

2. The Unseen Culprits: Exploring the Chemicals in Our Food

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Abstract:

In the modern world, food is more readily available and diverse than ever before. However, with this convenience and variety comes a growing concern about the hidden and often unpredictable chemicals that find their way into our meals. From pesticides to preservatives, food additives are now a ubiquitous part of the modern diet. In this chapter, we will delve into the world of food chemicals, exploring their origins, purposes, potential impacts on our health and possible remedies.

2.1 Introduction:

All living organisms require energy to carry out their essential life activities, such as growth, reproduction, movement, and maintaining bodily functions. This energy is derived from the food they either produce or obtain from other organisms.

Plants and certain bacteria possess the remarkable ability to create their own food through the process of photosynthesis, while the rest of the organisms, including human beings, rely on plants, either directly or indirectly, to obtain their sustenance. With the exception of humans, wild animals do not cultivate or store their food; they gather it from nature as needed. Humans, on the other hand, stand alone as the unique species on earth that cultivates plants, stores grains, processes food, and preserves it for extended periods. This innovation, which began with agriculture, has enabled humans to establish settled societies, develop civilizations, and ensure a stable food supply.

Generally, food is primarily composed of carbohydrates, proteins, fats, vitamins, enzymes, minerals, and a limited array of other organic constituents. However, the food we consume today contains more than 10,000 types of organic and inorganic chemicals that are not natural components of our diet. These chemicals find their way into our food, either accidentally or intentionally, during various stages of cultivation, storage, processing, cooking, or preservation.

Plants serve as the primary source of food for humans. With the exception of a few wild edibles, almost all our food comes from the commercial cultivation of crops. Agriculture and food processing have employed a wide range of chemicals, varying from mild to highly dangerous.

It is generally believed that these chemicals persist for only a few days to weeks and eventually dissipate over time. However, certain chemicals found in some pesticides have a much longer lifespan, lasting several months and posing severe risks to consumers.

In addition to these pesticides, several synthetic chemical molecules are introduced into food during processing and storage, known as additives. These additives can be highly harmful and even deadly when used in excessive quantities. Therefore, it is very important to identify such chemicals, study their nature and impact on health, and restrict their use.

2.2 Use of Chemicals:

In agricultural practices, various chemicals have been utilized to safeguard plants from different types of threats, including bacteria, nematodes, fungi, insects, birds, and other animals collectively known as pesticides. Specific chemicals are employed to eradicate weeds and reduce competition, known as herbicides. Additionally, some chemicals are used to enhance plant productivity, referred to as fertilizers.

All of these chemicals play a crucial role in increasing crop yields and reducing labor costs, thereby contributing to the prosperity of farmers. However, it is important to note that certain chemicals used in these formulations can be highly harmful to human beings when present in specific concentrations, potentially causing severe health effects and even fatalities.

Pesticide residues are indeed trace amounts of pesticide active ingredients or their metabolites that can remain in or on food products after they have been treated with pesticides. These residues can arise from diverse origins, encompassing agricultural methods, post-harvest procedures, and potentially even environmental contamination. These residues are considered to be of toxicological significance because they can pose health risks to humans and animals when consumed.

Furthermore, various chemicals are used in the processing of various plant-based food materials. These chemicals are either used to protect food from various pathogens and insects or to preserve them for extended periods.

Some chemicals are also employed to enhance palatability and streamline processing. However, these chemicals can be highly dangerous when present in excessive concentrations, causing severe health issues. Certain chemicals can leach from packaging materials such as plastic bottles and aluminum cans, posing health risks to consumers. Additionally, cooking vessels can release certain chemicals into the food, further posing potential risks to human health.

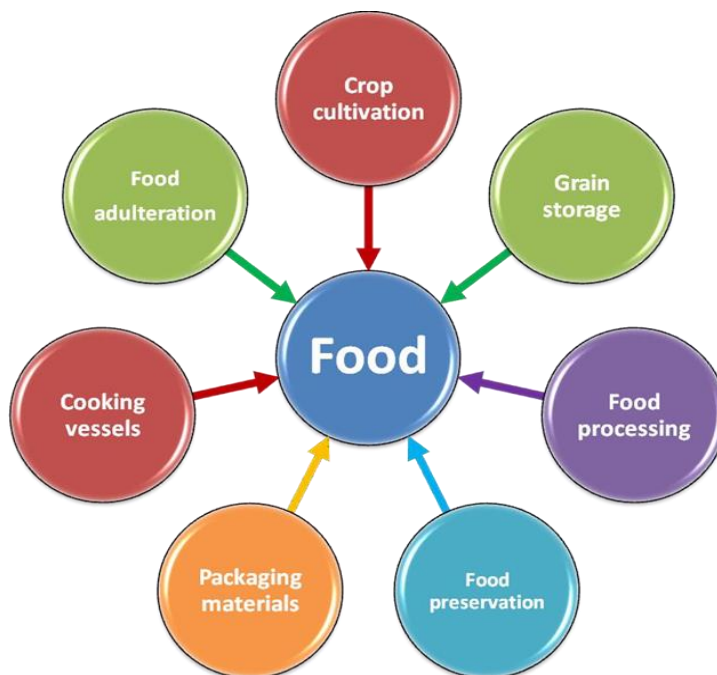


Figure 2.1: Various Modes of Entry of Chemical Residues in to Food

2.2.1 Chemicals Used in Food Production and Storage:

A wide array of natural and synthetic molecules is used in agriculture, post-harvest handling, processing, and storage. These chemicals can be classified based on various criteria, such as their chemical nature, target organisms, mode of entry, mode of action, toxicity, and more.

Depending on the chemical structure, pesticides can be classified as organochlorines (endosulfan, hexachlorobenzene, DDT, HCH, cyclodiene, toxaphene, mirex and chlordecone), organophosphates (diazinon, omethoate, glyphosate, malathion, parathion, fenthion, dichlorvos), natural and synthetic pyrethroids (cypermethrin, permethrin, bifenthrin, deltamethrin), carbamates (thiobencarb, propoxur, molinate, disulfiram, pyridostigmine), heterocyclic compounds (benzimidazole and triazole derivatives), carboxylic acids and their derivatives, urea derivatives, phenol and nitro phenol derivatives, hydrocarbons, ketones, aldehydes and their derivatives, fluorine containing compounds, copper-containing compounds, metal organic and inorganic compounds.

Depending on target organisms these chemicals can be classified as bactericides (streptomycin sulphate, aureomycin), fungicides (copper oxychloride, mancozeb, hexachlorobenzene), insecticides (endosulfan, malathion, aldrin and dieldrin, mirex and chlordecone), nematicides (DD, oxamyl, fenamiphos), rodenticides (zinc phosphide, warfarin), acaricides (dicofol, azinphos methyl), avicides (TMTD, anthraquinone), molluscides (metaldehyde, trifenmorph), and herbicides (glyphosate, 2,4-D, butachlor, atrazine). Fertilizers are primarily formulated to provide essential nutrients to plants. When used correctly and in recommended quantities, they should not result in harmful chemicals in food. However, excessive use of fertilizers can lead to the accumulation of certain trace elements in the soil, which can then enter the food chain and pose health risks.

Certain fertilizers may contain trace elements or heavy metals like cadmium, arsenic, selenium, chromium, nickel, and lead. These elements may be naturally present in the raw materials used to produce fertilizers or can be contaminants. These toxic heavy metals can contaminate the soil and accumulate in food grains, fruits, and vegetables, potentially causing severe health problems.

2.2.2 Chemicals Used in Food Processing and Preservation:

Numerous chemicals are added to food products for various purposes, including enhancing color, stability of artificial flavors, and extending shelf life. More than 1,000 chemicals are permitted for use in food sold in the market. These chemicals can be categorized into several groups based on their functions, including anti-caking agents, anti-foaming agents, antioxidants, artificial sweeteners, bulking agents, etc.

Table 2.1: Chemicals Used in Food Processing and Preservation

Category	Function	Chemicals
Anti-caking agents	Prevent products from clumping and binding together and to ensure the product remains dry and free-flowing	Silicon dioxide, calcium silicate, magnesium stearate, sodium bicarbonate, sodium ferrocyanide, potassium ferrocyanide, calcium silicate, magnesium silicate, aluminium silicate, polydimethylsiloxane, iron ammonium citrate.
Antifoaming agents	Compounds that minimize or mitigate foam production and broth formation	Dimethyl polysiloxane, propylene glycol
Antioxidants	Prevent foods from oxidizing, or going rancid	Ascorbic acid, butylated hydroxyl anisole (BHA), butylated hydroxyl toluene (BHT), propyl gallate (PG), sulfites, tertiary butylhydroquinone, tocopherols.
Artificial sweeteners	Increase the sweetness	Cyclamates, aspartame, and acesulfame K, xylitol, saccharin.
Bulking agents	Non-nutritive substances added to foods to increase the bulk and hence sense of satiety	Potassium bitartrate, aluminium ammonium sulfate, aluminium potassium sulfate.

Category	Function	Chemicals
Chelating agents	Helps to form precipitate useful in color and flavor	Citrates, tartrates, phosphates, and EDTA trimercaptotriazine, potassium/sodiumthiocarbonate.
Clarifying agents	Remove haziness or sediments and oxidative deterioration products	Bentonite, polyamides and poly vinyl pyrrolidone.
Artificial colors	Add or enhance color to the food	Allura red AC, brilliant blue FCF, erythrosine, fast green FCF, sunset yellow FCF.
Emulsifying agents	Stop fats from clotting together	MDGS, stearyl lactylates, sorbitan esters, polyglycerol esters, sucrose esters, and lecithin
Flavoring agents and flavor enhancers	Add and increase the flavor	Vanillin, monosodium glutamate, sodium aspartate, disodium inosinate (IMP), disodium guanylate (GMP), Potassium bromated.
Flour treatment	Improves baking quality	Benzoyl peroxide, bromelain, azodicarbonamide, polysorbates, alpha amylases, calcium sulfate, calcium lactate.
Foaming agents	Maintain uniform aeration of gases in foods.	Calcium glycyrrhizinate, disodium glycyrrhizinate, propylene glycol alginate.
Glazing agents	Improves appearance and can protect food	Paraffin wax, microcrystalline wax.
Humectants	Keep foods moist	Glycerol, propylene glycol, polydextrose
Leavening agents	Help dough or batter rise, resulting in light and airy textures	Ammonium bi-carbonate, ammonium carbonate.

Category	Function	Chemicals
	in baked goods.	
Acidity regulators	Used to control and adjust the acidity or alkalinity (pH level) of food products	Sodium fumarate, potassium malate, sodium hydroxide, acetic acid or lactic acid, tartaric acid, phosphoric acid.
Preservatives	Stop microbes from multiplying and spoiling the food.	Acetic acid, sodium benzoate, benzoic acid, natamycin, nisin, nitrates, nitrites, propionic acid, sorbic acid, sulfites and sulfur dioxide.
Propellants	Help propel food from a container	Nitrous oxide, propane, butane.
Stabilizers, thickeners and firming agents	Maintain even dispersion of food. Enhance texture and consistency	Pectin, gelatin, carrageenan, propylene glycol alginate.

2.2.3 Chemicals from Other Sources:

Furthermore, chemicals can leach from storage materials and cooking vessels, which can impact food safety and human health.

The extent of leaching depends on factors such as the type of materials used, the temperature of the food or liquid, and the duration of contact. Chemicals like bisphenols (including BPA), phthalates, perfluoroalkyl chemicals, perchlorate, vinyl chloride, acrylamide, caprolactam, 6-aminohexanoic acid, and aluminum can leach from storage cans and bottles, potentially causing health issues. Certain types of cookware, under specific conditions, can produce chemicals such as nickel, lead, cadmium, aluminum, PFOA, and PFAS, which have health concerns.

2.3 Impact of Chemical Residues on Human Health:

The presence of pesticide residues or other chemical additives in food does not automatically imply that it is hazardous to our health.

The toxic effects of these substances depend on their toxicological properties, the level of residues, and the extent of human exposure to those residues.

It is essential to recognize that the severity of health effects can vary widely, influenced by factors such as the type and concentration of the chemical, the duration and route of exposure (e.g., inhalation, ingestion, dermal contact) and individual susceptibility (e.g., age, genetics, underlying health conditions).

Here are some common impacts of chemical residues on human health:

- 1. Toxicity:** Chemical residues may contain toxic compounds that can harm human health, affecting various bodily systems and leading to acute or chronic health problems. For instance, exposure to pesticides in food can cause acute poisoning or contribute to long-term health issues.
- 2. Carcinogenicity:** Certain chemical residues present in pesticides, food additives, cooking, and packaging materials are either known or suspected carcinogens. Prolonged exposure to these substances can elevate the risk of developing cancer. Substances such as organophosphates, organochlorines, bisphenols, phthalates, acrylamide, polycyclic aromatic hydrocarbons, and certain herbicides fall into the category of potential carcinogens.
- 3. Endocrine Disruption:** Some chemical residues, like phthalates and bisphenols, are recognized as endocrine-disrupting chemicals (EDCs). These substances can interfere with the normal functioning of the endocrine system, which regulates hormones in the body. Such disruption can lead to a range of health problems, including reproductive and developmental issues, as well as other hormone-related disorders. Nitrates and nitrites can interfere with the thyroid, as well as with the blood's ability to deliver oxygen to the body. Glyphosate an active ingredient of herbicides has potential to interact with the endocrine system.
- 4. Neurological Effects:** Exposure to specific chemical residues, such as arsenic, lead, or mercury, can adversely affect the nervous system. Children are particularly vulnerable to these effects, which can result in developmental delays, learning disabilities, and behavioral problems. Some studies have suggested a potential link between long-term exposure to arsenic and an increased risk of developing Parkinson's disease, a

neurodegenerative disorder. The organophosphate, organochlorine and related pesticides act by binding to the enzyme acetylcholinesterase, disrupting nerve function, resulting in paralysis and may cause death.

5. **Respiratory Issues:** Certain chemicals used as preservatives in food and beverages can irritate the respiratory system and contribute to the development or worsening of respiratory conditions like asthma. Sulfite sensitivity or sulfite allergy is a well-documented condition. Sulfite-sensitive individuals with asthma may be at greater risk of experiencing asthma attacks or exacerbation of their symptoms when exposed to sulfites. Sulfites can irritate the respiratory tract and trigger Broncho-constriction in susceptible individuals.
6. **Allergic Reactions:** Certain chemical residues in food have the potential to trigger allergic reactions or sensitization in susceptible individuals. This can manifest as skin rashes, respiratory symptoms, or other allergic responses. Synthetic food additives, including artificial colors, flavors, and preservatives, have been associated with allergic reactions, especially in children.
7. **Reproductive and Developmental Effects:** Exposure to specific chemical residues during pregnancy can lead to adverse outcomes, including birth defects, preterm birth, and developmental delays in children. Phthalates, for example, can disrupt hormone balance in pregnant women and the developing fetus, leading to adverse reproductive outcomes.
8. **Immune System Effects:** Some chemical residues may weaken the immune system, making individuals more susceptible to infections or autoimmune diseases. Certain pesticides, particularly organophosphates and organochlorines, have been linked to immune suppression.
9. **Cardiovascular Health:** Several chemicals found in food have been associated with severe cardiovascular issues, including heart attacks and strokes. Substances like arsenic, phthalates, bisphenols, and artificial food additives have been investigated for their potential links to cardiovascular diseases.
10. **Gastrointestinal Problems:** Ingesting chemical residues in food can lead to gastrointestinal issues such as nausea, vomiting, and diarrhea. These symptoms can stem from various factors, including foodborne contaminants, food additives, or individual food intolerances. Some individuals may have heightened sensitivity to

specific chemicals or preservatives, which could result in discomfort in the gastrointestinal tract. Excessive consumption of disodium inosinate may lead to headaches, heartburn, and other digestive disturbances. Phosphoric acid, when ingested at high levels, has the potential to erode tooth enamel and cause irritation to the lining of the mouth and esophagus. Large quantities of xylitol can potentially result in liver toxicity.

It's important to note that while these impacts are possible, they may not occur in all individuals or under all circumstances. The level of risk varies based on factors such as the specific chemical, its concentration, and individual susceptibility.

2.4 Addressing The Issue:

Presence of chemical residues in food can be a concern for consumer health and safety. These residues can result from pesticides, herbicides, fungicides, antibiotics, growth hormones, and other chemicals used in agriculture and food preservation. To reduce or eliminate chemical residues in food, several remedies and preventive measures can be taken at domestic, cultivation and government levels.

2.4.1 Domestic Measures:

At the domestic level, one can take several specific actions to reduce or eliminate chemical residues in the food that we prepare and consume:

- 1. Wash Thoroughly:** Wash fruits and vegetables under running water, scrubbing them gently with a brush if necessary, to remove surface residues. Soaking them in a mixture of water and vinegar for a few minutes can help remove some residues.
- 2. Peel When Appropriate:** Consider peeling fruits and vegetables, as many residues are concentrated in or on the skin. However, keep in mind that peeling can also remove some of the nutrients.
- 3. Use Baking Soda:** For fruits and vegetables with thicker skins (like apples and cucumbers), we can use a solution of baking soda and water to remove residues. Soak for a few minutes and then rinse thoroughly.

4. **Grow Your Own:** If you have space and resources, consider growing your own fruits, vegetables, and herbs at home using organic practices. This gives you full control over what goes into your food.
5. **Choose Organic Foods:** Opt for organic foods, which are produced without synthetic pesticides and herbicides, reducing exposure to pesticide residues.
6. **Buy Locally and Seasonally:** Support local and seasonal produce, which may reduce the need for long-distance transportation and associated preservatives or packaging.
7. **Inclusion of Wild Edibles:** wild edibles wont contain any chemical residues hence use of locally and seasonally available wild foods will reduce pressure on crops.
8. **Limit Processed Foods:** Reduce consumption of highly processed foods, which often contain preservatives and packaging materials.
9. **Cook at Home:** Prepare meals at home to have more control over ingredients and cooking methods. Use safe cookware materials.
10. **Use Natural Cleaning Products:** Clean cooking vessels and kitchen surfaces with natural cleaning products.
11. **Avoid Microwaving Plastic:** Avoid microwaving food in plastic containers and opt for microwave-safe glass or ceramic containers.
12. **Read Food Labels:** Carefully read food labels to identify products with artificial additives and preservatives. Choose products with shorter ingredient lists and recognizable ingredients.
13. **Educate Your Family:** Teach family members about the importance of food safety and how to make informed choices about the food they eat.

By implementing these domestic-level strategies, we can reduce the risk of chemical residues in our daily meals and promote a healthier and more sustainable approach to food consumption within household.

2.4.2 Farm Level Remedies:

Farmers are pivotal players in the quest to reduce chemical residues in our food. Adopting sustainable and responsible agricultural practices is paramount. Here are some remedies and actions that farmers can take to mitigate the issue of chemical residues in food:

- a. Integrated Pest Management (IPM):** Implement IPM strategies, which focus on using a combination of biological controls, crop rotation, natural predators, and cultural practices to manage pests and diseases. This reduces the reliance on chemical pesticides.
- b. Proper Chemical Use:** If chemicals are necessary, use them judiciously and strictly adhere to recommended application rates, timing, and safety precautions. Follow label instructions and guidelines. Regularly inspect crops for signs of pests and diseases. Early detection can help minimize the need for chemical treatments.
- c. Natural and Organic Alternatives:** Explore natural and organic alternatives for pest and disease management, such as neem oil, diatomaceous earth, and beneficial nematodes.
- d. Compost and Organic Matter:** Improve soil health by adding compost and organic matter. Healthy soils are better able to resist pests and diseases, reducing the need for chemicals.
- e. Safe Storage:** Store food grains properly without using chemicals. Proper drying of seeds and use of natural insect repellants will be useful.
- f. Training and Education:** Ensure that farm workers are properly trained in the safe handling and application of chemicals. Promote awareness of the potential risks associated with chemical residues.
- g. Soil Testing:** Conduct regular soil testing to determine nutrient levels and pH. Properly balanced soil can reduce the need for chemical fertilizers.
- h. Seek Expert Advice:** Consult with agricultural extension services, agronomists, and experts who can provide guidance on sustainable and chemical-free farming practices.

Farmers play a pivotal role in reducing chemical residues in food by adopting responsible and sustainable agricultural practices. These actions not only contribute to food safety but also promote environmental sustainability and long-term farm viability.

2.4.3 Government Involvement:

At the government level, addressing the presence of chemical residues in food involves the development and implementation of policies, regulations, and enforcement mechanisms to safeguard public health and food safety.

A comprehensive approach includes the following key measures:

- a. **Stringent Regulation:** Governments should establish and enforce strict regulations governing the use of pesticides, herbicides, antibiotics, growth hormones, and other chemicals in agriculture and food processing. These regulations should specify allowable chemical limits and safety standards.
- b. **Monitoring and Testing:** Implement comprehensive monitoring and testing programs to regularly assess chemical residues in food products. This includes random sampling of food items in the market and testing for chemical contaminants.
- c. **Maximum Residue Limits (MRLs):** Strict enforcement of maximum residue limits (MRLs) for chemical substances in food products. MRLs are the maximum allowable concentrations of chemical residues in or on food commodities. These limits should be based on scientific assessments of safety.
- d. **Risk Assessment:** Conduct comprehensive risk assessments of pesticides and other chemicals used in agriculture to evaluate their long-term effects on human health and the environment.
- e. **Labeling and Transparency:** Require clear and informative labeling on food products to indicate the use of chemicals, pesticides, and genetically modified organisms (GMOs). Ensure that consumers have access to information about the food they purchase.
- f. **Support for Organic Farming:** Offer incentives and subsidies to farmers who adopt organic and sustainable farming practices. This encourages the reduction of chemical use.
- g. **Research Funding:** Allocate funding for research into safer and more sustainable agricultural practices, as well as the development of low-residue or residue-free alternatives to chemicals.
- h. **Public Awareness Campaigns:** Launch public awareness campaigns to educate consumers about the importance of safe food handling and the potential risks associated with chemical residues in food.
- i. **Food Safety Agencies:** Establish dedicated food safety agencies or strengthen existing ones to oversee and regulate food safety measures effectively.

- j. **Regular Reviews:** Periodically review and update food safety regulations to reflect advancements in scientific knowledge and changing circumstances.



Figure 2.2: Measures to Reduce Chemical Residues in Food

Government intervention and regulation are crucial for ensuring food safety and minimizing the presence of chemical residues in food. However, there can be challenges and shortcomings in the implementation and enforcement of these measures like weak enforcement, corruption, lack of awareness, resource constraints, global trade and import challenges, political pressure, etc. While complete elimination of chemical residues in food may be challenging, informed choices and advocacy for safer food production practices can help minimize potential health risks to individuals and the environment.

2.5 Conclusion:

In our exploration of the unseen culprits lurking in our food, we have uncovered a complex web of chemicals that infiltrate our diets at various stages of production, processing, and preservation. From the pesticides sprayed on crops to the additives used to extend shelf life,

these substances have become an integral part of our modern food system. However, the presence of these chemicals raises concerns about their potential impacts on human health. The chemicals we discussed encompass a wide range of categories, from pesticides and herbicides to food additives, packaging materials, and cookware. They find their way into our meals either intentionally or inadvertently.

While some of these chemicals serve vital roles in food production and preservation, they can also pose significant risks to our well-being when present in excessive quantities or when used carelessly. Our examination of the impact of chemical residues on human health reveals a sobering reality. These residues can lead to various health problems, including toxicity, carcinogenicity, endocrine disruption, neurological effects, respiratory issues, allergic reactions, reproductive and developmental effects, immune system effects, cardiovascular health concerns, and gastrointestinal problems. The severity of these effects can vary based on factors such as the type and concentration of the chemical, exposure duration, and individual susceptibility.

To address the issue of chemical residues in our food, we discussed remedies and preventive measures at domestic, farm, and government levels. At the domestic level, individuals can take steps to minimize their exposure to chemical residues by adopting practices such as washing fruits and vegetables thoroughly, choosing organic foods, and cooking at home. Farmers play a pivotal role in reducing chemical residues through sustainable agricultural practices and responsible chemical use. Finally, government involvement is essential to regulate and monitor the use of chemicals, establish maximum residue limits, support organic farming, and raise public awareness.

In conclusion, the presence of unseen chemicals in our food demands our attention and action. While complete elimination of chemical residues may be challenging, a collective effort to make informed choices, advocate for safer food production practices, and hold governments and industries accountable can help minimize potential health risks to individuals and the environment. As consumers, farmers, and policymakers, we all have a role to play in ensuring that the food on our plates is not only nourishing but also safe.