac arrest, carcinogenic effects, kidney failure, digestive system disorders, and all sorts of things. That is, this may be their food adulteration, which may impact consumers, who may be affected by all these.

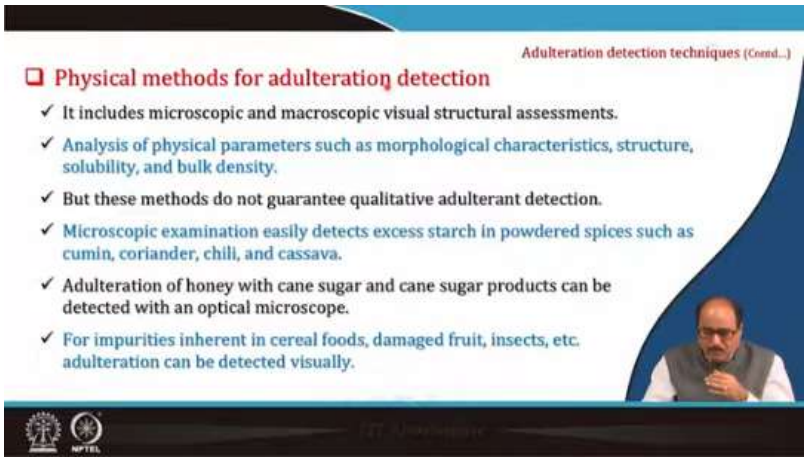


So, let us talk about adulteration detection techniques. There are methods to detect adulteration, such as conventional methods to detect food adulteration or electronic devices to identify food adulteration. There may be laboratory tests using chemical substances, even manual inspection of food products or observation-based methods to detect common food adulteration. In automated food adulteration detection techniques, there may be vision-based methods or strategies based on the chemical composition of the products. In vision-based methods, there may be machine learning models and deep learning models like decision trees, nav-based, random forest, logistic regression, even artificial neural networks, conventional convolution neural networks, etcetera. All the methods and

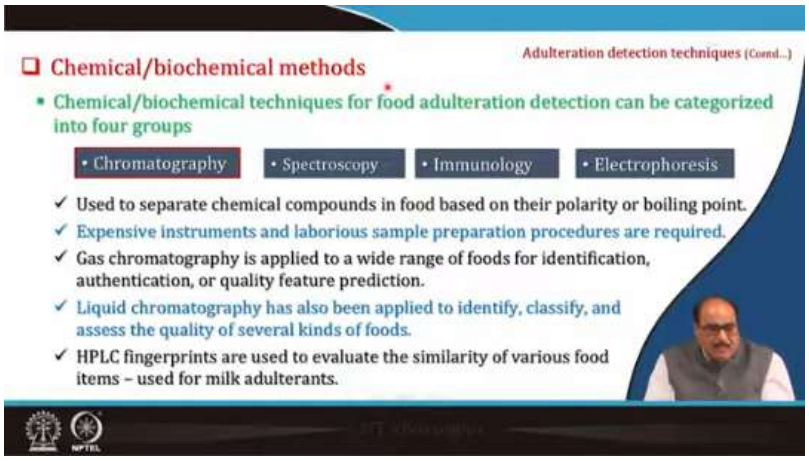
processes can be used for adulteration, that is, the vision-based technique. The techniques based on the chemical composition of the food, like IOT-based methods for data collection, quality control of food using electronic methods or use of IOT-based sensors such as temperature, colour, pH, etcetera, and even e-nose, e-tanks all can be used for the detection of adulteration.



So, the other techniques for detecting adulteration in food may be physical, chemical, biochemical, or even molecular techniques. In the physical methods, one can go. So, structural analysis like microscopic and microscopic visual evaluation, structural evaluation to see whether these materials are present in some foreign body, foreign materials are present and if they can be visually seen, etcetera. Then, physical properties analysis, analysis of physical parameters, texture, solubility, bulk density, etcetera. Chemical or biochemical methods that can be used to detect adulteration may be high-performance liquid chromatography, HPLC, or even thin-layer chromatography or gas chromatography. So, there may be chromatography-based or spectroscopy-based methods like nuclear magnetic resonance spectroscopy. GCMS, LCMS, LCNMR, and then electrophoresis-based like polyacrylamide gel electrophoresis, capillary electrophoresis, or immunology-based like enzyme-linked immunosorbent assays. Then, molecular-based methods like PCR-based, sequencing-based, and hybridization-based will be used. So, depending on because there is a very vast category, there are several possibilities, as we have briefly discussed here. So, depending upon that, one has to choose a method and Identify whether the food is adulterated. So, let us discuss this briefly because it is essential. One should know how adulteration can be detected.

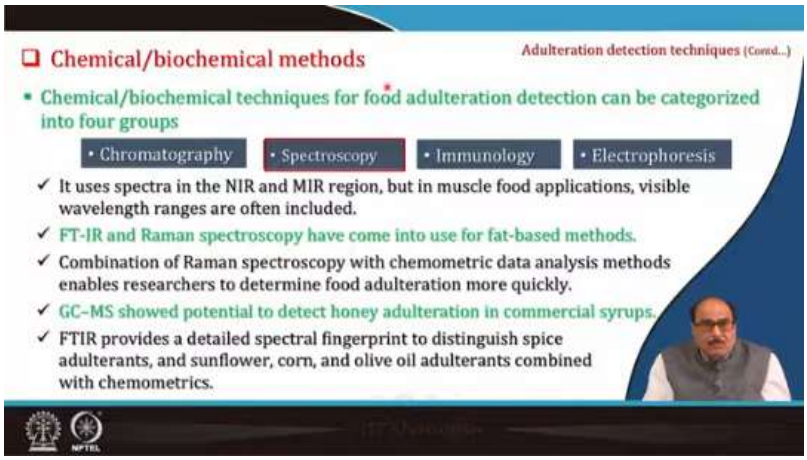


So, the physical methods include microscopic and macroscopic visual structure assessment. Analysis of physical parameters such as morphological characteristics, structure, solubility, and bulk density. However, these methods do not guarantee qualitative adulterant detection. By this, you can visually see that macroscopic examination quickly detects excess starch in powdered spices such as cumin, coriander, chilli, cassava, etcetera, or even adulteration of honey with cane sugar and cane sugar products can be detected with an optical microscope. For impurities inherent in cereal foods, damaged fruits, insects, etcetera, adulteration can be detected visually by just seeing the things.



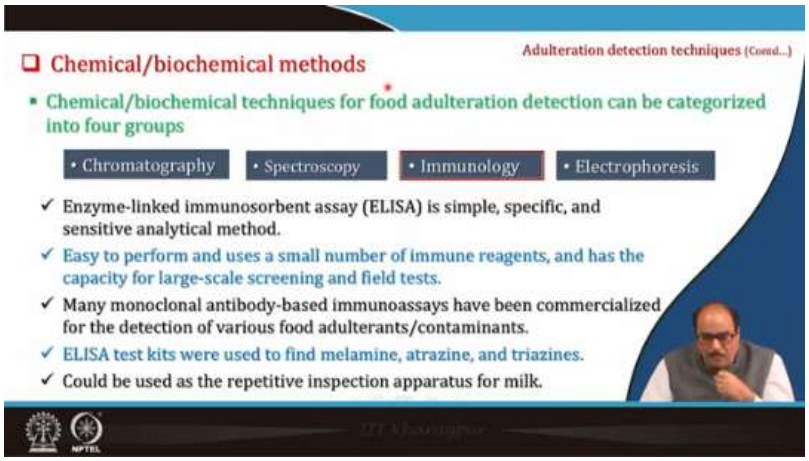
Then, in the chemical or biochemical methods, the chemical or biochemical techniques for food adulteration detection can be categorised into four groups. One is that we have already discussed briefly that chromatography is used to separate chemical compounds in food based on their polarity or boiling point. Expensive instruments and laboratories and laborious sample preparation procedures are required in these methods, like gas

chromatography, which is applied to a wide range of foods for identification, authentication, or quality feature prediction. Liquid chromatography has also been applied to identify, classify, and assess the quality of several kinds of foods. HPLC fingerprints are used to evaluate the similarity of various food items used for milk adulteration or other adulteration, etcetera.

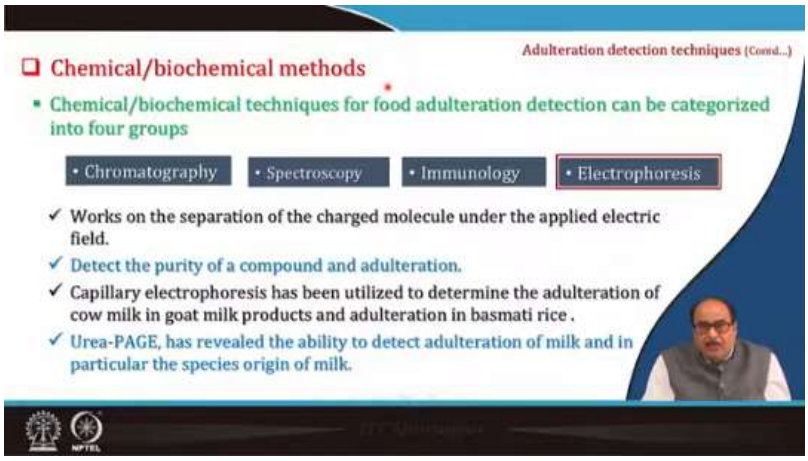


Spectroscopy uses the spectra in the NIR or MIR regions, but visible wavelength ranges are often included in muscle food applications. FTIR and Raman spectroscopy have been used as fat-based methods. Combining Raman spectroscopy with chemometric data analysis methods enables researchers to detect food adulteration more quickly. GCMAs show potential in detecting honey adulteration in commercial syrups. FTIR provides a detailed spectral fingerprint to distinguish spice adulterants, sunflower, corn, and olive oil adulterants when combined with chemometrics, etc.

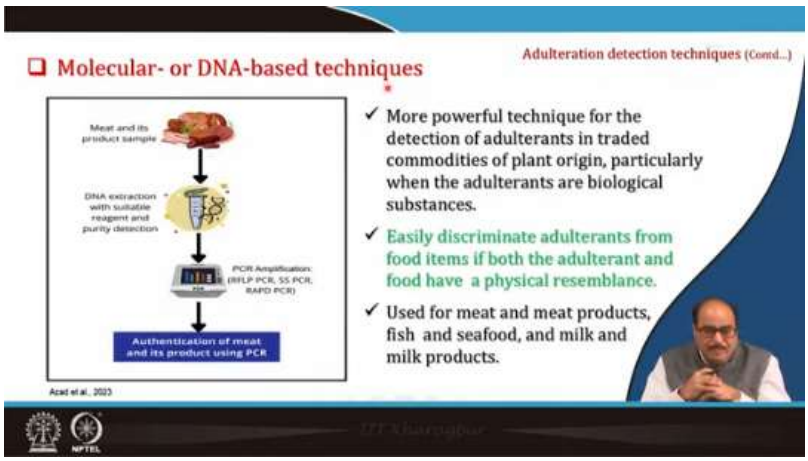
Immunological methods like enzyme-linked immunosorbent assay (ELISA) are simple, specific, and sensitive analytical techniques. They are easy to perform and require only a small number of immune reagents. They also have the capacity for large-scale screening and field tests.



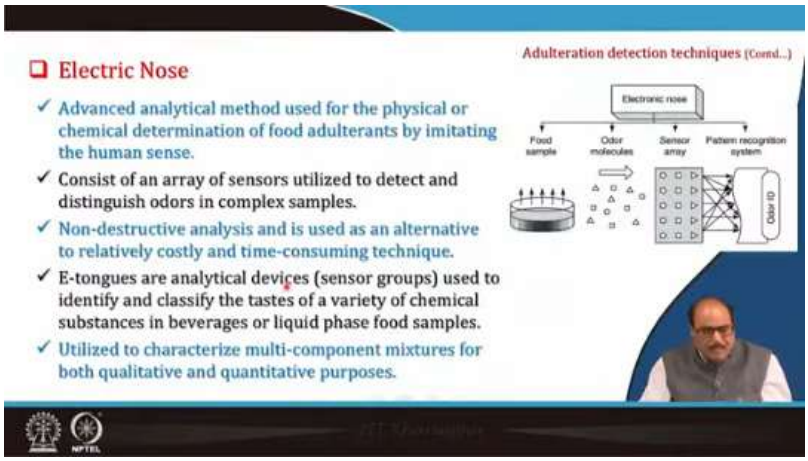
Many immunological antibody-based immunosensors have been commercialised for the detection of various food adulterants or contaminants. ELISA-based test kits detect melamine, atrazine, tetrazine, etc. Electrophoresis methods work on separating charged molecules under an applied electric field. They detect the purity of a compound and its adulteration.



Capillary electrophoresis has been utilised to detect adulteration of cow milk in goat milk products and adulteration in basmati rice, etcetera. Urea-PAGE has revealed the ability to detect adulteration of milk and, in particular, the species origin of milk if different cow milk, buffalo milk, and goat milk are added one to the other. So, that can also be detected by these methods.

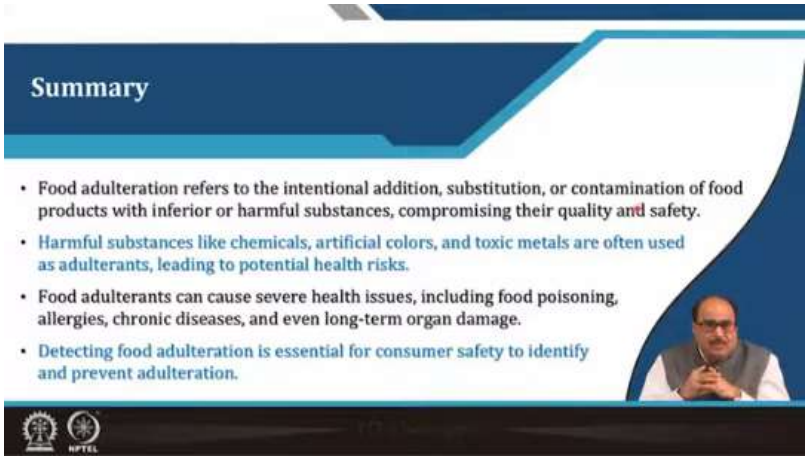


Then, molecular or DNA-based techniques are more powerful for detecting adulterants in traded commodities of plant origin, mainly when adulterants are biological substances. They easily discriminate adulterants from food items if both the adulterants and food have a physical resemblance. They are used for meat and meat, fish, seafood, and milk and milk products. That is molecular-based meat, a product you can see here on the finger. Then, the DNA extraction with suitable and purity detection is done, and then one can proceed with PCR amplification, which gives the product authentication.



The electronic nose, e-nose, is an advanced analytical method used for the physical or chemical determination of food adulterants by imitating the human sense. It consists of an array of sensors to detect and distinguish odours in complex samples. It is non-destructive analysis and is an alternative to relatively costly and time-consuming techniques. E-tongues are analytical devices like this sensor group used to identify and classify the taste of various chemical substances in beverages or liquid-phase food samples. They are utilised

to characterize multi-component mixtures for both qualitative and quantitative purposes. Here, the food sample is there; then other molecules go. There is a sensor array in the metal oxide sensor or other sensors in the instrument, a detail of this instrument, e-nose and e-tongue. etcetera, which we also discussed in earlier class. So, that is finally evaluated and analyzed by the computers, etcetera.



So, now I would like to summarize this lecture by saying that food adulteration refers to the intentional addition, subtraction, or contamination of food products with inferior or harmful substances, compromising their quality and safety. Harmful substances like chemicals, artificial colors, toxic metals are often used as adulterants, leading to potential health risks. Food adulterants can cause severe health issues, including food poisoning, allergies, chronic diseases, and even long-term organ damage. Detecting food adulteration is essential for consumer safety to identify and prevent adulteration. Consumers must be aware of these food frauds and their menaces. The regulatory agencies or other agencies must take every possible step to prevent the adulteration of food, make the food free from any undesirable components, and ensure that the health of the consumers is properly protected.

So, these are the references that were used in making this lecture.

Thank you very much.