NEW APPROACH ON

AGRICULTURE, FORESTRY, HORTICULTURE AND FISHERY

(Research and Applied)

Editor

Dr. Debabrata Das

Kripa Drishti Publications, Pune.

NEW APPROACH ON AGRICULTURE, FORESTRY, HORTICULTURE AND FISHERY (RESEARCH AND APPLIED)

Editor

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Role of Secondary Metabolite in Plant Defense

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1.1 Introduction:

Plants face an enormous number of enemies and therefore have evolved stacks of defense mechanisms by which they are able to tackle various kinds of abiotic and biotic stress like fungi, bacteria, viruses, parasites, weeds, and insects. To overcome the biotic and abiotic stresses they have evolved multiple mechanisms of defense. These stresses result in abnormal physiology of the plant which impairs the plant's normal growth, structure, and functions. For accommodating these changes in their fluctuating growth conditions and for better functional flexibility under the influence of various abiotic factors without impacting various physiological and biochemical processes plants have developed numerous mechanisms by producing a repertoire of metabolites in response to changing environment that plays a variety of roles (Yang *et. al.*, 2018). Metabolites are the intermediates and end products of various metabolic processes. The plant produces a vast and diverse assortment of organic molecules, which are classified into two major groups: primary and secondary metabolites. Primary metabolites are intermediate or end products of all living systems, essential for the growth and life of plants. Secondary metabolites are products that do not significantly participate in the direct growth and development of the plant. Their absence does not result in the death of the plants, unlike primary metabolites. These bioactive compounds are used in pharmaceuticals, flavorings, and agrochemical industries.

Humans have been using these metabolites as a source of medicines and drugs for the treatment of many human diseases. Studies on bioactive metabolites have shown their nutritional value in food and flavoring industries. The natural products of plants have shown prominent antimicrobial activity in many in-vitro studies. They provide protection against pests, pathogens, and herbivores some of them also are involved in defense against abiotic stresses (e.g. UV radiations) (Schafer *et al.*, 2009). Plant are able of synthesizing secondary metabolites, like phenols, terpenes, alkaloids, cyanogenic glycosides, tannins, and flavonoids (Cowan, 1999). Phenolics, like thymol, eugenol and carvacrol are highly bioactive compounds against pathogenic microbes.

These compounds show defensive properties against pathogenic microorganisms due to their toxicity and repellency. Allicin is a volatile antimicrobial compound found in garlic and its accumulation increases rapidly when the garlic tissues are damaged by biotic factors. Allicin was found effective to control many seed-borne pathogens like *Alternaria* spp. in carrot, leaf blight of tomato caused by *Phytophthora*, *Magnapor the* on rice, downy mildew of *Arabidopsis thaliana,* and tuber blight of potato by *Alternaria solani* (Slusarenko *et. al.,* 2008). Various metabolites are also effective to control post-harvest diseases. Phytochemicals also have antiviral properties. Anti-viral proteins (AVP) are found in extracts of *Prosopis chilinesis* and *Bougainvillea spectabilis* were effective to manage the sunflower necrosis virus (SFNV) of sunflower and cowpea (Lavanya *et. al.,* 2009). The current focus is to search for biological properties of new phytochemicals or natural bioactive products for antibiotics, medicines, insecticides, herbicides, and fungicides production.

1.2 Plant Secondary Metabolites:

Secondary metabolites can be broadly divided into four major classes: Terpenes, Phenolics, Alkaloids, and Glycosides.

1.2.1 Terpenes:

The terpenes comprise a large class of secondary natural products. All terpenes are derived from the union of five carbon elements that have the branched carbon skeleton of isopentane. The plant produces a wide range of different terpenes structures as a secondary metabolite that are believed to be involved in defense against plant-feeding herbivores, insects, and mammals as toxins and feeding deterrents (Gershenzon,1991). The mode of defense can be either directly or indirectly. Accumulation of phytochemicals that have antimicrobial activities can be included in the direct mode of defense. In response to various biotic stress i.e., fungal or bacterial infection antimicrobial compounds such as phytoalexins are synthesized as part of plant defense. Phytoalexins are a low-molecular-weight chemical compound that accumulates at the site of infection that help in limiting the spread of the pathogen. Few plants produce phytoalexins such as diterpenes and sesquiterpenes e.g. In *Oryza sativa* 14 different diterpenes phytoalexins have been investigated which can be grouped into four types- oryzalexin A-F (Peters, 2006), monilactones A and B and oryzalexin S (Tamongani and Mitani, 1993). In papaya fruit, a phytoalexin Danielone is found against a pathogenic fungus *Colletotrichum gloesporioides*, which exhibits high antifungal activity.

The indirect mode of defense is indicated by their ability to defend plants against herbivores by enhancing the effectiveness of natural enemies of the herbivores. Certain monoterpenes and sesquiterpenes are produced by corn, wild tobacco, cotton, and other species, released only after tissues damaged due to insect feeding. Terpenes play an important defensive role in plants due to their toxicity and deterrent nature toward plant-feeding insects and mammals (Gershenzon, 1991). Like, Pyrethroids a monoterpenoid ester, found in the flowers and leaves of Chrysanthemum species have insecticidal properties. Both natural and synthetic pyrethroids have negligible toxicity to mammals and very low persistence in the environment so they are highly demanding ingredients in commercial insecticides.

1.2.2 Phenolic Compounds:

Phenolics are chemical compounds that contain a phenol group or hydroxyl substituents on an aromatic ring. They probably constitute the most abundant and largest group of secondary metabolites and are usually found as esters or glycosides rather than as free compounds. Phenolics play a variety of roles in plants. They are involved in the defense against UV-radiation. They contribute significantly as defense compounds against herbivores and pathogens. Phenolic compounds are primarily synthesized from the product of the Shikimic Acid Pathway. Most of the phenolic compounds in plant-derived from the deamination of phenylalanine to cinnamic acid. This conversion is catalyzed by phenylalanine ammonia-lyase (PAL).

A. Lignin:

It is a branched polymer of phenylpropanoid groups. After cellulose, it is second most abundant substance present in secondary cell walls of xylem tracheary elements. It provides physical toughness and chemical durability rigidity to plants and acts as a physical barrier to herbivores and rigid to pathogens and insects. It has been reported that lignification blocks the invasion and growth of pathogens and is a defense response by plants to infecting or wounding pests. Monolignol biosynthesis in wheat plays an important role in cell wall apposition (CWA)-mediated defense against penetration of powdery mildew fungus into wheat (Bhuiyan et.al. 2009). In wheat monolignol genes led to the high susceptibility of wheat leaf tissues to an appropriate pathogen, Blumeria graminis f. sptritici, and compromised penetration resistance to a non-appropriate pathogen, B. graminis f. sp. hordei.

B. Flavonoids:

More than 5000 different flavonoids are known and they constitute a diverse class of natural phytochemicals present in all plant species. A flavanone Sakuranetin is found manily in Polymnia fruticosa and Oryza sativa, where it acts as a phytoalexin to inhibit the spore germination of Pyricularia oryzae (Kodama et. al., 1992). A Study by Wuyts (2006) shows that flavonoids can inhibit egg hatching of plant parasitic nematodes in the egg stages kaempferol, a flavonoid that inhibited the egg hatching of burrowing nematode Radopholus similis. For plant parasitic juveniles, flavonoids (1) Induces quiescence by Slowing down their movement resulting in periods of reversible inactivity (2) Repel them by modifying their migration (3) sometimes kill

Them. At micromolar concentrations the flavonols kaempferol, quercetin, and myricetin repelled and slowed the movement of root-knot nematode *M. incognita* juveniles. At various duration of exposure and concentration Patuletin, patulitrin, quercetin, and rutin killed the juveniles of cyst nematode *Heterodera zeae* (Faizi *et. al.*, 2011).

1.2.3 Tanins:

They are second category of phenolic polymers, besides lignins which provide toughness and rigidity to plants. It has been reported that pigmented red onions are resistant to fungus *Colletotrichum circinans* cause of onion smudge due to presence of catechol and protocatechuic acid in significant amount while white onions do not contain significant quantities of these phenolic compounds so are susceptible to onion smudge. Catechol and protocatechuic acid show defensive properties in onion against smudge disease (Walker, 1923).

1.3 Nitrogen Containing Metabolite:

This category includes alkaloids and cyanogenic glycosides.

1.3.1 Alkaloids:

Approximately 20% species of vascular plants synthesizes nitrogen containing secondary metabolites. They are one of the diverse and largest metabolites (Hegnauer *et al.*, 1988). Due to their high toxicity, they are efficient against pathogens and predators and acts as defense compound in plants. Poulton (1990) found that dhurrin, a nitrogenous alkaloid, present in sorghum is highly effective against soilborne pathogens. It has been reported berberine induces crop resistance in the greenhouse conditions against TMV, *Blumeria graminis, Botrytis cinerea, and Phytophthora nicotianae*. It induces immune responses, including an increase in defense enzymes, accumulation of H2O2, hypersenstivity response, upregulation of salicylic acid (SA) biosynthesis, and high accumulation of pathogenesis-related (PR) protein

1.3.2 Glycoside:

A glycoside is a molecule in which a carbohydrate (sugar) is bound to a non-carbohydrate moiety containing a hydroxyl group by a glycosidic bond. Three most important glycoside are saponins, cyanogenic glycosides and Glucosinolates. Cyanogenic glycosides are a particularly toxic class of nitrogenous compound. They are bioactive plant product have protective function in plants. These are natural source of HCN. On enzymatic hydrolysis cyanogen glycosides yield the aglycone (that is an alpha-hydroxynitrile) and the sugar moiety.

The plant produces cynogenic glycosides and also produces enzymes that convert these compounds into hydrogen cyanide, including glycosidases and hydroxyl nitrile lyases. The breakdown of cyanogenic glycosides releases HCN, which inhibits the activity of iron-containing cytochrome oxidase. It has been reported in rice HCN inhibits hyphal growth of *Magnaporthe grisea*, a blast fungus of rice to protect against fungal attacks.

A cyanogenic glycoside Amygdalin is found in excessive amounts in seeds and kernels of almonds, cherries, peaches, apples, and apricot (Nahrstedt, 1972; Jones, 1957) and is also abundant in seeds of plums. In sorghum Dhurrin a glycoside accumulates in vacuoles of epidermal cells, in response to attack or damage by insects, and herbivores. It has been reported transgenic that sorghum was severely attacked by herbivores and insects, since it cannot produce dhurrin while in wild-type varieties of sorghum dhurrin accumulate at the site of damage (Krothapalli *et al.,* 2013).

Glucosinolates are immensely found in the Brassicaceae family also known as mustard oil glycosides and break down to release defensive substances. In unfavorable environmental stimuli and other biotic stresses, they rapidly breakdown to release defensive substances isothiocyanates by enzyme beta-thioglucoside glucohydrolases (TGGs), also known as myrosinases (Andreasson et.al. 2001; Husebye et.al. 2002). Due to serve infection of white rust and club roots in and Indian mustard roots and Broccoli there is an accumulation of glucosinolates in excessive amounts (Islam, 2009). In *Arabidopsis thaliana* non-host resistance against bitrophic fungi is enhanced by glucosinolates derived from tryptophan. (Sanchez *et al.,* 2010). Also, *Arabidopsis thaliana* establish disease resistance to *Phytophthora brassicae* in response to this pathogen plant induces genes which encode for enzymes involved in biosynthesis glucosinolates biosynthesis. Therefore, tryptophan-derived secondary metabolites establish disease resistance in Arabidopsis. The active metabolic products released in soil by degradation of Brassicaceous tissues is widely used to tentatively control soil-borne pests (Angus e*t al.,* 1994; Brown *et al.,* 1997).

Saponin are one of diverse groups of secondary metabolite widely found in plant kingdom to provide protection against pathogen and herbivores. Structurally saponins consists of steroid aglycone to which one or more sugar is attached. The aglycone part called sapogenin can be either a triterpene (C30) or steroid (C27), which is widely found in monocots and dicots. Their main role in plants is to dispense protection against attack by pest and pathogen. (Price *et al.,* 1987; Morrissey and Osbourn, 1999). A class of saponin triterpenoid have been reported from oats species. Oats contain four the aglycone part called sapogenin can be either a triterpene (C30) or steroid (C27), which is widely found in monocots and dicots.

Their main role in plants is to dispense protection against attack by pest and pathogen. Unique saponins, Avenacins A-1, B-1, A-2, and B-2 which are structurally related to each other (Crombie *et al.,* 1986). Among the four in extracts from roots of young oat plant Avenacin A-1 is present in plenteous amount constituting around 70% of the total avenacin content (Crombie and Crombie, 1984).

Saponins act on pathogen by the formation of micelles like complex with sterols in fungal membranes resulting in membrane perturbation and loss of membrane integrity. It has been reported oat confer resistance against “take-all disease” which is caused by *Gaeumannomyces graminis var. tritici,* a root-infecting fungus due to the presence of Avenacin (triterpenoid saponin). Even though the fungus *G. g. var. tritici* causes extreme yield losses in barley and wheat, which is unable to infect oats, and unlike the oat-attacking variety of *G. graminis, G. g.* var. *avenae,* it is relatively sensitive to avenacins. Therefore, resistance conferred by oats to *G. g. var. tritici* is attributed to presence of these saponins in oat roots (Turner, 1953).

1.4 Mode of Action of Secondary Metabolites:

They form covalent bond with free amino groups or sulfide group which results in loss of function or change in structure in three-dimensional structure of protein (Wink, 2008). Most of the secondary metabolites act on pathogens by inhibiting their enzymes, reproductive system and DNA alkylation, etc and also affect the physiological activities of the pathogen.

Phenolic compound results deformation of structure and function of membrane proteins which changes cell permeability of microbes which disturbs pH gradient, membrane bonded enzymes, ATP production, and substrate utilization for ATP production. The multitarget mechanisms of action of alkaloids are disruption of the outer membrane or cytoplasmic membrane and leakage of cell components, respiratory inhibition in aerobic pathogens, the Z-ring perturbation, and inhibition of cell division (Cushnie *et al.*, 2014).

Table 1.1: Mode of Action Different Secondary Metabolite

Sr. No	Secondary Metabolite	Mode Of Action
1	TERPENIODS AND ESSENTIALOIL	Membrane disruption
2	TANNINS	Bind to proteins, Inhibition of enzymes, substratedeprivation
3	PHENOLICS	Membrane disruption, substrate deprivation
4	PHELOLICS ACID	Bind to adhesins, complex with the cell wall, inactivate enzymes
5	FLAVANOIDS	Bind to adhesins, complex with cell wall, Inactivate enzymes
6	ALKALOIDS	Intercalate into cell wall, Z-ring perturbation, Respiratory inhibition
7	SAPONIN	Cell membrane disruption and cell component leakage

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Water Footprint Management in Agri-Food Industries

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Abstract:

Freshwater consumption in food processing industries is a significant factor affecting water resources and water environmental sustainability. Water footprint (WF), as a comprehensive assessment indicator, can be used to assess the consumptive water use in food processing industries. Industrial water management approaches can be divided into two parts: internal strategies and external strategies. At industrial level, water audit helps to find out actual water requirement at different processing stages. Similarly, if the water quality standards are adjusted to the particular process, water reuse can be more effective. Treated waste water can be use in different stages where it does not come in direct contact of food. Now a days, new technologies like use of infrared radiation, extracting water from crops, desalinization etc. also helpful to reduce water requirement. External strategies include both regulatory measures, such as gradually increasing water fees for increasing water volumes used, imposing specific water conservation taxes, incentives for green technologies etc. also require from government side. High innovation cost, low water pricing, lack of awareness are the main challenges, that why government support is require to improve water use efficiency.

Keywords: *Sustainability; water footprint; water reuse; green technologies; conservation taxes*

2.1 Introduction:

The need for food has increased due to the ever-increasing population growth, which has sped up change and led to an increase in the number of food manufacturers. In order to feed expanding populations (estimated to ~9 billion people by 2050), it was suggested during the 2009 World Summit on Food Security that global food production needed to increase by at least 70%. (FAO, 2009).

Water is necessary for food production, with agriculture alone using an estimated 70% of all freshwater extracted. Only 10% is used for domestic usage after an additional 20% is used in the production and processing sectors (UNFAO, 2012). (E.g. drinking water). According to studies, these pressures on freshwater will continue to rise as a result of a combination of socioeconomic demands, population growth, and climate change (SAB Miller and WWF, 2014).

Numerous indicators, including groundwater depletion, decreased river flow, and deteriorating water quality, show that present levels of water consumption in many regions of the world exceed sustainable levels (S.L. Postel, 2000). By 2030, it is predicted that worldwide water withdrawal would rise by 53%, from 4,500 billion m3/year to 6,900 billion m^3/year (McKinsey, 2009).

The globe is dealing with a difficult problem, as consumer demand for food is being driven by population increase, urbanization, and quickly rising economies (SAB Miller and WWF, 2014). More individuals are selecting western-style diets as a result of a growing middle class. These diets are heavy in fat, sugar, and protein, all of which require a lot of water to produce. Virtual water is the word used to describe the water used in the production of an agricultural or industrial product (D. Renault, 2002).

A person will ingest 2-4 L of water per day in addition to the 2,000–5,000 L of virtual water that is included in their daily meal. Water has a hidden cost in the food we consume. Water intake is significantly influenced by dietary choices. According to calculations of the water used in US meat production, raising beef takes 11 times more irrigated water than raising pork or poultry (G. Eshel., 2014).

There might be serious consequences, including increased food costs, food shortages, pollution, famine, social discontent, and geopolitical instability, if water consumption in the production of food and drink is not more effectively managed globally. In fact, it has been proposed that this may trigger a "global water war" (S. Goldenburg, 2014).

To determine if water usage is sustainable, it is necessary to examine water consumption in primary production systems and comprehend how it affects water availability. In order to lessen its consumption of water resources and decrease risk associated with water, the agrifood business has been compelled to adopt a responsible approach to developing water plans (T. Lambooy, 2011).

2.2 Water use in agri-food system:

The largest consumer of freshwater on earth is the agriculture industry. Similarly, one of the major uses of water is industry. With an increase in income, industrial water usage rises.

In low-income nations, industrial usage only makes for 2% of all freshwater withdrawals, but in high-income countries, industrial use may account for up to 43% of all water consumption. In certain high-income nations like Canada, France, Germany, the United Kingdom, and Switzerland, it may make up as much as 69–75% of all water usage (World Bank,2011) (Figure 2.1).

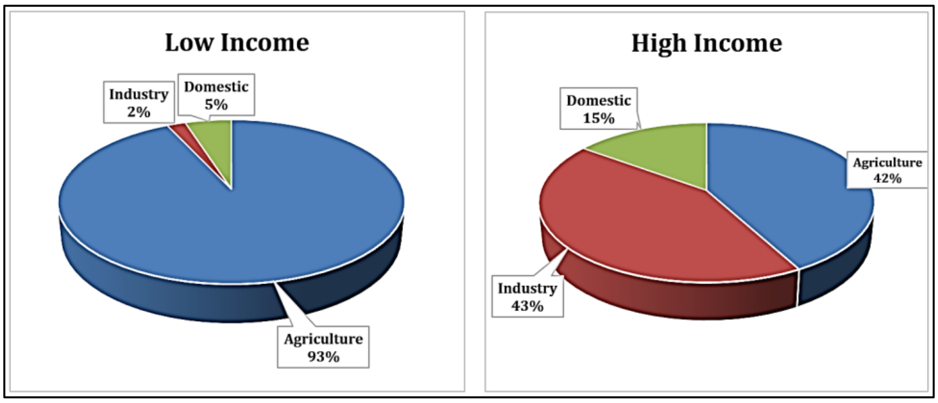

Figure. 2.1: The dependence of sectoral breakdown of annual freshwater withdrawals to income levels (Data obtained from World Bank, 2011)

The food processing sector, which comes in third after the chemical and refinery sectors, uses a lot of water. In certain specialized areas of the food business, sanitation procedures account for about 70% of all water usage (Henningsson et al., 2004). As a result, washing and sanitation procedures are a top priority in lowering the food industry's overall water use. Cooling and heating come in second, using 20% or more of the total water used in the food sector. Even in the brewing and soft drink industries, only 20 to 30% of the water used makes it into the final food product. Thus, in average, more than 70% of the total water utilized is released as effluent, which has significant quantities of fats, oils, and grease as well as biological oxygen demand (BOD) and chemical oxygen demand (COD) (FOG). The food and beverage business, out of all the other industries, contributes the most to the emissions of organic water pollutants. The food and beverage sector accounts for between 10 and 30 percent of all industrial emissions of organic water pollutants in high-income nations (World Bank, 2011) (Figure 2.2).

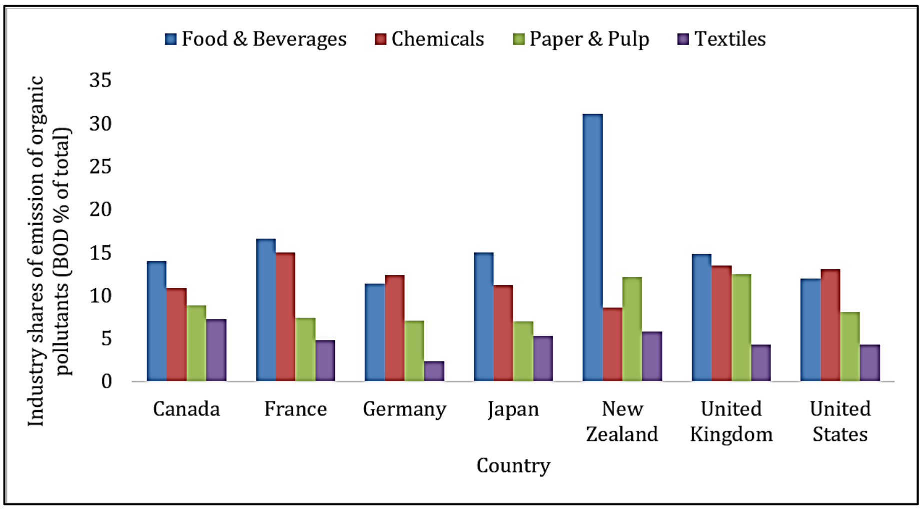

Figure 2.2: Industry shares of emission of organic pollutants (BOD % of total) (World Bank, 2011)

Wastewater from the food processing sector might have BOD and COD levels that are 10–100 times greater than home wastewater (FDM-BREF, 2006). The effluents from food processing factories have a significant influence on nearby water bodies because of the large organic load and high COD and BOD demand. The adoption of water conservation measures in the food business is significantly hampered by the laws governing food safety. The existing laws allow processors to recycle or reuse water as long as it doesn't endanger the finished product's safety or wholesomeness (Council Directive 98/83/EC). The meat, dairy, and vegetable processing industries are among the activities included in the European Commission (EC) Council Directive 96/61/EC on Integrated Pollution Prevention and Control (IPPC) that is laying out steps to decrease emissions in water. The organo-halogen chemicals, which are mostly linked to the use of chemical sanitizers, are included in the indicative list of the major pollutants. The need to develop eco-efficient innovative technologies that will help reduce water consumption and wastewater generation rates while also improving wastewater quality in the food industry is therefore necessary. Sustainable water use is one of the environmental challenges facing the food industry.

2.3 Water Consumption Reduction Strategies in the Food Processing Factories:

Food manufacturers have been lawfully adding water to their goods ever since the first foods were processed. In addition, water may be utilized for cleaning, transportation, and heat transfer. The effective use of water and the regulation of wastewater quality are the two key areas of attention for water management in the food sector. Since highly contaminated wastewater discharges, rather than water usage, are what have the greatest industrial impact on water resources, wastewater management and quality are of utmost importance.

Food firms may monitor their water usage and the effects of their goods on water resources by using the water footprint (WF), a tool that has been designed specifically for this purpose. The private sector may analyse risks and find hotspots in the supply chain using the information supplied by the WF. Food companies are now working very hard to reduce the amount of water used during processing since they stand to benefit greatly. Industrial water management approaches come in two flavours: internal strategies and external strategies (Grobicki, 2008).

2.3.1 Internal Strategies:

A. Water auditing:

A fraction of total water consumption is accounted for by leakage, some of which is the result of inaccurate metering, some of which is unauthoritative use, and some of which is water provided to consumers. A water audit identifies the locations and quantities of water usage. Depending on the data available on the system, the water audit's level of detail will change (Ganorkar et al., 2013).

One of the objectives of the water audit is to reduce physical losses caused by pipe leaks and overflows, losses from metering mistakes, unauthorised connections, and free water supplies given by the municipal authority for public stand posts and parks in the distribution system (Ganorkar et al., 2013).

B. Water reuse:

If the water quality standards are adjusted to the particular process, water reuse can be more effective. Examining key control points and determining the risk of food contamination are necessary in order to match the water quality criteria to the kind of water consumption. The water used for rinsing, for instance, may be transferred to the washing tanks and then used once more for the pre-washing procedure. As an alternative, receiving areas for raw materials might be cleansed using rinse water. These ideas put into practice might result in a 30% reduction in water use (Gil et al., 2009). As a result, when it is feasible, industrial water reuse should be integrated into existing HACCP systems in addition to creating a framework for water reuse in food production and processing (Figure 2.3).

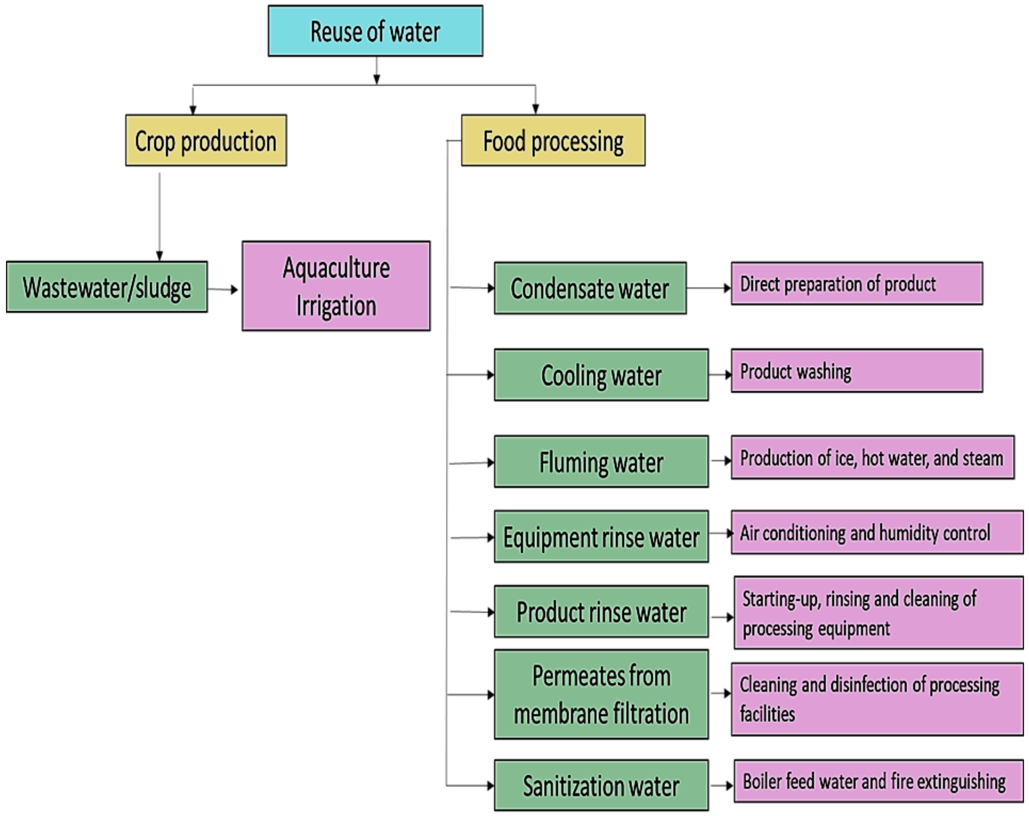

Figure 2.3: Water reuse in food and beverage production (Source: CODEX Alimentarius Commission, 2001)

C. Water recycle and reclamation:

Water reuse is described as the use of water in several processes where increasingly lower quality water is required, whereas recycling is the act of bringing treated water back into service after having been used before for a variety of purposes. Reusing wastewater produced elsewhere once it has been adequately cleaned is known as water reclamation, and it is one more way to increase industrial water efficiency.

If recycled water will come into contact with food or drink products or is used to clean surfaces that will come into contact with them, it will need to be treated to improve its quality (Table 2.1)

Table 2.1: Overview of representative unit processes and operations used in water reclamation (Ölmez, 2013).

Process	Description	Application
	1. **Solid/liquid separation**	
Sedimentation	Gravity sedimentation of particulate matter, chemical floc, and precipitates from suspension by gravity settling	Removal of particles from turbid water that are larger than 30 mm
Filtration	Particle removal by passing water through sand or other porous medium	Removal of particles from water that are larger than about 3mm. Frequently used after sedimentation or coagulation / flocculation
	2. Biological treatment (wastewater)	
Aerobic biological treatment	Biological metabolism of wastewater by microorganisms in an aeration basin or biofilm process	Biological metabolism of wastewater by microorganisms in an aeration basin or biofilm process
Biological nutrient removal	Combination of aerobic, anoxic, and anaerobic processes to optimize conversion of organic and ammonia nitrogen to molecular nitrogen (N_2) and removal of phosphorus	Reduction of nutrient content of reclaimed water
Waste stabilization ponds	Pond system consisting of anaerobic, facultative and maturation ponds linked in series to increase retention time	Reduction of suspended solids, BOD, pathogens, and ammonia from wastewater
Disinfection	The inactivation of pathogenic organisms using oxidizing chemicals, ultraviolet light, caustic chemicals, heat, or physical separation processes (e.g. membranes)	Protection of public health by removal of pathogenic organisms
	3. Advanced treatment	
Activated carbon	Process by which contaminants are physically adsorbed onto the surface of activated carbon	Removal of hydrophobic organic compounds
Air stripping	Transfer of ammonia and other volatile components from water to air	Removal of ammonia and some volatile organics from water

Process	Description	Application
Ion exchange	Exchange of ions between an exchange resin and water using a flow through reactor	Effective for removal of cations such as calcium, magnesium, iron, ammonium, and anions such as nitrate
Chemical coagulation and precipitation	Use of aluminium or iron salts, polyelectrolytes, and/or ozone to promote destabilization of colloidal particles from reclaimed water and precipitation of phosphorus	Removal of particles by sedimentation and filtration
Lime treatment	The use of lime to precipitate cations and metals from solution	Used to reduce scale-forming potential of water, precipitate phosphorus, and modify pH
Membrane filtration	Microfiltration, Nano filtration, ultrafiltration	Removal of particles and microorganisms from water
Reverse osmosis	Membrane system to separate ions and particles from solution based on reversing osmotic pressure differentials	Removal of dissolved salts and minerals from solution; also effective for pathogen removal

D. Implementation of best practices:

With little financial effort, simple operational and cultural changes may often cut water use by up to 30%. As a first step in reducing wastewater output at the processing plant, it is advised to do the washing, grading, and trimming of raw products in the field. Other useful strategies used by the sector include using air cooling rather than hydro cooling, switching from water to steam blanching, using multi-stage countercurrent washing systems, installing high-pressure cleanup systems for plant sanitation operations, reusing water in another processing step, and separating low and high-strength waste streams, among others.

Investment in Water-Efficient Technologies:

A. Extracting Water from Food:

One of the food production processes that use the least amount of water is the processing of sugar beets in Europe. A sugar beet typically contains 75% water, and this water is utilized to produce sugar. In the UK, the water utilized in manufacturing operations originates from the sugar beet itself in excess of 60% of the time (Sugar et al; 2011). After being cleaned on-site, the water used to make sugar from sugar beet is either released into nearby water sources or reused for agriculture. Grey water anaerobic digestion also yields biogas, which is subsequently usable as a thermal process fuel (CIBE and CEFS environmental report, 2003). This is a nice illustration of an integrated process created and applied using chemical engineering concepts. PepsiCo does the same thing by drawing water out of potatoes. Process water efficiency has increased by PepsiCo by more than 20% (Pepsico Water report, 2014). To extract water from potatoes before they are cooked to make crisps, chemical engineers have invented a technique. The business is able to capture water and reuse it throughout their plants thanks to thermodynamic technology (stack heat).

B. Rainwater Capture:

Green water, or rainwater, is frequently used in agriculture. Utilizing rainwater effectively is become more typical in the food production process.

C. Desalination:

Large-scale desalination of water requires a lot of energy and is not economically feasible for most nations. In dry areas (such as the Middle East), excessive groundwater use has led to a dependency on salt water desalination as a source of potable water for human use. Thermal energy (using phase-change processes) or electrical energy (powering membrane processes) are the two energy sources that enable water desalination, and both technologies are most suited to the individual needs (Al-Karaghouli et al., 2009).The feasibility of using desalinated water in the food business may be improved by new advancements that employ renewable solar and wind energy to power the desalination process. It is possible to treat water with solar thermal desalination by using a variety of chemical engineering techniques (eg distillation, separation and solar still methods). These technologies are still in the early stages of development and are pricey. However, there is a lot of promise.

D. New Innovative Technologies:

Now days, food processing industries give focus on development of innovative green technologies to reduce water requirement. For example, peeling of tomato with infrared dry peeling technology (Xuan Li et al., 2014), use of pulse light in salad industry (Manzocco et al., 2015), water reclamation from the sorting/grading operation in mandarin orange canning production (Wu et al., 2016), water footprint study in gazpacho soup (Ibáñez et al., 2017), reducing water footprint by changing diet and imported products (Mirzaie et al., 2020) etc. Government also provides incentives for green technologies which motivate researchers and food scientists to discover new technologies.

2.3.2 External Strategies:

External strategies include both regulatory measures, such as gradually increasing water fees for increasing water volumes used, imposing specific water conservation taxes on operations using more than a certain amount of water, and requiring pre-approval from local authorities for new factories anticipating more than a certain level of water consumption on a monthly or annual basis. Making decisions regarding purchasing water recycling and wastewater treatment systems involves weighing several costs, including those related to water supply and effluent discharge. Therefore, strict environmental laws will be crucial in promoting the creation and application of eco-innovative technology for responsible water use.

A major objective of the sector for sustainable water use is zero water discharge, which means that all wastewater effluents that would typically be released into the environment are treated, recycled, or sold to other users (Gorbicki, 2008; Bagajewicz, 2000). The idea is to reduce the amount of fresh water used in single- or multiple-contaminant systems in the industry (Koppol et al., 2003).

2.4 Challenges and opportunities:

The creation or adoption of eco-innovative procedures that would lessen the negative effects of the food industry on the environment and on natural resources, especially on water, is one of the major difficulties facing the food industry in ensuring its sustainability. When possible, water-based technologies should be replaced with "water-free technologies," and a well-proven systematic strategy to reducing water consumption during processing should be used to minimise water use and wastewater discharge in the food business.Nevertheless, there are a number of obstacles to boosting water efficiency in the food processing sector.

The first is the expense in terms of the amount of time and money required to put a water management strategy into action. The second is the low water pricing, which make investing in water management systems unreasonable from a cost-profit perspective (Wallis et al., 2007).

The food business has a vital potential to improve the efficiency of its water consumption through technological advancements. Due to technical advancements in the water-intensive sectors, it is anticipated that by 2030, the industry's water usage would have decreased by 25–36%, depending on the industry (Florke and Alcamo, 2004).

Government backing of technical advancements aimed at increasing water efficiency in business is crucial. This should encompass both support for the industry's adoption and investment in water-efficient technology, as well as funding for all relevant areas of research. The industrial grant programs may serve as incentives to get business to spend money on water-saving equipment.

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Secondary Metabolites as Health Building Functional Compounds

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Abstract:

Secondary metabolites are known to access extra health benefits in addition to basic nutrition and their biological activities are well reported and documented from time to time about their effectiveness and reliability. Currently, most heated debate due to prevalence of pandemic COVID-19 is to discover novel secondary metabolites having potency to battle severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Cancer, diabetes and obesity are most fatal widespread disease across the globe with fact of interest that obesity along with type-2 diabetes have been related with more probability of cancer. Moreover, health ailments due to overconsumption of secondary metabolites also need attention for risk assessment of the same. But at present, very limited literature is available on toxicity, risk assessment and health safety. Therefore, this chapter is focused on classification, source, plant function, biological significance and toxicity of plant secondary metabolites available till date.

Keywords: *COVID-19. SARS-CoV-2, PSMs.*

3.1 Introduction:

Organic compounds synthesized by plant can be categorized into primary metabolites directly involved in plant growth and metabolic processes whereas, secondary metabolites are metabolic byproducts or intermediates which are not necessary for plant's normal growth and development but are essential for the interaction of plants with their environment and are often generated in response to stress (Yang et al. 2018). Due to structurally diverse group of low-molecular weight these are known as plant secondary metabolites (PSMs) having origin from either primary metabolites or biosynthetic pathway intermediates (Piasecka et al. 2015).

Highly diverse set of pathogen-inducible metabolic pathways that have led to the accretion of thousands of distinct metabolites and having major role in the adaptation of plants (Isah, 2019). It is now well evident that secondary metabolites are active and important components of defence mechanisms, particularly in the chemical warfare between plants and their pathogens. Some of these substances have also been shown to have roles in warding off herbivores, attracting pollinators, acting as allelopathic agents, protecting against toxicity, UV radiation and other abiotic and biotic stresses, and signal transduction (Pang et al. 2021). The increased importance in these compounds is sparked by their commercial relevance as dyes, medicines, polymers, waxes, glues, fibers, antibiotics, herbicides, and insecticides (Lu et al. 2017). In humans, they possess various health benefits; many of them exhibit anti-microbial, anti-inflammatory, and anti-allergic actions due to their antioxidant activity and are able to prevent illnesses (Pedro et al. 2016).

Their role is indispensable in several human diseases for example. Sulforaphane a glucosinolate found in cruciferous vegetables like broccoli, and cabbage, showed anti-inflammatory effects against SARS-CoV-2 respiratory infections (Ordonez et al. 2022). Their multifaceted involvement has led to reevaluating their potential functions, particularly in ecological interactions, was prompted by the increased awareness in plant and human life.

3.2 Classification, Source and Role of Secondary Metabolites in Plant Functions:

As per biosynthetic pathways, these can be grouped into four bigger molecular families: terpenes, phenols, glycosides and alkaloids (**Fig.1**; Kessler and Kalske, 2018). Terpenoids are volatile compounds responsible for fragrance such as carotenoids, sterols, limonene and pinene. Phenolics act as antioxidants, structural polymers (lignins), attractants and UV shield (flavonoids), signaling molecules (salicylic acid) and defense response chemicals (tannins and phytoalexins). Glycosides having both sugar and non-sugar aglycone moiety such as cyanogenic glucosides whereas alkaloids contain at least one nitrogen atom and are highly reactive for biological activity such as caffeine, morphine, papaverine and coaine etc. PSMs performs crucial functions of repelling pests and pathogens and serving as symbiosis signals between plants and microorganisms (**Table 3.1**; Guerrieri et al. 2019).

Table 3.1: Classification source and role of secondary metabolites in plant functions

Sr. No.	Secondary metabolite	Source	Class	Plant Function	Reference
1.	Taxanes	*Taxus spp.*	Diterpene	Repress growth and cell cycle progression	Sharma et al. 2014
2.	Camptothecin	*Camptotheca acuminata*	Monoterpene indole	Cytotoxic to invader pathogens	Mazumder et al. 2022
3.	Baicalin	*Scutellaria baicalensis*	Flavonoids	Induces apoptosis and prevent signal pathways	Hu et al. 2022
4.	Isoflavones and saponins	*Glycine max*	Flavonoids	Association with rhizobia	Hartman et al. 2017
5	Flavones	*Laccaria bicolor*	Flavonoids	Germination of *Pisolithus and Suillus* enhanced	Pei et al. 2020
6	7, 4′-dihydroxyflavone	*Medicago sativa*	Flavonoid	Increase in soil *Acidobacteria*	Szoboszlay et al. 2016
7	Hydroxycinnamic acid amide	Potato	Flavonoid	Plant cell wall reinforcement to resist *Phytopthora infestans*	Yogendra et al. 2015
8	Steroidal glycoalkaloid	Tobacco *and C. roseus*	Glycoalkaloid	Defend against phytopathogens and insect infestation	Cardenas et al. 2016
9	Phytoalexins	*Brassica* sp.	Phenolics	Resist pathogenic colonization	Ahuja et al. 2012
10	Triterpenes saponins	*Medicago truncatula*	Triterpenes	Abiotic and biotic stress response	Mertens et al. 2016
11	Proanthocyanidins (PA)	Norway spruce	Flavonoid	Resistance against *Heterobasidion annosum*	Danielsson et al. 2011

3.3 Biological Activities and Significance:

Wide range of biological activities exhibited by secondary metabolites has been reported and documented well from time to time via different researcher **(Table 3.2)** and many yet to come. Currently, most heated debate due to prevalence of pandemic COVID-19 is to discover novel secondary metabolites having potency to battle severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Recently, family Brassicaceae; nearly cole crops which are known as ‘Crown Jewel of Nutrition’ and specifically Broccoli due to presence of sulforaphane showed promising results with anti-inflammatory activity to battle SARS-CoV-2 (Ordonez et al. 2022). On the same note, myricetin inhibited SARS-CoV-2 viral replication and ameliorated pulmonary inflammation (Xiao et al. 2021).

Cancer, diabetes and obesity are most fatal widespread disease across the globe with fact of interest that obesity along with type-2 diabetes have been linked with more chances of cancer incidence (Scully et al. 2021). Indeed, certain secondary metabolites viz., glucoraphanin, naringenin, luteolin, lutein and cyanindin-3-glucoside revealed their effectiveness in treatment and management of the same. Glucoraphanin a glucosinolate of sulforaphane in numerous studies (Gupta et al. 2022; Tian et al. 2020; Xu et al. 2018; revealed and confirmed antidiabetic activities.

Table 3.2: Biological activity and significance of plant secondary metabolites

Sr. No.	Secondary metabolite	Class	Biological activity and significance	Reference
1	Sulforaphane	Glucosinolate	Anti-cancerous, antidiabetic and anti-cardiovascular	Zhang et al. 2022; Rhoden et al. 2021
2	Glucoraphanin	Glucosinolate	Antiobesity, antidiabetic	Xu et al. 2018
3	Indole-3-carbinol	Glucosinolate	Leukaemia therapeutic agents	Karimabad et al. 2022
4	Isothiocyanates	Glucosinolate	Anti-cancerous and chemopreventive	Mitsiogianni et al. 2019
5	Sinigrin	Glucosinolate	Antimicrobial	Tarar A & Peng, 2022
6	Glucoerucin, erucin	Glucosinolate	Antiobesity	Lucarini et al. 2019; Chaea et al. 2015
7	Quercetin	Flavonols	Anti-cancerous	Veiga et al. 2022
8	Catechin	Flavonols	Antiviral i.e., severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)	Chourasia et al. 2021
9	p-coumaric	Flavonols	Anti-inflammatory and antimicrobial	Aldaba-Muruato et al. 2021
10	Gallic acid	Flavonols	Anti-fungal activity against *Candida albicans*	Liberato et al. 2022
11	Ferulic acid	Flavonols	Antioxidant	Adeyemi et al. 2020
12	Myricetin	Flavonols	Antiviral (SARS-CoV-2)	Xiao et al. 2021
13	Kaempferol	Flavonols	Anticancerous	Govindaraju et al. 2019

Sr. No.	Secondary metabolite	Class	Biological activity and significance	Reference
14	Naringenin	Flavonols	Antiobesity & antidiabetic	Navya et al. 2020
15	Apigenin	Flavones	Anticancerous	De and Blay, 2021
16	Luteolin	Flavones	Antidiabetic	Sangeetha, 2019
17	Cyanidin-3-glucosides	Anthocyanin	Antioxidant, antidiabetic and neuroprotection	Cásedasa et al. 2019
18	Astaxanthin,	Carotenoids	Antioxidant, antiaging	Mahendra and Kamaludeen, 2022; Tominaga et al. 2017
19	Lycopene	Carotenoids	Antioxidant, anticancer	Khathuria et al. 2020
20	Crocin	Carotenoids	Antioxidant	Yaribeygi et al. 2019
21	Lutein	Carotenoids	Antidiabetic, prevention of macular degeneration and eye related disease	Kotagiri et al. 2022; Saisugun et al. 2019
22	Betanidin	Betacyanins	Antioxidant	Ramirez-Velasquez et al. 2022
23	Atropine	True alkaloids	Anticholinergic	Schmoll et al. 2022
24	Morphine	True alkaloids	Narcotic and anesthetic	Kim et al. 2017

3.4 Toxicity and Health Safety:

In spite of numerous progressions in synthetic drug chemistry, medicine and antibiotics, till date plants continue to be major source of drugs for treating multiple human ailments. Therefore, risk assessment through lethal dose 50 (LD50) methodology of secondary metabolites is must to ensure health safety. Another side of coin revealed health ailments due to overconsumption of secondary metabolites enriched crops. For instance, Ma and co-workers (2018) conducted a cohort study based on 200,907 type-2 diabetic free population (88, 293 man and remaining women) in which higher glucosinolate consumption was positively correlated with 19 % high risk of incidence of type-2 diabetes. Although in majority of studied literature carotenoids are known for their beneficial antioxidant and eye sight improving characteristics but despite all, Mikkelsen and co-workers (2009) reported adverse effect of excessive beta-carotene consumption in diabetic persons.

So, to conclude its truthfulness and reality more clinical trials are needed. Among phenols, Rocha et al. 2009 in resveratrol for hepatic oxidative stress and Suh et al. 2009 in epigallocatechin-3-gallate for oxidative cell damage.

3.5 Future Perspective and Conclusion:

Secondary metabolites are known to access extra health benefits in addition to basic nutrition and their biological activities are well reported and documented from time to time about their effectiveness and reliability. But at present, very limited literature is available on toxicity, risk assessment and health safety. Therefore, further clinical trial and evidences are required before reaching up to a satisfactory inference about adverse effect of plant secondary metabolites on human health. Despite availability of synthetic drugs, plants continue to be major source of drugs on which human population relies across the globe. So, discovering and identifying novel techniques of phytoextraction is a need of hour. Moreover, genetic engineering and new biotechnological interventions of genome editing such as CRISPR-Cas9 and TALENs are thought to revolutionize next generation nutrition breeding by enhancing status of secondary metabolites within plant system.

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Ethno-Medicinal and Therapeutic Potentialities and Update of Different Species of Aloe –A Miraculous and Wonderful Ancient Medicinal Herb

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Abstract:

The term ethno-medicine is the medical practices for the treatment of ethnic or aborigine people for their health care and myriad uses in traditional therapeutics. Perhaps, genus Aloe has the longest recorded history of traditional therapeutic usage, beauty, skin care and is amongst the most widely used as alternative medicinal plants through worldwide. This indigenous medicinal herb are used for treatment of skin disorders like burns, cuts, eczemas, insect bites, wound etc. in dermatology and digestive protective properties due its anti-inflammatory, anti-microbial, anti- cancerous action, anti-neoplastic activity, analgesic, anti-tumours and wound – healing for its antiseptic properties and pharmacological or therapeutic properties. Almost 75 potentially active components includes enzymes, essential amino acids, vitamins, lignins and steriods, minerals, carbohydrate, saponin, salicylic acids, phenolics etc. and rich in bioactive ingredients like aloe- emodin (anti-diabetic, cardio-protective, skin and bone protection, anti-cancer and anti-microbial activities etc.), aloin or barbaloin (anti-diabetic, skin and bone protection, anti-cancer activities), aloesin (skin and anti-cancer properties), acemannan (digestive protection, skin care, anti- microbial properties), alprogen (anti-allergic and anti-inflammatory activity) etc. have been isolated from different aloe species and most of them have therapeutic uses due to their analgesic, emollient, anti-oxidant, anti-helminthic, anti-arthritic, anti-diabetic, purgative, anti- fungal, antiseptic, aphrodisiac, antimicrobial and antiviral activities. This review provides an update overview of medicinal and therapeutic possibilities or potentialities of aloe plant products or their active phytochemicals in the treatment of several health hazards or their innumerable therapeutic use.

Keywords: *Aloe species, ethno-medicinal, therapeutics, bioactive compounds and potentialities.*

4.1 Introduction:

Aloe Vera is a succulent plant grown in arid and subtropical regions and best known herbal medicinal wonder plant that is most widely used for their healing and therapeutic properties in Ayurvedic, homeopathic and allopathic streams of medicines. The word ‘Aloe’ comes from the Arabic word **‘Alloeh’** meaning ‘**shinning bitter substances**’ and ‘Vera’ is a Latin word meaning ‘true’. Aloe vera is regarded as ‘**universal panacea**’ by Greek and as ‘**the plant of immortality**’ by Egyptian. In Sanskrit, Aloe vera is also called **Ghritkumari** meaning **“Young girl”** which gives woman youth and femininity. At present about 580 species of aloe have been identified out of which nearly 160 species are indigenous to South Africa and among them *Aloe barbadensis* Miller belongs to Asphodelaceae (Liliaceae) family and this miller variety is best known beneficial for therapeutic use, skin ailments and usually mentioned as edible one.

Aloe vera is specifically refers to the *Aloe barbadensis* Miller and it is most commonly used in commercially as Aloe-based products (latex, cream, lotion, gel etc.) in many cosmetic industries for its healing as well as nourishing properties. Aloe gel obtained from the parenchymatous cells in the inner leaves and latex obtained from pericyclic cells in the leaf margins that mainly used for its laxative purpose. Aloe vera has also been recommended for relieve during constipation and gastrointestinal disorders and to improve health and to boost up immune system. It also used to prevent several diseases. *Aloe Vera*, *Aloe ferox, Aloe barbadensis, Aloe perryi, Aloe arborescens* are well investigated and most widely aloe species used as herbal medicinal industries and also therapeutic purposes. Among these, only two species viz. *Aloe barbadensis* Miller and *Aloe arborescens* are grown commercially. In this present article, an overall focuses may have to be represented on the details bioactive compositions isolated and identified from different parts of *Aloe vera* and their medicinal uses due to their pharmacological activities as well as therapeutic properties.

4.2 Botanical and Anatomical Depiction:

Aloe vera is a shrubby arborescent, perennial, xerophytic and succulent plant that depicted by stem less, thick and fleshy triangular leaves with serrated edges and spiny margin. Leaves contain saps or juices that are yellow in colour with bitter in taste due to presence of anthraquinone and glycosides and leaf pulp is the innermost portion of the leaf that contains colorless aloe gel (mucilage) obtained from parenchymatous leaf cells [Bruneton, 1995]. The aloe gel from innermost layer of leaf contains water up to 99% along with 1% of glucomannans, amino acids, lipids, vitamins and sterol etc. [Reynolds and Dweck, 1999; Brown, 1980] . Plant bears yellow tubular flowers and fruits that contain large number of seeds.

4.3 Phytochemical Composition of Aloe and Their Properties:

Several physiologically bioactive compounds have been isolated and well-identified from different species of *Aloe vera* which have different pharmacological activities and therapeutic properties. The composition of these photochemical may varies with the fluctuation of weather and climate and variation with the soil, growing regions, age of the plant etc. [Eshun and He, 2004; Boudreau and Beland, 2006]. *Aloe vera* contains more than 75 various bioactive substances identified and isolated mostly from leaves in the form of gel or latex that includes sugars (mannose, glucomannans); minerals (Zn, Cu, Se and Ca), enzymes (aliiase, amylase, alkaline phosphate, cellulose, catalase, kinase, carboxypeptidase, peroxidase, and lipase etc.); vitamins (A, C, E and B12), anthraquinones with laxative actions (aloin, emodin), fatty acids (lupeol, campesterol), hormones (auxins and gibberellins with anti-inflammatory activity) and some other phytochemicals like salicylic acid, amino acids, lignin and saponins etc. [Surjushe et. al., 2008; Malik and Zarnigar, 2003 and Mann et. al., 2018; Atherton, 1998; Shelton, 1991 and Atherton, 1997; Rodríguez et. al., 2005]. According to Rabe and Staden (1997), various phytoactive substances isolated from Aloe vera act as antiseptic, anti-inflammatory, anti-bacterial, anti-oxidant, antoi-diabetic and anti-cancer etc. as these bioactive constituents are used in the treatment of stomach ailments, gastrointestinal disorders, skin ailments, wound healing, burns and diarrhea etc.

Table 4.1: Major phyto-active substances identified and isolated from *Aloe vera* and their properties.

Major active compounds	Active bio-components	Properties and activities
Enzymes	Amylase, alkaline phosphate, lactate dehydrogenase, lipase [Hayes, 1999], aliiase, catalase, kinase, carboxypeptidase, peroxidase, cellulose and lipase oxidase, cyclooxidase etc.	Catalytic breakdown in sugars, proteins and fat and reduces excessive inflammation.
Amino acids	**Essential amino acids**: Lysine, leucine, isoleucine, valine, threonine,phenylalanine and methionine. **Non-essential amino acids:** Histidine, proline, glycine, tyrosin, alanine, hydroxyl proline, arginine, aspartic acid, glutamic acid etc.	Basic building blocks of proteins and muscles tissue.
Minerals	Zn, Cu, Se, Cr, Fe, K, Cl, Mg,P, Na, Mn and Ca etc. Al, B, Ca, Fe, Mg, Na, P and Si etc. [Yamaguchi et. al.,1998; Femenia et. al., 1999 and Choi et. al., 2001].	Activating various enzymes indifferent metabolic activities and some of them act as anti- oxidants.
Vitamins	A, C, E and B1, B2, B6 and B12, folic acid and choline etc.	Act as anti-oxidants and protect the body by neutralizing free radicals
Hormones	Auxins and gibberellins.	Wound healing with anti-inflammatory activity.
Anthraquinones, chromones	Aloin, barbaloin, emodin[Hayes, 1999], aloetic acid, alovin, anthracine, anthranol, isobarbaloin, ester of cinnamic acid.	Act as laxatives; analgesic, antiviral and antibacterial. These quinines and chromones have also anti-cancer, anti-inflammatory andevacuating activities [Choi et.al. 2001].

Major active compounds	**Active bio-components**	**Properties and activities**
Steroids	Campesterol, cholesterol, β-sitosterol and lupeol.	Anti-inflammatory [Haller, 1990], and have antiseptic and analgesic properties.
Fatty acids	Linolenic acid, arachidonicacid, γ γ-linolenic acid, triglycerides.	Anti-inflammatory properties.
Saccharides/carbohydrates	Mannose, glucomannans, cellulose, glucose, fructose, galactogalacturan, acemanan, glucogalactomannan, galactoglucoarabinomannan, arabinogalactan, pecticsubstance, xylan, cellulose, L- rhamnose, and aldopentose.	Anti-viral, immune modulating activity.
Glycosides	Saponins	Cleansing and antiseptic properties.
Salicylic acids	Aspirin	Analgesic, anti-inflammatory,anti-bacterial properties. [www.healingaloe.com]

4.4 Medicinal and Therapeutic Potentialities of *Aloe Vera*:

Different aloe products like aloe gel, aloe juice, aloe leaf extracts, aloe cream and powered extracts from leaf rind latex (laxative properties) etc. have wound healing, anti-inflammatory, antibacterial, antiviral, anti-tumours, antiseptic, analgesic, anti-proliferative, anti-diabetic, anticancer, antifungal, skin soothing and moisturizing, cooling and anti-aged properties and cosmetic and skin protection from UV and gamma radiation, laxative and immunization activities.

It has role in gerontology and rejuvenation of aged skin. It is suggested to use aloe vera products in the treatment of arthritis, asthma, diarrhea, constipation, inflammatory bowel diseases, and ulcer and provides relief from several skin ailments (skin burns, rash, insect stings, eczema and allergy etc.). This herb contains lupeol, salicylic acid, cinnamonic acid and phenols that are used as potent antiseptic agents.

The aloe gel contains a number of glycoproteins that has anti-ulcer and anti-tumour activities (Choi et. al., 2001; Yagi et.al., 1997 and 2003); gel is used in ulcerative colitis (Langmead et. al., 2004 and Thomas et. al., 1998) and for treatment in wounds, burns and skin irritations, constipation, diabetes, arthritis, coughs and ulcers (Eshun and He, 2004; Vogler and Ernst, 1999). Such gel is also used for the treatment of radiation burns and ulcers [Syed et. al., 1997] and they have been reported as protective against the radiation damage to the skin [Sato et. al., 1990 and Rajput et. al., 2009]. The application of aloe gel also has been reported in dentistry [Wynn, 2005]. In cosmetic industry, Aloe gel is used as skin tonic as improved the skin integrity, decreased acne wrinkle appearance (anti-acne effect) and decrease erythema [West and Zhu, 2003].

The leaf pulp is used externally for the treatment of skin disorders like burns, acne etc. It has been reported that also juice is used to improve the digestive system, proper functioning of the gallbladder, liver and kidneys. Due to its detoxifying activity, it is extensive used in the treatment of arthiritis, liver complaints, bronchitis, jaundice, piles, eye disease and tumours etc. Aloin (Aloe glucosides) are extensively used as drugs in many pharmaceutical industries for treating urine related problems, pimples, ulcers and used in gerontology and rejuvenation of aged skin. Aloe juice is used as stomach tonic and purgative. It's sterols like campesterol, lupeol, cholesterol and β-sitosterol etc. are used in reducing inflammation and act as natural analgesic. The different bioactive compounds in aloe vera are used in ayurvedic formulations due to its anti-helminthic and purgative properties for treatment of cough, cold, piles, asthma and jaundice [Joseph and Raj, 2010]. Due to presence of antiseptic agents in aloe vera like lupeol, salicylic acid, phenols, sulfur, cinnamonic acid, urea nitrogen etc. they exhibits different anti-fungal, anti- viral and anti-bacterial activities [Surjushe et. al., 2008; Zawahry et. al., 1973].

4.5 Conclusion and Future Scenario:

Aloe vera has proven its wide range of application in the arena of medicinal and therapeutic ailments. This plant showed importance in everyday life for skin ailments, anti-aging, wound healing, antiseptic, antioxidants, analgesic, and anti- inflammatory and also used in cosmetic and pharmaceuticals industries. The active ingredients identified as well as isolated till date already showed diversified uses in herbal medicinal treatment and hopefully many of its hidden ingredients may have immense power to treat several other diseases also. Among various bioactive compounds, major research focused on aloe-emodin, aloin, aloesin, amodin, acemannan etc. whereas emodin and aloin have been most studied ones and they have been well reputed for their anti-microbioal, anti-diabetic, anti-septic, anti-inflammatory and skin protective properties. Basic clinical research on this plant's bimolecular compounds and their application particularly on bone protection, cardiovascular diseases, cancer and diabetics etc. is utmost essential in future. Thus, this wonder plant is in need to further research emphasizing for better utilization for human kind.

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Role of Non Timber Forest Resources in the Livelihood of Forest Dwellers in Ayodhya Hills Areas of Purulia District, West Bengal

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Abstract:

Scientific harvesting, storage and commercial handling of NTFPs for economic benefit primarily of the forest dwellers, need to be introduced and nurtured at grass root level since these perspectives can play a potential role in imparting sustainability to the system in operation in the forest and foster its conservation. Interest in non-timber forest products (NTFPs), especially the phyto-resources, is increasing rapidly since resources are harvested from trees in such a way that the trees are not felled down. Considering the urgency in conserving the forests in Ayodhya Hills Forest Range of Purulia District simultaneously with economic development of forest dwellers. The present work was undertaken which after a tenure of three years could document the indigenous Traditional Knowledge regarding various uses of forest plants. As many as 125 plant species have been documented out of which 19 as source of edible fruit, 7 each for marketable flower, 11 as source of wood-pieces useful in minor carpentry; 19 each for miscellaneous purposes including making of basket, mat, hand-fan, broom etc. and for leaves; 7 each for marketable flowers; tannin and gum 6, 6 for extraction of oil, 2 as source of fibers, 2 for resins and 2 for floss. However both traditional knowledge and practices have been undergoing changes over time involving impoverishment. In view of this, the present author feels the need of an 'in time documentation' of traditional knowledge prevailing in this area which is certain to prove worthwhile in human welfare.

Keywords: *Scientific harvesting, NTFPs, Awareness, Ayodhya hills, Forest Range, Economic benevolence.*

5.1 Introduction:

Non-timber forest products (NTFPs) happen to contribute one such resource on which the forest dwelling communities are dependent to a great extent. Non-timber forest products (NTFPs) are an integral part of lives of tribal communities surviving in and around forests and depending on them. Since use of NTFPs always spares felling of trees or rather encourages growth of species of all types including trees, its role in sustenance of forest and conservation of biodiversity is invaluable. Moreover their economic potential can address issues of poverty of the forest dwellers (Dante and Koch, 2011).

The potential economic value of NTFPs either in terms of utilization or their market value is often unknown or improperly estimated. The scientists have also been giving importance to the documentation and protection of the age-long knowledge of the tribal communities regarding the use of NTFPs. This traditional knowledge has been proving useful in stock-taking of bio-resources, innovation of novel genetic resources from them and setting conservation strategies.

Non-Timber Forest Products (NTFPs) have an important role in the household economy of forest fringe dwellers in the dry-deciduous forests of India (Shackleton and Shackleton, 2004; Babalola, 2009). People who live within forested areas can collect NTFPs for their subsistence use and at the same time are also allowed to collect some NTFPs for commercial purpose without any permission from the Forest Department. Unprocessed NTFPs are sometimes given less commercial as well domestic importance compared to value-added products, as the price of the processed products is greater. It is estimated that of the 6.2 billion world population, about 25 percent are dependent on forest resources including plant and animal products (Iqbal, 1993; Walter, 2001). It is also estimated that about 60 million aboriginal people all over the world depend on the forest ecosystem for their livelihood (Anon., 2001).

The importance of Non-wood forest products to (NWFP) the forest dwellers is much greater since quite a good number of such products are primarily consumed at local level. As such stock-taking of non-wood forest products (NWFP) and their sustainable use for the economic benevolence of the indigenous people have been presently prioritized in optimizing and conserving forest ecosystems. In view of the foregoing, the present authors took up the work of documenting the age-long indigenous knowledge regarding use of plants of Paharia tribe composing the forests in different parts of Ayodhya hills (Chanda and Mukherjee, 2012), which is rich in both density and diversity of tribal populations work was undertaken in such an forested area of Purulia district. The present work, new of its kind for the area, adheres to the objective of assessment of the commercial prospect of NTFPs as documented from the indigenous knowledge of the forest dwelling Santhals, Mundas, Paharia, Bhumij and Birhors and personal experience gained about their uses during field work.

5.2 Materials and Methods:

Field survey was carried out in the areas under Ayodhya hills Forest Range and adjoining areas of Purulia District in West Bengal State to collect and document the traditional knowledge pertaining to plant-diversity and their ethnic uses for all purposes other than timber from primary sources, i.e. the ethnic communities by conducting structured questionnaire based interviews of such knowledgeable informants, especially aged and knowledgeable persons belonging to both the men and women categories, following the standard guidelines given by Rao (1987) for ethnobotanical studies. The documented information was further confirmed through cross checking and our own experience gained through careful observations. During field studies the species were provisionally identified and their identification was confirmed with the help of authentic specimens preserved in the Central National Herbarium (CAL) and in our departmental Herbarium (BURD) and taxonomic literature (Prain, 1903; Guha Bakshi, 1984; Bennet, 1987).

Data sheet for recording NTFP-based income generation

a. Name: Sex: Age:
b. Tribe
c. No. of family members
d. Village
e. Plant part(s) collected
f. Purpose

- Own consumption
- Sale in the local market
- Sent outside for sale

g. Processing:

- Raw
- Processed

h. Availability
i. Monthly income from NTFPs.

5.3 Study Site:

Purulia, lying between 22° 60' and 23° 50' north latitude and 85° 75' and 86° 65' east longitude, is one of the draught prone and economically backward districts of West Bengal state. The district occupies an area of 6259 sq km with forests covering nearly 87.60 thousand hectares and ranks second in West Bengal so far diversity and density of indigenous or tribal population are considered. The Ayodhya hills include Jhalda, Baghmundi, Balarampur and Arsha Blocks of Purulia district.

Table 5.1: An Item Wise Enumeration of Species Having Commercial Prospect

Item of NTFP	No. of plant species with economic potential	Names of the suitable plant species	Percentage of useful plant species
Fruits	19	*Ficus racemosa, Ficus hispida, Buchanania lanzan, Aegle marmelos, Semecarpus anacardium, Mangifera indica, Diospyros melanoxylon, Zizyphus mauritiara, Carissa spinarum, Limonia acidissima, Syzygium cumini, Dillenia pentagyan, Emblica officinalis, Cajanus cajan, Borassus*	*15.2*

Item of NTFP	No. of plant species with economic potential	Names of the suitable plant species	Percentage of useful plant species
		flabellifer, Phoenix sylvestris, Psidium guajava, Tamarindus indica and *Aannona squamosa.*	
Flowers	7	*Madhuca indic, Indigofera tinctoria, Woodfordia fruticosa, Cassia fistula, Nymphaea nouchali,* *Butea monosperma, Pongamia pinnata.*	*5.6*
Oil seeds	6	*Pongamia pinnata, Ricinus communis, Argemone mexicana, Madhuca indica,* *Schleichera oleosa, Azadirachta indica.*	*4.8*
Leaves	5	*Shorea robusta, Bauhinia vahlii, Diospyros melanoxylon, Borassus flabellifer, Phoenix sylvestris*	*4*
Tannin and Gum	6	*Terminalia chebula, Terminalia bellirica, Sterculia urens, Acacia nilotica, Annona squamosa, Boswellia serrata.*	*4.8*
Resins	2	*Tectona grandis, Boswellia serrata.*	*1.6*
Fibers	2	*Agave sisalana, Phoenix sylvestris.*	*1.6*
Floss	2	*Bombax ceiba and Holarrhena pubescens*	*1.6*
Lac culture	3	*Schleichera oleosa, Zizyphus mauritiana, Butea monosperma*	*2.4*

Item of NTFP	No. of plant species with economic potential	Names of the suitable plant species	Percentage of useful plant species
Minor carpentry	11	*Albizzia lebbek, Annona squamosa, Azadirachta indica, Dalbergia sissoo, Garcinia xanthochymus, Lagerstroemia parviflora, Pongamia pinnata, Shorea robusta, Terminalia alata, T. arjuna* and *T. bellirica*	*8.8*
Misllaneous purpose	19	*Combretum roxburghii ,Shorea robusta , Ficus hispida , Dendrocalamus strictus, Albizzia lebbek, Azadirachta indica, Careya arborea, Dalbergia sissoo, Gmelina arborea ,Holoptelea integrifolia, Lagerstroemia parviflora, Mangifera indica, Borassus flabellifer, Phoenix sylvestris, Justicia adhatoda, Holarrhena pubescens ,Ricinus communis, Madhuca indica, Schleichera oleosa,*	*15.2*

5.4 Strategies Proposed for the Optimization:

Interest in non-timber forest products (NTFPs) is increasing rapidly. At present there are numerous efforts to convert them (non-timber produce or raw materials) into usable products (NTFPs) and to increase awareness of these products, management of their production and exploration of commercial prospect and potential. Thus it is felt that in case of Ayodhya Hills strategies for the sustainable management, value addition and marketing of non-timber forest products need to be worked out for conveying economic benevolence to the local people and safeguarding the existence of tree and other associated species of the concerned forests. Some important observations and views in this regard are enumerated in the following:

a. Scientific harvesting, storage and handling of NTFPs need to be introduced and enhanced at grass root level since these perspectives can play a potential role in imparting sustainability to the system in operation.
b. Intensive researches and sincere efforts are necessary at the grass root level in order to address all aspects of value addition to the NTFPs, diversification of the products and enhancement of production aptly making use of the skill, vigor and efficiency of the forest dwellers.
c. Well organized NTFP marketing channels to be operated to create job opportunities for the forest dwellers, alleviate their poverty and improve the economy.

d. Restorative revegetation of the exploited forest patches with indigenous species especially with those used extensively by the local communities is immediately needed.
e. Proper guidance regarding economic improvement can also shift forest dwellers to other professions which can reduce the dependency on forest resources and augment the self-restorative ecological processes of the existing forests in the study area.
f. Perpetuation of the cultural performances and religious activities of the tribals making use of the indigenous phyto-resources totally in local environmental conditions must be encouraged and ensured protection since these activities have adequate certainty to promote conservation and optimization of the forest ecosystem.

5.5 Results and Discussion:

The NTFPs documented in this work are all those which are procured from the forest without felling of trees by local inhabitants, mainly the Santhals, Mundas, Birhor, Bhumij and Paharias and have certain qualities for gaining entry into the commercial sphere.

The medicinal plants have not been covered in the present work since documentation of their ethnic uses and commercial prospect deserve special attention and distinction. The different utilitarian perspectives recorded in the present work (Table 1) concern as many as 124 species of Angiosperms (Magnoliophytes), of which 106 species are dicotyledonous (Magnoliopsids)and 18 species monocotyledonous (Liliopsids). At specific, generic, family and class levels, dicots show higher percentages over monocots. The ratios of trees, shrubs, herbs and climbers associated with the forest abodes of tribals were found to be 51, 35, 25 and 14 respectively**.** The commercial prospect of this plant is very high. There are as many as 19 other species capable of handing over fruits for sale.

As many as 11 species were seen to bear woods which can be used commercially in minor carpentry works. But such a use is no way should affect the health of the concerned plant. A sustainable use of the products enlisted in the present work collaterally with forest protection is certain to ensure conservation of the forest along with perpetual economic welfare of the indigenous people.

5.6 Conclusion and Future Aspects:

There is a growing recognition by the international forest policy and forest communities of the importance and relevance of Traditional knowledge about forests, and the need to consider this knowledge in the development of policies and practices that support sustainable management of forest resources. In India Traditional knowledge on the forest ecosystems is as old as ancient scriptures, bio-geographical niche, cultural history, and natural resource utilization. Many tribal communities possess considerable knowledge of the natural resources they utilize. This knowledge, by providing a source of baseline data on non-timber forest resources or by filling information gaps in this regard, can guide scientific approaches to forest resource management, or provide novel management alternatives. The Traditional Knowledge (TK) base can be used for their time tested, cost effectiveness, purity, environment friendly nature and popular beliefs. There is need for registration of grass-root innovations, certification of products for the authentication, besides developing benefit sharing mechanism on sustainable basis.

The economy of the people in Ayodhya Hill region is mainly sylvan and fractionally Agrarian with uncertain livelihood security generating extremely low per capita income. Moreover geographical isolation, past history of shifting cultivation, overexploitation of forests mainly for timber, hydropower generation, developmental activities, water scarcity especially in the post- and pre-monsoon seasons, desertification, natural calamities, political restlessness etc. are the obstacles impairing socioeconomic growth in the region. The situation needs to be improved on war footing. Even though the region is still bestowed with adequate and good quality of forest resources it has been experiencing very poor management and lack of application of technologies for sustainable harvesting, processing and storage of non-timber produces. The only praiseworthy aspect noticed by the present author is the awareness of the ethnic communities about the existing state of their forests and their concern in sustainable use of the resources. However their 'below poverty level' economic status may change their virtues, ethics, values and it might so happen that their hunger makes them hostile to the forests. So any endeavour to protect the existing forests must first protect the lives of forest dwellers from hunger, poverty and livelihood insecurity. Therefore it is essential to launch an integrated resource conservation measure in such a way so that the tribal economy can grow collaterally with that of forest through optimum sustainable use of the resources abiding by the laws of nature. The integrated programme must ensure provisions for conservation of water and soil so that the forest flora and fauna can ensure uninterrupted production of resources maintaining variety, quality, and value of an inspiring standard. The integrated conservation programme must utilize the traditional knowledge of the indigenous communities, expertise of forest officers and scientists keeping a good alignment with the self-designing capacity of the nature. The land and the water resources of the region need to be used efficiently. Documentation of traditional knowledge about the use of the non-timber forest produce followed up by their scientific sustainable harvesting, processing, value addition, storage and marketing need to be augmented and compensated by watershed management, revegetation with indigenous species approved by the ethnic communities and soil conservation. This kind of integrated resource conservation measure is certain to achieve sustainability if it ensures improvement of the livelihood and economic security of the ethnic communities.

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Implications of Methylamine Residues in Bhopal Soil and Water under Diverse Climatic Factors

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Abstract:

It was determined to conduct this study invitro in context of the methylisocyanate catastrophe, in which methylamine, which has been reported as carcinogenic, was developed as a result of the hydrolysis of methylisocyanate (MIC). The methylamine sensitivity in water and soil were 0.14 and 0.25 ppm, respectively. The dissipation rate of methylamine in water and soil have been shown to be faster during the summer season, slower during the rainy season, and still slower during the winter season.

6.1 Introduction:

On December 3, over five lakh individuals were exposed to methyl isocyanate from UCIL (Union Carbide India Limited) pesticides factory in Bhopal, the capital city of Madhya Pradesh in the heart of India. Due to India's strategic position, the American company Union Carbide Corporation built a pesticide plant there. Sevin, a pesticide, was meant to be produced by the plant. According to an agreement between Union Carbide and the Indian Government, Union Carbide held a 50.9% stake in the company, and Indian investors held a 40.1% stake.

The Union Carbide India Limited was the name of the facility (UCIL). In 1979, UCIL began producing pesticides. While this insecticide was being made, Methyl Isocyanate, a hazardous substance, was also being made (MIC). Since MIC is a highly dangerous compound, it needed extensive upkeep. People who were sound asleep on December 4, 1984, around one in the morning, began to feel the change in the air as the MIC gas began engulfing the entire city of Bhopal. They attempted to flee for their lives but were unable to do so. Some people who managed to survive were unable to shield themselves from the impending infirmities. All of this occurred as a result of MIC gas leakage from tank E106. Additionally, there have previously been complaints about the plant's upkeep and the minor levels of MIC leakage.

The earlier leakage episodes had also resulted in a number of fatalities and serious injuries. But the authorities gave it no thought. There was no replacement for the worn-out machines. According to reports, about 3000 people died and more than 6 lac more suffered severe injuries. With ongoing respiratory issues among other challenges, the survivors made it through. Health problems were seen in new born who weren't even yet born at the time. In order to give the Bhopal tragedy victims better medical care, the Permanent Peoples' Tribunal urged in 1992 that an international commission be established. Later, a request for the same was made in 1993 by the Bhopal Group for Information and Action. In 1993, the International Medical Commission on Bhopal (IMCB) was established to offer medical aid to the survivors of the 1984 Bhopal tragedy.

6.2 Immediate Effects of the Bhopal Gas Tragedy:

The colourless liquid called methyl isocyanate (MIC) is used to make insecticides. It is quite poisonous. It needs regular care since it reacts strongly to water. In order to raise the pressure necessary for turning the liquid into a deadly gas, only a minimal amount of water is required. Three tanks of MIC were to be kept in storage at the UCIL, and its temperature had to be kept below zero celsius. Additionally, it had to be held under pressure using inert nitrogen. However, a few days prior to the tragedy, the tank E106 in which the MIC was stored could no longer withstand the pressure, which forced a temporary halt in production.

Even after becoming exhausted, the tank was unable to cease the production for an extended period of time. After some time, the production process was resumed. However, due to a lack of upkeep, on the night of December 2-3, 1984, water began to leak from the connecting pipe and mix with the MIC liquid. This led to a significant heating reaction, which produced pressure at a splitting rate and caused the release of the MIC gas. The dangerous gas began to affect adjacent residents as they started to evacuate. They began to experience breathing difficulties, eye discomfort, chemical burns on the skin, and lung contractions. They were subsequently rushed to the hospital, but the physicians couldn't properly treat them without knowing what caused the mishap in the first place. Methyl isocyanate is extremely poisonous. According to the American Conference of Government Industrial Hygienists, MIC exposure to a worker is safe up to a level of 0.02 ppm. By inhalation or consumption, it becomes dangerous as soon as the level reaches 0.4 ppm. Most people cannot detect it at 5 ppm, but they are warned because of symptoms.

The following are some exposure symptoms:

- Reddening of the eyes
- A difficulty breathing
- An irritation of the nose and throat
- Skin burning
- Coughing

When the exposure level exceeds 21 ppm, it may cause:

- Death
- Pneumonia - An illness that results in lung inflammation

- Lung edoema - A condition in which there is an excessive build-up of fluid in the lungs, making breathing difficult

When the hazardous gas methylisocyanate react with water, the first notable hydrolysis product generated is methylamine (Monomethyl amine, Amino-methane). When the poisonous methylisocyanate interacted in the atmosphere, it wreaked devastation to flora, wildlife, and living things. Almost no research has been carried on the sustainability of MIC hydrolysis chemical residues in Bhopal's water and soil. As a result, the current study recognizes the importance of knowing the degree of MIC hydrolyzed products dissipation, particularly in Bhopal's water and soil, in order to provide baseline data in the field of residue toxicology.

6.2.1 Material and Method:

The analysis was carried in vitro with Bhopal-specific soil and water. The water from the Upper Lake, which is a significant drinking water source for Bhopal city and its surrounding terrain, was collected in three environmental conditions over the years 2020-21. The persistence of Methylamine (MA) in water and soil was evaluated employing varying quantities of methylamine ranging from 2.50 to 3.75 ppm. Seasonal temperature fluctuations were also recorded, which would provide the data needed for persistence. The cleanup of final extract appropriate fractions was performed using a Nitrogen-Phosphorus detector in a Gas Chromatography Sigma 300 (Perkin Elmer, USA).

6.2.2 Results and Discussion:

For the persistence investigation in water and soil, the concentration ranges of Methylamine were 2.50 to 3.75 ppm and 5.00 to 7.50 ppm, respectively. The rate of methylamine dissipation in water was higher during the summer trial, lower during the rainy season, and slow during the winter season. The physico-chemical properties of the test water and soil were also investigated. (See Table 6.1) After 10 days, practically all of the doses showed 50% dissipation, as seen in the data (Table 6.2).

Lower doses had completely dissipated after 35 days. The physicochemical properties of test water may be to blame for the variability in data seen in Methylamine residues. Dissolved oxygen, total alkalinity and hardness, pH, Chemical Oxygen Demand, and temperature may have interfered with the degradation reaction that happened in the Lake water sampled. The residual data observed during and after 35 days was significant, which could have an impact on the Lake's ecosystem.

In an experiment conducted throughout the summer, followed by the rainy season, and finally the winter season, the nature of methylamine dissipation in soil reveals a faster rate. The extensive data on methylamine persistence in soil over three seasons is given in (table 6.3). After 35 days, the remnants had dropped below the detection level, according to the representative. The variance in data reported in methylamine residues could be related to seasonal physio-chemical features, specifically variations in pH, moisture, clay content, and abundance, which could have hampered decomposition in soil. The dissipation was also enhanced significantly by the seasonal shift in temperature.

In conclusion, when experiments were conducted in vitro, methylamine, which is the breakdown product of MIC, showed a significant decrease in residue in water and soil of Bhopal. Methylamine residues may have had a long-term negative impact on the flora, fauna, and all living systems.

Table 6.1: Physico-chemical parameters of test water and soil

Sr. No.	Physico-chemical parameters	RANGE	AVERAGE
1.	Temperature (^{0}c)	17.4-25.8	22.0
2.	Dissolved oxygen (mg//)	6.3-11.9	8.5
3.	Total alkalnity (mg//)	117.0-142.0	126.0
4.	Total hardness (mg//)	81.0-123.0	101.0
5.	Ph	7.2-9.1	8.4
6.	Chemical oxygen demand (mg//)	6.7-13.4	9.7

Soil:

1	pH	7.6-8.0	7.8
2	Electrical conductivity	0.50-0.58	0.54
3	Clay content	38%-42%	40.3%
4	Organic carbon	0.40-0.48%	0.44%
5	Moisture	3%-5%	4%

Table 6.2: Representative persistence of methylamine in water

Sr. No.	Conc. M. A. Applied (ppm)	Dissipation (days)						
		5 (ppm)	10 (ppm)	15 (ppm)	20 (ppm)	25 (ppm)	30 (ppm)	35 (ppm)
1	2.50	1.56	1.05	0.45	0.15	BDL	BDL	BDL
2	2.85	1.86	1.38	0.71	0.38	0.16	BDL	BDL
3	3.10	2.71	1.51	0.93	0.65	0.36	0.15	BDL
4	3.45	2.88	1.71	1.23	0.86	0.56	0.31	0.14
5	3.75	3.10	1.96	1.71	1.21	0.86	0.60	0.41
BDL < 0.14ppm								

Table 6.3: Representative persistence of methylamine in soil

Sr. No.	Conc. M. A. Applied (ppm)	Dissipation (days)						
		5 (ppm)	10 (ppm)	15 (ppm)	20 (ppm)	25 (ppm)	30 (ppm)	35 (ppm)
1	5.00	2.80	1.78	1.05	0.53	0.25	BDL	BDL
2	5.70	3.46	2.16	1.35	0.83	0.50	BDL	BDL
3	6.30	3.98	2.86	1.50	0.98	0.55	0.26	BDL
4	6.90	4.21	3.45	2.03	1.68	0.81	0.35	BDL
5	7.50	4.65	4.55	3.76	2.75	1.35	0.51	BDL
BDL < 0.25ppm								

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The Need and Prospects for New Approaches in Horticultural Crop Production

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Abstract:

Horticultural crops are an integral aspect of daily life and serve a social function in influencing human lifestyles, enhancing landscapes, and forming human culture. However, there are numerous difficulties in growing horticulture crops, including the urbanisation of the world's population, environmental issues, the efficient use of resources, and problems with the environment and human health brought on by the excessive use of pesticides. Horticultural experts must concentrate on developing innovative technologies to lessen the demand for human labour and boost productivity in order to tackle these problems. Horticultural crops require complicated post-harvest processing before consumption, are difficult to grow and manage, are vulnerable to pests and diseases, and require additional planting control.Flavor and quality are typically diminished as a result of significant losses during processing, warehousing, transit, and sale. To guarantee food and nutritional security for humanity, a combination of high-tech cultivation techniques and post harvest management of horticulture crops is required. The need to boost production, earnings, and productivity heavily influenced the technologies that were available to farmers. The sector has to accomplish multiple aims, such as being internationally competitive, producing agricultural goods of high quality while achieving sustainability requirements. The horticulture industries face many issues, and innovation is essential to finding solutions. New concepts, technologies, and methods will be vital in assisting farmers, growers, and enterprises to become more productive and sustainable.

Keywords:

Horticulture, Innovation, Productivity, Smart Farming, Sustainability

7.1 Introduction:

Horticultural crops, which mostly include fruits, vegetables, ingredients for beverages and fragrances, herbal medicines, and ornamental plants, play a significant role in our daily lives. Horticultural crops now serve a social role in moulding human culture, enhancing landscapes, and influencing human lifestyles in addition to their economic significance in supplying food as contemporary society advances (Litt et al., 2011). Horticultural workers have been motivated to produce more types and better products as a result of this change in duties, which is becoming increasingly significant. Also, it motivates researchers in horticulture to conduct more useful work to enhance the functional applications of horticultural crops(Yang& Xu,2021).However, establishing horticulture crops requires a lot of delicate manual labour that significantly relies on skilled personnel to complete tasks like pruning branches, thinning flowers and fruit, picking fruit and controlling insect and pest infestations. Present day horticultural crop production has a number of obstacles(Muendo&Tschirley,2004). These issues stem from a number of root causes, including an increasing global population that is skewed towards urban populations and consumes rather than produces our food supply, the increased negative impact of environmental issues that reduce crop yield and restrict the availability of arable land, problems with resource use efficiency to limit chemical releases into the environment, and an increase in the use of pesticides, fungicides, bactericides, herbicides, and other chemical control agents(Lastochkina et al., 2022). It is necessary to increase crop output without considerably increasing the amount of land, water, or fertiliser used (Zhang et al., 2011).Horticultural researchers must focus on developing new technologies in order to make better orchard management decisions and dramatically increase horticultural output in order to meet the upcoming needs and challenges (Pearce et al., 2018). Consequently, the main objective of intelligent horticulture is to produce high-quality fruits, vegetables, and decorative crops by utilising cutting-edge technology, tools, and systems to decrease the use of human force and increase its effectiveness.

7.2 Challenges in Research and Production of Horticultural Crops:

The quantity and quality of horticulture crops have significantly increased in the twenty-first century as a result of the advancement of agricultural technology. These gains, nevertheless, still fall short of what the constantly expanding population needs. According to estimates, the population of the world was at 7 billion in 2020 and will increase to 9 billion by 2050. There will be decreasing and lesser land accessible for farming due to severe issues like global warming, desertification, and environmental contamination, and securing food supply and security is already a difficult task (Jamnadass et al., 2020). Sustainability has been a big problem for agriculture since horticulture production is coming under more and more pressure (Tilman et al., 2002). The cultivation of horticultural crops presents a number of unique challenges or issues as compared to the production of stable crops such as rice, wheat, maize etc.

For the majority of horticultural crops, lengthier breeding cycles are needed, and quality enhancement has become more important. Perennial fruit trees with long juvenile periods are frequently bred using conventional techniques like mutation and crossing. However, they frequently require labor- and time-intensive cutting or grafting propagation in order to guarantee genetic stability or acquire superior features, respectively. While developing tea cultivars, for instance, lines are initially chosen by hybridization or from natural populations, then they are reproduced by cutting, and the lines with the best features are found after planting for three years.Typically, the procedure takes longer than 10 years. Horticultural crops have essential quality attributes including scent, taste, and colour as breeding targets since these features affect the crop's nutritional and economic worth. Long-term focus in breeding has been on produce, whereas flavour characteristics have been disregarded (Gao et al., 2019; Zhu et al., 2019). Second, it is technically more challenging to grow and manage horticultural crops. They come in a variety of kinds, and the most of them are perennials that have been regularly cultivated for many years, if not decades.

Horticultural crops are hence more susceptible to pests and illnesses.In order to provide the essential conditions for the growth and harvest of horticultural crops, greenhouses or other facilities are sometimes needed (Castilla & Hernandez, 2006; Eigenbrod&Gruda, 2015). As a result, it is clear that, in general terms, horticultural crops demand more work and better planting management. Last but not least, because horticultural commodities have a high rate of post-harvest loss, the majority of fruits, vegetables, and flowers need to be stored fresh (Kasso& Bekele, 2018; Kader & Rolle, 2004).

Before being consumed, several horticultural crops need intricate post-harvest processing.For instance, following harvest, the fresh leaves of tea trees must be processed into green, black, or oolong tea or other types of tea, which necessitates thorough metabolism of fresh tea leaves' constituents (Zeng et al., 2020). Similar to bitter almonds, Prunus dulcis, harmful cyanogenic glucosides must be removed through processing before eating (Cortés et al., 2019). Usually, significant losses during production, storage, shipping, and sale lead to a decline in both flavour and quality.

7.3 Need for New Approaches in Horticulture:

Horticulture is one of the finest solutions for increasing land productivity, providing human nutrition security, and maintaining the livelihood of the farming community globally. This is a well-known fact. By 2050, the world's population is expected to reach 9 billion, with the majority of that growth occurring in underdeveloped nations where malnutrition and chronic food shortages currently predominate. Due to overexploitation of natural resources, this anticipated population growth would undoubtedly result in a decrease in the per capita availability of natural resources, which will ultimately increase hunger, poverty, and malnutrition as well as raise food costs.So, it is essential and imperative to address the wise use of natural resources.

The world's agriculture is now being seriously threatened by climate change (Malhotra, 2017; Datta, 2013). Throughout the past century, the earth's surface temperatures have increased dramatically, with agriculture being the sector most affected.

The increase in temperature increases the rate of respiration, shortens the duration between crops, hastens crop maturity, and accelerates ripening, all of which have a negative impact on agricultural output. Climate change is the primary cause and trigger of a number of climatic extremes, including droughts, floods, tropical cyclones, heavy precipitation events, hot extremes, and heat waves that have a detrimental effect on agriculture.

Precision farming, which involves managing resources in time and space for horticulture, is one of the key high-tech interventions needed to optimise resource usage. The goal of technology infusion is to increase crop productivity per unit of inputs by making the best use of available resources (Srivastava & Singh, 2022). Only the use of contemporary high-tech apps and precision farming techniques would make this viable. These technologies need to be broadly used and implemented in order to increase agricultural output and returns to farmers.A collection of high-tech cultivation techniques and postharvest management of horticultural crops is required, given the horticulturist's challenges listed above and their expected role in guaranteeing food and nutritional security for humanity.

7.4 Prospects for New Approaches in Horticulture:

Up until recently, farmers' ability to choose among a variety of technologies was mostly influenced by the need to boost output, profits, and productivity (Johnston & Mellor, 1961). The primary obstacles were a lack of cash, a lack of technological expertise, and market hazards against which government measures protected many nations' policies. As the goal of agricultural policies was to raise production, "good policy practises" used to be very straightforward and mostly related to raising output. For instance, agricultural and horticultural research and extension services could focus on enhancing small farms' output (Hazell, 2005). Currently, agriculture must accomplish a number of goals, including being internationally competitive, producing high-quality agricultural goods, and achieving sustainability goals (Garnett &Godfray, 2012). Agricultural producers want quick access to innovative technologies in order to stay competitive. Farmers now have both more opportunity and much more restrictions. They must not only be successful but also adhere to environmental laws and norms. Consumers may also be overwhelmed with information from numerous government and business sources, that make choosing acceptable technology more difficult. Farmers must adapt their management and production methods in response to agricultural regulations that take environmental factors into account (Mertz et al., 2009). Future events could see an even greater rise in uncertainty. The future policy environment may also be uncertain, particularly in light of support, trade, and challenges from the agro-food sector. Farming technology adoption requires financial investment. Yet, it takes time for the benefits to materialise, and farmers could be hesitant to make investments in an unstable environment with more restrictions, where part of the advantages are for society.

The foundation for boosting development and productivity has been technological advancement. With the development of new technologies, research influences the productivity of farming systems. If these technologies are suitable for farmers' needs, they will be quickly implemented. To address the issues the horticultural industries are currently facing, innovation is essential (Alaie, 2023). For farmers, producers, and enterprises to become more productive, new concepts, technology, and methods will be crucial. They will also make the industry more robust and environmentally sustainable. Fruits and vegetables play a crucial role in combating the triple dangers of hunger, micronutrient deficiencies, and overnutrition thanks to elements of the value chain for horticulture commodities that create jobs and open new market opportunities.Horticultural crops contribute to wealth generation because they are often high value crops. The growth of horticulture is thought to benefit greatly from the advances made in basic research and new technologies, such as multi-omics technique, gene editing, big data mining, cloud computing, and novel sensor instruments (Gimode et al., 2021; Jha et al., 2019; Huang et al., 2016). Multi-omics, single-cell sequencing, genetic mapping, genetic engineering, cultivation, and post-harvest processing are a few examples of the interdisciplinary methodologies that could be integrated to produce new insights into crop improvement, domestication, evolution, storage, and synthetic biology.Modern agriculture has been fundamentally revolutionised by new technological discoveries, including robotics, drones, and computer vision software. These developments are still making their way forward, opening the door to new innovations and efficiencies. Several new data opportunities have arisen as a result of the development of digital agriculture and the technology that support it. During the course of a whole field, information can be gathered continuously by remote sensors, satellites, and Drones.

They can keep an eye on things like soil quality, humidity, temperature, and plant health.In recent years, horticulture has made sustainability one of its main objectives. This entails taking action in response to environmental factors, good agricultural practises, biodiversity preservation, and novel plant breeding techniques.

7.5 Conclusion:

Horticultural crops serve a crucial part in human life by providing us with food, beverages and decorative items. It is exciting that, as a result of amazing technological developments and very beneficial joint efforts, there has been significant program-based progress and success in the field of horticulture research. The issues brought on by population increase, the precipitous depletion of land resources, and the dangers posed by pests and illnesses are getting worse. In light of these facts, the future of horticultural research will revolve around the selection of superior varieties, efficient prevention and management of pests and diseases, and maintaining quality and yield to satisfy human needs while protecting the environment.Researchers should boost post-harvest storage and processing procedures for horticulture goods, optimise cultivation and management practises, and innovate the use of genetic resources. Particularly, we must meet the obstacles in terms of preservation and characterisation of the natural genetic variety of horticulture crops before adopting the revolutionary technology.The adoption of multi-disciplinary tools and contemporary biology and AI technologies will be effective to address horticultureproblems by highlighting the traits and significance of horticultural crops and summarising the major challenges anticipated in the future horticultural production process, including breeding, planting management, harvesting, and post-harvest processes. Researchers should work to accomplish sustainable development of smart horticulture, which has significant potential for future horticultural output, in addition to closely relating horticultural products and market consumption.

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