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BOTANICALS IN ECO-FRIENDLY POST HARVEST DISEASE MANAGEMENT

Mini Review Article

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ABSTRACT

Synthetic fungicides are widely used in conventional agriculture to control plant diseases. Post harvest pathogens which causes serious losses annually in Indian fruits and vegetables. The disease is currently managed with synthetic fungicides under post harvest condition by fungicidal dipping. Applied chemical pesticides are one of the effective and fast means for reducing the loss of post-harvest diseases. Nevertheless, the excessive use of these chemicals for controlling fungi in fruit has been counterproductive, causing damage to the environment and humans, with increased demands to reduce the use of these chemicals that accumulate in fruits and vegetables.

Introduction

Large numbers of synthetic chemicals are being used for the management of plant diseases. However, due to the development of new physiological races of pathogens, many of these synthetic chemicals are gradually become ineffective. Considerable attention has also been given to exploit the potential of biological control as a viable alternative. When applied as standalone treatments under commercial conditions, leads to the reduction in efficiency and consistency. Because of this, further alternative control methods particularly those which are environmentally safe and biodegradable have to be developed. The drawbacks in alternative methods have increased interest in developing environmentally safe and biodegradable products for the management of diseases. The replacement of synthetic fungicides by natural products (particularly plant origin), which are non toxic and specific in their action, is gaining considerable attention. Higher plants contain a wide spectrum of secondary substances *viz.*, phenols, flavonoids, quinones, tannins, essential oils, alkaloids, saponins and sterols. Such plant chemicals may be exploited for their different biological properties.

Why Consider Botanicals?

- Sustainable solutions in agriculture
- Reduce crop losses
- Eco-friendly
- Easily bio-degradable
- Organic farming
- Cheaper
- Integrated Diseases Management

Widely Adopted Botanicals for Plant Disease Management

The components with phenolic structures like carvacrol, eugenol, and thymol were highly active against plant pathogens. These groups of compounds show antimicrobial effect and serves as plant defence mechanisms against pathogenic microorganisms. The volatile antimicrobial substance allicin (diallyl thio sulphinate) is synthesized in garlic when the tissues are damaged and the substrate alliin (S-allyl-L-cysteine Sulphoxide) mixes with the enzyme alliin lyase. Allicin is readily membrane permeable and undergoes thiol disulphide exchange reactions with free thiol groups in proteins. Allicin effectively controlled most of seed and soil borne diseases especially, seed-borne *Alternaria* spp. in carrot, *Phytophthora* leaf blight (late blight) of tomato and tuber blight of potato as well as *Magnaporthe* blast disease on rice and downy mildew of *Arabidopsis thaliana*. Application of plant products especially essential oils is a very attractive method for

controling post harvest diseases. Essential oil extracted from lemon grass (*Cymbopogon* spp.) was widely used for post harvest anthracnose control of field and stored mango fruit.

Table 1. Mode of Action of Botanicals

Class	Sub-class	Mechanism
Phenolics	Simple phenols	Membrane disruption, substrate deprivation
Phenolic acids	Phenolic acids	Bind to adhesins, complex with cell wall, inactivate enzymes
Terpenoids, essential oils	Membrane disruption	Terpenoids, essential oils
Alkaloids	Intercalate into cell wall	Alkaloids
Tannins	Bind to proteins, enzyme inhibition, substrate deprivation	Tannins
Flavonoids	Bind to adhesins, complex with cell wall, Inactivate enzymes	Flavonoids
Coumarins	Interaction with eucaryotic DNA	Coumarins
Lectins and polypeptides	Form disulfide bridges	Lectins and polypeptides

The anti viral protein (AVP) extracts from *Bougainvillea spectabilis, Cocus nucifera, Prosopis chilinesis* and *Sorghum bicolor* were found to be effective in reducing the Sunflower Necrosis Virus (SFNV) infection both in cowpea and sunflower plants. At present, scientists are investigating for plant products of antimicrobial properties. It would be advantageous to standardize methods of extraction and *in vitro* antimicrobial efficacy testing so that the search for new biologically active plant products could be more systematic. Thousands of phytochemicals which have inhibitory effects on all types of microorganisms *in vitro* should be subjected *in vivo* testing to evaluate the efficacy in controlling the incidence of diseases in crops, plants, and humans.

Methods for Evaluation of Efficacy of Plant Extract/Botanicals

In vitro antimicrobial susceptibility testing (AST)

1) Diffusion test

a) Agar well diffusion

b) Agar disk diffusion

c) Poison food technique

d) Bio autography

2) Dilution methods

a) Agar dilution

b) Broth micro dilution assay

c) Broth macro dilution assay

Methods of Plant Extract Preparation

Extraction methods involve separation of biologically active fractions of plant tissue from inactive/inert components by using selective solvents and extraction technology. Solvents diffuse into the solid plant tissues and solubilize compounds of similar polarity. Quality of plant extract depends on plant material, choice of solvents and the extractionmethods.

Table 2. Solvents used for active component extraction

Solvents	Biologically active compounds
Water	Tannins, Saponins and Terpinoids
Ethanol	Alkaloids, Tannins, Flavonol and Terpinoids
Methanol	Tannins, Saponins, Flavonol and Terpinoids
Chloroform	Terpinoids and Flavonoids
Dichloro-methanol	Terpinoids
Ether	Alkaloids, Coumarins and Terpinoids
Acetone	Flavanols

Compounds of Plant Origin in Plant Disease Management

Some plant contains components that are toxic to pathogens. When extracted from the plant and applied on infested crops, these components are called botanical pesticides or botanicals.

Commonly used botanicals:

Plant Extracts: Neem (*Azadirachta indica*, A. Juss), Garlic (*Allium sativum*, Linn.), Eucalyptus (*Eucalyptus globulus*, Labill.), Turmeric (*Curcuma Longa*, Linn.), To-bacco (*Nicotiana tabacum*, Linn.), Ginger (*Zingiber offi-cinale*, Rosc).

Essential Oils: Nettle oil (*Urtica* spp.), Thyme oil (*Thymus vulgaris*, Linn.), Eucalyptus oil *Eucalyptus glo-bulus*, Labill. Rue oil (*Ruta graveolens*, Linn.), Lemon grass oil (*Cymbopogon flexuosus* (Steud.) Wats. and Tea tree oil (*Melaleuca alternifolia*).

Volatile Oils: Black pepper (*Piper nigrum* Linn.), Clove (*Syzygium aromaticum* Linn.), Nutmeg (*Myristica fragrans* Houtt.), Oregano (*Origanum vulgare* Linn.) and Thyme (*Thymus vulgaris* Linn.).

Gel and latex: *Aloe vera* (Tourn. Ex Linn.).

Plant Extracts

- Concentrated preparations of plants with active constituents obtained by use of suitable solvent.
- Have antimicrobial action or they may induce disease resistance by activating a signal transduction system in plants.
- Over four lakhs compounds in plant origin - bioactive organic chemicals and more than 10,000 reported to possess activity against pests and diseases. 342 - Fungicidal properties, 92 - Bactericidal properties and 90 - Antiviral properties
- Plant extracts of many higher plants, exhibit antibacterial, antifungal and insecticidal properties.
- Plant extracts have nature specificity, biodegradability, low toxicity and minimum residual toxicity in the ecosystem.
- Methods of application- spraying, fumigation and dipping.

Table 3. Plant Derived Purified Biochemical Products

Scientific name	Compound	Class	Activity
Aegle marmelos Linn.	Essential oil	Terpenoid	Fungi
Allium cepa Linn.	Allicin	Sulfoxide	Fungi & Bacteria
Allium sativum Linn.	Allicin	Solfoxide	Fungi & Bacteria
Azadirachta indica A.Juss.	Azadirachtin	Terpenoids	Fungi & Bacteria
Curcuma longa Linn.	Curcumin	Terpenoids	Fungi, Bacteria & protozoa
Datura stramonium Linn.	Hyoscymine Scopolamine	Alkaloids	Fungi
Eucalyptus globulus Labill.	Tannin	Polyphenol	Fungi, Bacteria & Viruses
Malus pumila Mill.	Phloretin	Flavonoids	General
Piper nigrum Linn.	Piperine	Alkaloid	Fungi
Ricinus communis Linn.	Ricinine Ricininoleic	Alkaloids	Fungi
Thymus vulgaris Linn	Caffeic acid	Terpenoid	Fungi, Bacteria & Viruses
Withania somnifera Dunal.	Withafarin A	Lactone	Bacteria & Fungi

Table 4. Plant Extracts Effective against Post Harvest Pathogens

Plant products	Pathogens suppressed	References
Psidium guajava (Leaf extracts)	*Aspergillus flavus* and *Aspergillus niger*	Mishra *et al*., 1992
Eugenia polyantha (Leaf extracts)	*Aspergillus alternata*, *Aspergillus niger* and *Botryodiplodia theobromae*	Mohamed *et al*., 1996
Curcurma domestica (Leaf juice)	*Aspergillus alternata*, *Aspergillus niger* and *Botryodiplodia theobromae*	Mohamed *et al*., 1996
Piper nigrum (Leaf extracts)	*Aspergillus alternata*, *Aspergillus niger* and *Botryodiplodia theobromae*	Mohamed *et al.*, 1996
Solanum nigrum (Leaf extracts)	*Aspergillus alternata*, *Aspergillus niger* and *Botryodiplodia theobromae*	Mohamed *et al*., 1996
Populus alba (Bark extracts)	*Botrytis cinerea*	Mori *et al*., 1997
Syzygium aromatium (Bark)	*Colletotrichum spp.*	Rodriguz *et al.*, 1998
Vitex negundo var. purpurescens (Leaf extracts)	*Cladosporium oxysporum* and *Fusarium oxysporum* f. sp.*radicola*	Prakasam *et al*., 2001
Ocimum gratissimum and *Syzygium aromatium*	*Aspergillus spp.*	Awuch and Ellis, 2002
Vinca rosea (Root extracts)	*Botryodiplodia theobromae*	Alam *et al*., 2002
Solanum torovum (Plant extracts)	*Collectotrichum musae*	Thanga Velu, 2004

Essential Oils

- Essential oils are made up of many different volatile compounds.
- The composition of the oil quite often varies between species.
- Essential oils possess antimicrobial and antifungal properties.

- Role plant defense mechanisms against Phytopathogenic microorganisms.
- Alternative to fungicides.
- The potential essential oils used widely against post harvest pathogens.
- Terpenoides and aromatic compounds in nature.

Components - carvacrol, thymol, cymene, terpine, phenylpropene derivatives, eucalyptol and anisol.
Examples: Nettle oil (*Urtica* spp.), Thyme oil (*Thymus vulgaris* Linn.), *Eucalyptus* oil (*Eucalyptus globules* Labill., Rue oil (*Ruta graveolens* Linn.), Lemon grass oil (*Cymbopogon flexuosus* (Steud.) Wats.) and Tea tree oil (*Melaleuca alternifolia* Maiden & Betche).

Table 5. Essential Oils Effective Against Post Harvest Pathogens

Plant products	Pathogens suppressed	References
Thyme oil	*Botrytis cinerea*	Arras and Piga, 1994
Cymbopogan flexuosus oil	*Aspergillus niger*	Dixit and Tiwari, 1995
Tea tree oil	*Botrytis cinerea*	Jobling, 2000
Ocimum basilicum oil	*Colletotrichum musae*	Anthony *et al.*, 2003
Mentha arvensis oil	*Penicillium italicum*	Tripathi *et al.*, 2004
Garlic oil	*Rhizoctonia carotae* and *Sclerotinia sclerotiorum*	Horberg, 2008
Peppermint, sweet basil	*Rhizopus stolonifer* and *Monilinia fructicola*	Sayed *et al.*, 2008

Volatile Oils

- Volatiles are small molecular weight organic com-pounds having appreciable vapour pressure at ambient temperature.
- Inhibit the growth of pathogen.
- Generally Recognized As Safe (GRAS).
- Isolated by hydro distillation or steam.
- Terpinoides-monoterpenes (C10), sesquiterpenes (C15) and diterpines (C20).

Examples: Black pepper (*Piper nigrum* Linn.), Clove (*Syzygium aromaticum* Linn.) Merr. & Perry, Nutmeg (*Myristica fragrans* Houtt.), Oregano (*Origanum vulgare* Linn.) and Thyme (*Thymus vulgaris* Linn.)

Plant Based Gel

Gel derived from *Aloe vera* plants has been found to be effective against grape pathogen

- *Penicillium digitatum*
- *Penicillium expansum*
- *Botrytis cinerea*
- *Alternaria alternata*

Latex

- Latex- natural fungicide.
- Safe and effective against various diseases of banana, papaya and other fruits.
- Water-soluble fraction of papaya latex against post harvest pathogens.
- Hevein was isolated from the latex of the rubber tree *(Hevea brasiliensis)* for control of *Botrytis cinerea* fungal pathogen.

Advantages of Botanicals

- Alternative to chemical control method.
- Act as insect repellent and antifeedent.
- Environmentally safe and biodegradable.
- Non-toxic, economically feasible.
- Effective antifungal, antibacterial, antiprotozoal, antiviral and nematicidal agent.
- Specificity is more than other antimicrobial compounds.
- Local availability.
- Less chance for development of resistance.
- Safer to non-targeted organisms.
- Minimum residual toxicity in the ecosystem.

Disadvantages

- Limited range of effectiveness.
- Decreasing efficacy and lack of consistency when these methodologies are applied as stand-alone treatments under commercial conditions is limiting their use.
- Extraction methods are not standardized for all the antimicrobials.
- Rapid degradation.
- Most studies are *in vitro* efficacy.
- Need the development of formulations.
- Less effective or specific to restricted plants.
- Less availability formulations.

Conclusion

Naturally plants contain lot of biochemical constituents and are valuable sources of new and biologically active molecules possessing antimicrobial property. The ethno botanical study of plant is important for modern day biological science, but its usefulness cannot be overemphasized if methods are not standardized to obtain comparable and reproducible results. At present, scientists are investigating for plant products of antimicrobial properties. It would be advantageous to standardize methods of extraction and *in vitro*

antimicrobial efficacy testing so that the search for new biologically active plant products could be more systematic and interpretation of results would be facilitated. Efficient collaborations with pharmacologists and physicians, plant pathologists, plant physiologists, entomologist and microbiologists are crucial to see the complete development of an interesting lead compound into an exploitable product.

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