A Comprehensive Review of Plant Toxins

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***Abstract*—Plants typically produce toxins as metabolites to defend themselves against various threats, such as insects, predators, and microorganisms. These poisons are present in food plants. is a result of new or natural reproduction techniques that strengthen defenses. Roots, tubers, stems, fruits, buds, and foliage are among the plant parts that can have toxic effects. Many different kinds of plants contain natural toxins that can be consumed as food. If these are not cooked properly and are consumed in large quantities, food poisoning can result. When consumed, these toxic substances have the potential to be detrimental to human health. Any herbivore can be killed or seriously harmed by phytotoxins produced by certain plants. For example, harmful proteins that help protect against insects and infections. such as rRNA N-Glycosidase and resin, which may be employed as biothreat agents. They can be altered to demonstrate enhanced efficacy and affinity for health endorsement. A number of these plants are frequently eaten as food. They evolved as a self-defense evolutionary movement. When consumed in large quantities, these toxic substances can be uncomfortable and detrimental to human health.**

***Index Terms*—plant toxins; effects, occurrence of plant toxins, and plant toxicology.**

I. INTRODUCTION

These are metabolites that plants produce to defend themselves against different threats, such as bacteria and fungi that strengthen these defenses. Because of their phytochemicals, plants frequently cause medical dilemmas. The various species of flowering plants vary. not just in terms of profile but also in terms of infinite biochemical properties. In addition to compensating animal pollinators and distributors, the phytochemical substances also served to shield them from potentially dangerous animals. However, certain phytochemicals or secondary metabolites that plants produce have properties similar to those of extracellular bacterial toxins and can be harmful to humans.[1] Both humans and animals can benefit from these as well as suffer from them. The issues side effects that range widely, from neurological syndromes to skin irritation. Toxins from plants can enter the body through contact, ingestion, or inhalation. Their phytoconstituents, such as proteins, alkaloids, glycosides, tannins, volatile oils, terpenes, steroids, etc., are primarily responsible for the action. Different specific mechanisms involving receptors, transporters, enzymes, and even genetic material at specific cells and tissues are how they work in the body of an animal or a human.[2] Depending on their Phyto-constituents, which include alkaloids, glycosides, proteins, tannins, volatile oils, terpenes, and steroids, plant toxins can enter the body through inhalation. Through a variety of distinct mechanisms involving receptors, transporters, enzymes, and even genetic material at particular cells and tissues, they racially alter the body of an animal or human. Some plants contain poisonous substances that are found throughout the entire plant. In others, they are found in one or more sections. The most crucial element is the dosages of these drugs.

Aim: -Studying the review of plant toxins

Objective

1. Plant poisons could be Many different types of plants today have evolved to produce natural products as a defense against microbes
2. The goal is to describe the toxicological effect that plants evolve to produce and the mode of action of plant toxins.
3. Using a natural product to protect against animals.
4. Toxins found in plants Many edible plants have nutritional value and are good for your health in addition to their negative effects.
5. This perspective provides an overview of the various mechanisms of action and toxicological effects of plant toxins.

II. REVIEW OF THE LITERATURE

Miguel R. et al. (2021)

Their phytoconstituents, such as proteins, tannins, volatile oils, terpenes, steroids, alkaloids, and glycosides, are primarily responsible for the action. Using a variety of specific mechanisms that involve receptors, transporters, enzymes, and even genetic material at particular cells and tissues, they affect the body in both humans and animals. Depending on their Phyto-constituents, such as alkaloids, glycosides, proteins, tannins, volatile oils, terpenes, and steroids, plant toxins can enter the body through the respiratory system. They use different specific mechanisms to affect the human or animal body. involving particular cells and tissues' receptors, transporters, enzymes, and even genetic material.

Lewis et al. (2020)

Since ATP is necessary for all cellular and organ functions, this process, which occurs in mitochondria and produces ATP, is another vulnerable target in animals. This target can be attacked by a variety of plants and even some arthropods using HCN, which attaches to the terminal's icon ions. The mitochondrial respiratory chain forms cytochrome oxidase, which is beneficial but stored Plant vacuoles contain cyanogenic glycosides. Cellular compartmentation breaks down in injured plants, allowing the contents of the vacuoles to come into contact with cytosolic enzymes like §-glucosidase and nitriles, which hydrolyze the cyanogenic glucosides.

G. Ase1 et al. (2018)

In many cultures, medicinal plants and herbal remedies have been used extensively to treat a wide range of illnesses. In addition to their medicinal effectiveness. Certain medicinal plants are extremely toxic to humans, particularly to young people and the elderly. There have been few reports on the toxicities of natural products, despite the widespread belief that they are safe.

Eta1. Bourras (2015)

Through the stable integration of a DNA fragment known as T-DNA into the host genome, the pathogenic Agrobacteria employ genetic transformation of the host cell as an infection strategy. The host is oncogenically reprogrammed to the pathogens as a result of this genetic alteration.

White, l. et al. (2015)

Plants were the first known vectors for viruses, and research on virus species and their effects Numerous virus families are found in plants, and they are given general Numerous viruses have the ability to cause serious illnesses in a variety of plant foods.

Vargus T. et al. (2014)

For health endorsement, modify and implement enhanced infinity and efficiency. For self- defense, they have developed an evaluable movement. They can be altered to demonstrate enhanced efficacy and affinity for health endorsement. A number of these plants are frequently eaten as food. They evolved as a self-defense evolutionary movement. When consumed in large quantities, these toxic substances can have negative effects on human health. An overview of the various plant toxins, their modes of action, and the various toxicological effects they cause are provided in this review.

Wink M. et al. (2013)

A summary and discussion are provided of the molecular mechanisms of action of neurotoxins, cytotoxins, metabolic poisons, mutagens, and toxins that impact skin and mucosal tissue. significant poisonous Since European plants can supply lead compounds for the creation of natural pesticides against insects, slugs, or rodents, their toxins and toxicology are listed.

Plant Toxin Classification

Plant toxins are food ingredients derived from plants that may be toxic byproducts of secondary metabolism. Secondary metabolism products are defining factors that give plants their unique traits. Plant pigments, flavors, and compounds that protect plants are among them. When taken orally, some of these secondary metabolic products are toxic to the individual. These compounds could be teratogens, neurotoxins, or growth inhibitors.

Alkaloid:

These are basic organic compounds made from amino acids that contain nitrogen in a heterocyclic ring. The majority of them have high physiological activity. For instance, cocaine, toxins, nicotine, aconite, and colchicine's, among many others. [4].

Typical toxins from this class include:
Indole alkaloids: A hormone that acts on the central nervous system, similar to beta-carotene.

III. ZONETIME: LIVER VENGO DISEASE

L Tropane: active on the Autonomous Nervous System; contains atropine, scopolamine, and hyoscymine.

H. Glycoalkaloids: The acute toxicity of glycol alkaloids is the main cause for concern.
Numerous cases of human poisoning sometimes fatal caused by ingestion have been reported.
Tropane alkaloids, pyrrolizidine alkaloids, indole alkaloids, and opium are Examples of alkaloids.
Alkaloids, such as cocaine and Vicine alkaloids. Heart glycosides, goitrogenic glycosides, anthraquinone glycosides, mustard oil glycosides, saponin glycosides, and cyanogenetic
glycosides are examples of glucosidal toxins, Falcarinol, abrin, ricin, cicutoxin, gelonin, lectine, anisatin, oenotheatoxin etc. proteins, Antivitamins like thiaminases, Phytoestrogens like coumetarol. Volatile etheric layers such as Sauriol, Photo sensitizing substances including hype ricin.
Enzyme inhibitors like Cholinesterase inhibitors, Protease inhibitors, Amylase inhibitors. Others Include Lathy Rogens.

Plants	Pyrrolizidine alkaloids	Toxicity effects
Cynoglossum officinale	7-Angelylheliotridine, Echinatine, Acetylheliosupine and Helio supine	Anoresda, depression, diarrhea, photosensitivity, icterus, constipation, ascites and aberrant behavior
Senecio spp	Seneciphylline, Senecionine, Jacidine, Jacobine, Jacoline,	Hepatic Insufficiency, secondary photosensitization and central nervous system
	Jaconine, Jacozine and Retrorsine	derangement due to elevated blood ammonia
Senecio formosus	Retrorsine	Severe veno-occlusive liver disease in humans
Symphytum officinale	Lycopsamine, Echimidine and Lasiocarpine	Produce irreversible hepatic damage if ingested chronically as an herbal tea

Table: Pyrrolizidine alkaloids phyto materials and Toxic effects

Furocoumarins:
Numerous plants, including celery roots, citrus plants (lemon, lime, grapefruit, and bergamot), parsnips (which are closely related to carrots and parsley), and some medicinal plants, contain these toxins. Stress, such as physical harm to the plant, causes the release of furocoumarins, which are stress toxins. For those who are vulnerable, some of these toxins can result in gastrointestinal issues. Because furocoumarins are phototoxic, exposure to sunlight (UVA) can result in serious skin reactions.
Furocoumarins' toxic effects
Many plants contain furocoumarins that, when they come into contact with skin exposed to UVA light, can result in a phototoxic reaction. We refer to this as phytophotodermatitis. A burning
erythema appears several hours after exposure, and is followed by edema and the formation of vesicles or bullae.

Volatile oils:
Liquids called volatile oils are produced in specific oil glands, hairs, channels, or cells. All of them dissolve in alcohol. Some are emetic and irritant (causing blisters) at certain concentrations. Certain volatile oils have olfactory toxicity [6][7]. Certain plants use essential oils, which are fragrant compounds found in their specialized cells or glands, to both attract
pollinators and defend themselves against pests and predators. Stated differently, essential oils are a component of the plant's immune system. For instance, lavender oil and caraway seed oil.

The harmful effects of volatile oil: -
When essential oils are used improperly, they can cause negative side effects in people, including headaches, nausea, and skin irritation. Essential oils can cause functional damage to organs like the stomach and liver in animals and most likely in humans, so caution is usually needed if they are to be taken internally or applied to food products due to the potential cancer-causing effects of some of them. It may have an impact on the bloodstream through skin absorption.

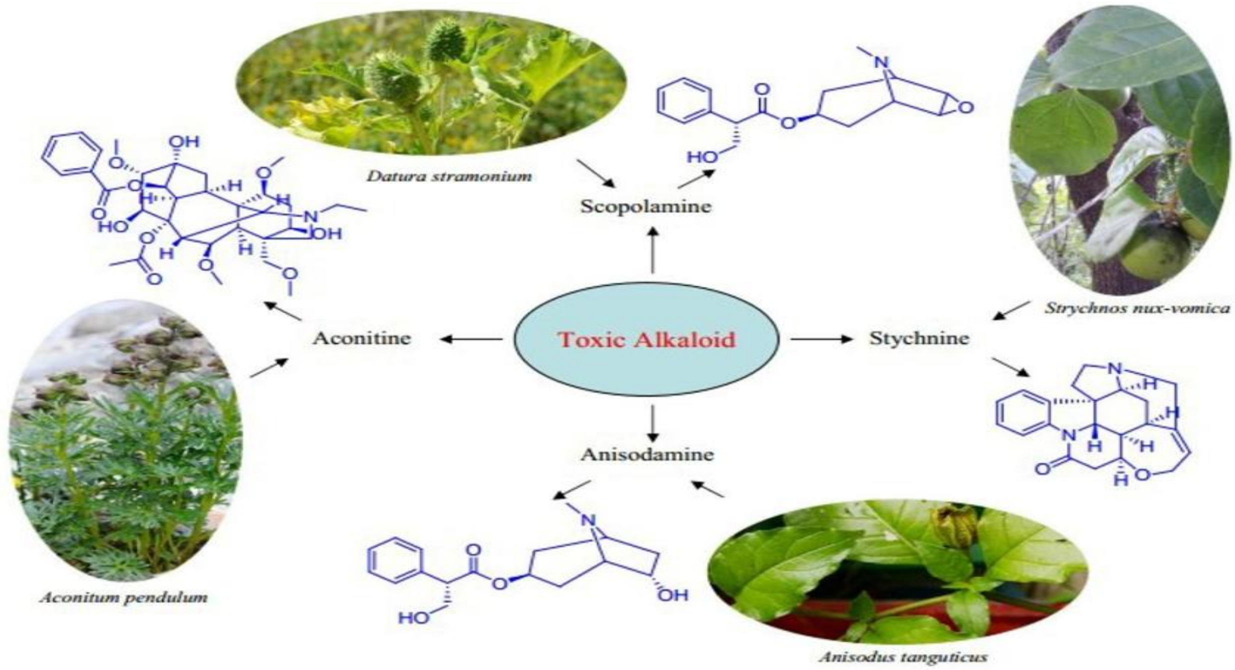
Chaconine and solanines:

Natural toxins known as solanines and chaconine, which are glycoalkaloids, are found in all Solanaceae plants, which include tomatoes, potatoes, and Eggplants.Although levels are typically low, green tomatoes, bitter-tasting peel, and potato sprouts have higher concentrations. [8] [9]

Stressors such as bruises, UV rays, microbes, and insect pest and herbivore attacks cause the plants to release toxins.

The harmful effects of chaconine and solanines: -

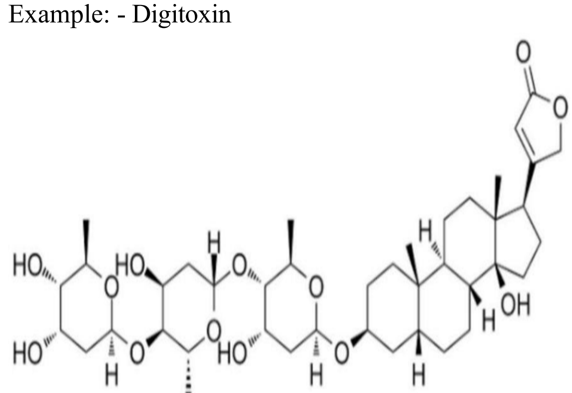
Neurotoxic and gastrointestinal impacts Ingestion of greened or otherwise damaged potatoes has been linked to numerous documented cases of human poisoning, which can occasionally be fatal. Low-grade solanine poisoning manifests as severe abdominal pain, vomiting, and acute gastrointestinal distress with diarrhea. Heart dysrhythmia, nightmares, headaches, lightheadedness, itching, eczema, thyroid issues, and joint pain and inflammation can all result from it.



Glycoside: -

These compounds are made up of an aglycone, or on-sugar moiety, to which one or more sugar chains are attached. Cyanogenic glycosides release prussic acid. By binding to mitochondrial cytochrome oxidase, the cyanide ions (CN-) prevent electron transport. Rapid breathing, a drop in blood pressure, fast heartbeat, headache, nausea, vomiting, diarrhea, mental confusion, stupor, and cyanosis with twitches and convulsions followed by terminations, like Digitoxin from fox gloves, are some of the clinical signs of acute cyanide poisoning. Digoxin inhibits the Na-ATPase enzyme. The main symptoms include vomiting, disorientation, changes in color perception, and especially cardiac arrhythmias. Thyroid issues may result from a lack of iodine. Cardiac glycosides, like foxglove's digitoxin.

Example: - Digitoxin



Structure of Digitoxin

Tannins: -

Plants contain tannins in large quantities, which are found in the cell sap in solution, frequently in separate vacuoles. These substances possess the ability to precipitate proteins. By tricking the skin's proteins, they make the skin tough. Plants use tannins as a defense mechanism against harmful environmental conditions, herbivores, and infections. When ingested, tannins typically cause a negative reaction. A delayed reaction linked to an antinutritional or toxic effect is possible, as are immediate effects like astringency or a bitter or disagreeable taste.

Tannins' toxic effects:

Consumption of foods high in tannins, like betel nuts and herbal teas, has been linked to incidences of some cancers, including esophageal cancer, indicating that tannins may be carcinogenic

Proteins: -

To deal with adverse conditions, plants have evolved to produce a wide range of toxic substances, including a sizable class of toxic proteins that are essential to their defense against microorganisms and predators. Numerous toxic proteins, such as lectins, ribosome-inactivating proteins, protease inhibitors, ureases, arcelins, antimicrobial peptides, and pore-forming toxins, have so far been identified in various plants. Plants produce a variety of toxins that enter eukaryotic cells and prevent the synthesis of proteins. Using enzymes White acacia, abrin (rosary pea), and ricin (castor plant) are a few examples of toxic proteins. A toxic amino acid that mimics glutamate is the cause of lathyrism.

Proteins' toxic effects:

When waste products from protein metabolism accumulate in the body, protein toxicity results. Nitrogenous wastes like urea, uric acid, ammonia, and creatinine are created during the metabolism of proteins. When there is protein toxicity, these substances build up in the kidney and cause kidney damage. Serious side effects like seizures, encephalopathy, additional kidney damage, and even death can result from untreated protein toxicity.

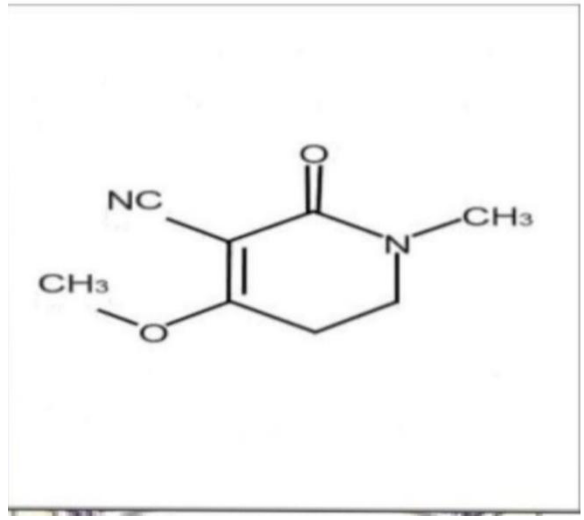


Fig:- Structure of Racin

Oxalate and oxalic acid:

Many plants, including leafy greens, fruits, vegetables, cocoa, nuts, and seeds, contain the organic compound oxalic acid. It typically forms oxalate in plants when it binds to minerals. In nutrition science, "oxalate" and "oxalic acid" are interchangeable terms. These compounds could be found in raphide (a structure resembling a needle) or trichrome. They have the potential to cause mechanical irritation. Oxalate that is consumed will be absorbed. Blood oxalate forms the insoluble calcium oxalate by binding calcium.

Oxalic acid and oxalate's toxic effects:-

Insoluble calcium oxalate is created when soluble oxalate binds to calcium ions and enters the bloodstream. Numerous pathological alterations take place, and the animal may experience: Animals with hypocalcemia, which affects normal cell membrane function, experience muscle weakness and tremors before collapsing and dying. Chronic oral consumption causes kidney damage and abnormalities in calcium metabolism in animals.

Toxic mushrooms:

A number of toxins, including muscimol and muscarine, which are found in wild mushrooms, can cause symptoms to appear 6–24 hours or a month after consumption.

A variety of chemicals found in wild mushrooms can have a major negative impact on a consumer's health, leading to permanent organ damage or even death [26]. There have occasionally been reports of such tragic outcomes in many cultures that consume mushrooms. Muscarine is a toxin found in mushrooms that can impact the autonomic nervous system's sweat gland and smooth muscle receptors. People who eat mushrooms high in muscarine primarily experience excessive perspiration. Amatoxins are cyclic octapeptides. Amatoxins are strong toxins that are special in that they do not cause any symptoms of poisoning for 6 to 48 hours (on average, 6 to 15 hours) after ingestion.

The harmful effects of poisonous mushrooms: -
At first, the symptoms, which include watery diarrhea, vomiting, and abdominal pain, resemble a serious gut infection. Increased salivation, sweating, and tearing are other symptoms of muscarine poisoning. Within 15 to 30 minutes of eating the mushrooms, breathing difficulties, nausea, diarrhea, and abdominal pain follow. While some mushroom toxins can result in muscle or renal damage, others can cause drunken symptoms, illusions, hallucinations, or even convulsions. whereas only after consuming alcohol together can one of them produce symptoms.

Fig: - Poisonous Mushroom

Cynotoxin: Many different types of planktonic cyanobacteria are capable of producing cyanotoxins. Microcystis, Dolichospermum (formerly Anabaena), and Planktothrix are a few of the most prevalent genera. The most prevalent genus that forms blooms is Microcystis, which is nearly always toxic.
1. Due to their significant cellular function, many constituents are considered cytotoxins.
These substances, which are involved in the import and export of metabolites in cells, are primarily targeted at bio membranes.

1. Both biosynthesis-related substances, including lectins, metine, amanitas, and alkaloids, can significantly impair membrane fluidity and integrity. These toxins can attach to cells by their 8-chain, the haptomer, whereas the A-chain is taken up by endocytosis into the cytosol, Animal cells are particularly vulnerable where it inhibits biosynthesis53. On, particularly microtubules that function in filaments.
2. Because they disrupt vital cellular processes, a number of poisons can be classified as cytotoxins. Bio membranes are a key target in this situation.

Cynotoxins' toxic effects:
Toxins produced by cyanobacteria can have an impact on different body parts. Toxins that harm the liver (hepatotoxins), the central nervous system (neurotoxins), and the renal and gastrointestinal tract (toxic alkaloids) can all be produced by various cyanobacteria species. [31] [32] where biosynthesis53 is blocked. Animal cells are particularly vulnerable to microtubules, which act in filaments. Because they disrupt vital cellular processes, a number of poisons can be classified as cytotoxins.

Lectins: -Lectins are proteins that specifically bind to carbohydrates, particularly the
carbohydrate components of glycoproteins present on the surfaces of most animal cells. They are present in a diverse array of vegetables. Plant lectins that are resistant to degradation by digestive enzymes and exhibit affinity for the surface of gut epithelial cells, particularly those found in the Leguminosae family,

1. Numerous varieties of beans possess toxins known as lectins, with red kidney beans exhibiting the highest concentrations.
2. Consuming as few as 4 or 5 raw beans can induce severe abdominal pain, vomiting, and diarrhea.
3. Lectins are eliminated when dried beans are soaked for a minimum of 12 hours and subsequently boiled vigorously for at least 10 minutes in water.
4. Tinned kidney beans have undergone this process and can be utilized without additional preparation.

Adverse effects of lectins

Highly publicized reports indicate that individuals experience severe reactions after consuming even minimal quantities of raw or undercooked kidney beans. They encompass phytohemagglutinin, a specific form of lectin that possesses the capability to induce aggregation of red blood cells. It may also induce nausea, vomiting, gastrointestinal distress, and diarrhea.

Research involving animals and cells has demonstrated that active lectins can disrupt the absorption of minerals, particularly calcium, iron, phosphorus, and zinc.

IV. TOXINS IN PLANT PARASITE INTERACTIONS

1.Non-host-specific toxins:

Non-host-specific toxins typically exhibit mild phytotoxic effects, impact a wide range of plant species, and are considered a contributing factor to disease in conjunction with penetration mechanisms and enzymatic processes [38]. For example, fungi produce non-host-specific toxins including tentoxin (TEN), alternaric acid, alternariol (AOH), alternariol 9-monomethyl ether (AME), brefeldin A (dehydro-), alternuene (ALT), Altertoxin-I, and Altertoxin-II.

Toxins specific to hosts:

a category of structurally intricate and chemically varied metabolites generated by plant pathogenic strains of specific fungal species, serve as crucial factors of pathogenicity or virulence. For example. Classical HST pathogens comprise species of Cochliobolus, Alternaria, and Pyrophore. Recent research has demonstrated that Stagonosporanodorum generates a minimum of four distinct HSTs that engage with four of the numerous quantitative resistance loci present in the host, wheat.

Mechanism of plant toxins:

Neurotoxins:

1. The neuroactive alkaloids can act as antagonists, which would block a particular neuroreceptor, or agonists, which would excite a neuroreceptor. Another important target for alkaloids like glutamate, acetylcholine, dopamine, noradrenalin, and adrenaline is receptors on neuronal cells.
2. Some of the enzymes that degrade neurotoxins also affect the channels that represent neuronal signals, including the Na+, K+, and Ca2+ channels, either permanently activating or deactivating them. These actions halt the transmission of neuronal
3. The sodium-potassium ion ATPase, a crucial ion pump in neurons and other cells that keeps an ion gradient vital for transport and action potentials.

Cellular respiration-inhibitors:

1. Since ATP is necessary for all cellular and organ function, cellular respiration, which takes place in mitochondria and produces ATP, is another vulnerable target in animals.
2. A variety of plant toxins can target this target by binding to iron ions of the terminal cytochrome oxidase in the mitochondrial respiratory chain 53,54. HCN is not found in a free form; instead, it is stored in plant cell vacuoles as cyanogenic glucosides.
3. When plants are injured, the gas inside the vacuole comes into contact with enzymes like nitriles and §-glucosides because the cellular matrix has ruptured.

The hydrolysis of these enzymes Highly poisonous HCN is released by cyanogenic glucosides.

Toxicological effects of plant toxins: General Toxicity Phyto dermatitis & phyto-photodermatitis:

1. When exposed to ultraviolet light, certain compounds released by plants cause irritation to the skin. Mangos and numerous other trees are known to irritate skin.
2. Another name for phytophotodermatitis is dermatitis. These skin lesions resemble burns. There is a lag between skin contact and the onset of irritation symptoms.

Food poisoning:

1. Food poisoning caused by plant toxins, primarily from eating partially raked beans, some types of potatoes, and wild herbs that are not intended for human consumption, like toxic mushrooms and berries. Because the symptoms of toxicity can be rather vague, cases of acute poisoning brought on by plant toxins are sometimes disregarded. In the past, microorganisms have been identified as the

cause of acute poisoning caused by high consumption of glycoalkaloids, such as solanine, from potatoes.
2. Natural toxins are a major health risk to both people and animals, and they can have a number of negative health effects. Some of these poisons are very strong.
3. Acute poisoning can have negative health effects, such as allergic reactions, severe diarrhea and stomachaches, and even death.
4. Long-term health repercussions include cancer as well as impacts on the immune, reproductive, or neurological systems.

Fig: - Symptoms of food poisoning

V. PHYTO ALLERGY

1. A common symptom of a phyto allergy is a high fever brought on by pollen from ragweed, birch, hazel, timothy grass, and rye grass.
2. Other known allergy conditions caused by phytoconstituents include urticarial, which is caused by eating strawberries, and peanut allergy.
3. Certain types of extrinsic allergic alveoli are brought on by specific phytoconstituents. Allergies to pyrethrum are well-known. Every spring, the Japanese cedar (Cryptomeria japonica) produces enormous amounts of extremely allergenic pollen, which causes yearly suffering.
4. In recent decades, the problem of photoallergies has significantly increased. In areas where poison ivy (Rhus toxic odendron, T. rydbergii), poison oak (Rhus Juglandifolia), and poison sumac (Rhus vernix) are found, an alternative allergic mechanism takes place.

Fig: Phyto-allergy from exposure to lime juice

VI. CONCLUSION

In addition to their detrimental effects, plant toxins are widely present in edible plants. These compounds could be proteins, tannins, glycosides, or alkaloids. These poisons are linked to a number of illnesses and could pose a threat as bioterrorism weapons. Nevertheless, it is an excellent tool for studying cellular and other mechanisms, and a better understanding of plant toxins could lead to the development of new medical products. Plants and their natural enemies interact and evolve together. The environment in which a plant grows is extremely competitive. It is constantly in danger from microorganisms, insects, large and small herbivores that are mammals, birds, or reptiles, as well as from other plants that are encroaching on the area from which it obtains its sustenance.

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