Management of Post Harvest Diseases of Fruits using Plant Products

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Abstract

This review deals with the scope of using some botanicals for the management of post harvest diseases of fruits, thereby prolonging their shelf life. Plant products are an important source of agrochemicals used for the control of various post harvest losses including diseases as well as insect pests. The overzealous and indiscriminate use of most of the synthetic fungicides has created different types of environmental and toxicological problems. Recently, in different parts of the world, attention has been paid towards exploitation of higher plant products as novel chemotherapeutants in plant protection. These are being used to manufacture natural or biopesticides, which are environmental friendly and do not have any toxic effects on plants and soil.

Keywords: Botanicals, biopesticides, plant extracts, post harvest diseases, fruits

1. Introduction

Plants have ability to synthesize aromatic secondary metabolites, like phenols, phenolic acids, quinones, flavones, flavonoids, flavonols, tannins and coumarins (Cowan, 1999). The components with phenolic structures, like carvacrol, eugenol, and thymol, were highly active against the plant pathogens. These groups of compounds show antimicrobial effect and serves as plant defence mechanisms against pathogenic microorganisms (Das et al., 2010).

Post harvest diseases of fruits caused by pathogens pose a major challenge throughout the fruit growing areas of the world accounting to about 20-25% of the harvested produce during postharvest handling (El-Ghaouth et al., 2004; Droby, 2006; Zhu, 2006; Singh and Sharma, 2007) in developed countries and even more exasperating in the developing countries, where it often exceeds over 35% due to inadequate storage, processing and transportation facilities (Abano and Sam-Amoah, 2011). Aside from direct economic considerations, diseased produce poses a potential health risk. A number of fungal genera such as *Aspergillus, Penicillium, Alternaria* and *Fusarium* are known to produce mycotoxins under certain conditions. Losses due to postharvest disease are affected by a great number of factors including: commodity type, the postharvest environment (temperature, relative humidity, atmosphere composition, etc.), produce handling methods, post harvest hygiene, produce maturity and ripeness stage, cultivar susceptibility to postharvest diseases and treatments used for disease control.

Synthetic fungicides are currently used as the primary means for the control of postharvest diseases of fruits. However, increasing public concern over the indiscriminate use of pesticides and associated health risks and environmental hazards, as well as occurrence of fungicide resistant pathogen strains, has stimulated research on alternative methods to control postharvest diseases (Yao and Tian, 2005). So, there is urgent need to adopt safer and environment friendly alternative to manage the postharvest decay in fruits and vegetables Recently, plant extracts are emerging as safer alternatives to conventional fungicides for the control of plant diseases (Tripathi and Shula, 2007). Natural product based fungicides have the ability to decompose rapidly, thereby reducing their risk to the environment (Fokialakis et al., 2006). The antifungal activities of different plant species and the importance of plants as possible sources of natural fungicides are well established. They play an important role in the preservation of foodstuffs against fungi and have potential to replace synthetic fungicides (Tripathi and Shukla, 2007).

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. The objective of this review is to give information about various medicinal plants that have been screened for their antifungal activity and can act as a good source for the bio-management of fungi causing postharvest rot diseases.

2. Mode of Action of Botanicals

Plant produces some chemicals to protect itself from diseases and insect pests. These chemicals are known as phytochemicals. Phytochemical studies are considered as an important step in the understanding of antimicrobial compounds isolated from plant products. There are a number of families of phytochemicals like tannins, saponins, steroids, alkaloids, phenolics, flavonoids, lignins, quinones and cyanogenic glycosides (Shetty, 1997). The mechanism of action (Table 1) of plant products on fungal cells is thought to be: (a) granulation of cytoplasm, (b) membrane rupture in cytoplasm, (c) inhibition and inactivation of intracellular and extracellular enzyme synthesis. These actions can occur in an isolated or in a concomitant manner and culminate with mycelium germination inhibition (Cowan, 1999).

Table 1: Mode of action of botanicals

Class	Mechanisms
Phenolics	Membrane disruption, substrate deprivation
Terpenoids, essential oils	Membrane disruption
Alkaloids	Intercalate into cell wall
Tannins	Bind to proteins, enzyme inhibition, substrate deprivation
Flavonoids	Bind to adhesins, complex with cell wall, Inactivate enzymes
Coumarins	Interaction with eucaryotic DNA
Lectins and polypeptides	Form disulfide bridges

3. Biological Control Using Botanicals

Extensive work has been carried out to evaluate the antimicrobial efficacy of various medicinal plant extracts against phytopathogenic fungi. It has been reportedthat they play an important role in controlling diseases of plants caused by thesefungi (Hossain et al., 1993; Anwar et al., 1994; Jacob andSivaprakasan, 1994; Arya etal., 1995; KaradeandSawant, 1999;Datar, 1999; Anwar and Khan, 2001; Lin et al., 2001;Okemo et al., 2003; Choi et al., 2004; Mares et al., 2004; Khalil et al., 2005; Abd-El-Khair and Haggag, 2007; Ogbebor et al., 2007; Perez-Sanchez et al., 2007; Baka, 2010; Znini et al., 2011; Raji and Raveendran, 2013; Parveen et al., 2014, Ekwere et al.,2015; Nweke, 2015). Dababneh and Khalil (2007) studied the effect of five different medicinal plant extracts, viz. *Crupina crupinastrum*, *Teucrium polium*, *Achillea santolina*, *Micromeria nervosa* and *Ballotaphilistaea*, against four pathogenic fungi, viz., *Fusarium oxysporum*, *Rhizoctonia solani, Penicillium* sp. and *Verticillium* sp.

Webster et al. (2008) screened 14 plants for their antifungal activity against various pathogenic fungi and concluded that *Fragaria virginiana*, *Epilobium angustifolium* and *Potentilla simplex* show a promising antifungal potential. Bobbarala et al. (2009) reported the antifungal activity of 49 different plant extracts against *Aspergillus niger*. Among the 49 plants used, 89% showed antifungal activity, while 11% were not effective. Satish et al. (2009) reportedthe antifungal potential of 46 plants against eight species of *Fusarium*, viz. *F. equiseti*, *F. moniliforme*, *F. semitectum*, *F. graminearum*, *F. oxysporum*, *F. proliferatum*, *F. solani* and *F. lateritium.* Taskeen-Un-Nisa et al. (2010, 2011) reported the antimicrobial activity of some plant extracts including onion *(Alliumcepa*), garlic (*Allium sativum*) and mint *(Menthaarvensis*), against *Alternariaalternata*, *Rhizopusstolonifer* and *Fusarium oxysporum* (Table 2).

Table 2: Botanicals used for the control of post harvest pathogens

Plant extract	Fungal pathogens	References
Aframomummelegueta	*Botryodiplodia theobromae, Fusarium oxysporum Aspergillusniger*	Okigbo and Ogbonnaya (2006)
Allium sativum	*Penicillium sp., Aspergillus candidus, Fusarium culmorum, Aspergillus niger, Fusarium oxysporum, Rhizopus stolonifer, Penicillium chrysogenum*	Magro et al. (2006), Taskeen-Un-Nisa (2010, 2011), Hadi and Kashefi (2013)
Annonareticulata	*Rhizopus stolonifer, Colletotrichum gloeosporioides*	Bautista-Banos et al. (2000)
Artemisia absinthium	*Alternaria alternata* (Alternariarot), *Penicilliumexpansum* (Penicilliumrot), *Aspergillus niger* (Black mould rot)	Parveen et al. (2013, 2014)
Boragoofficinalis	*Monilinia laxa*, *Botrytis cinerea*, *Penicillium* spp, *Aspergillus* spp.	Gatto et al. (2011)
Curcuma longa	*Colletotrichum gloeosporioides* (anthracnose diseases of fruits)	Imtiaj et al. (2005)
Daturainnoxiaand Daturastramonium	*Alternaria solani*, *Fusarium oxysporum*	Jalander and Gachande (2012)

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Plant extract	Fungal pathogens	References
Ferula communis	Identical to the pathogens of *Dittrichia viscosa*	Mamoci et al. (2011)
Hypochaerisradiata	*Mucor* sp., *Trichoderma viride*, *Candida albicans*, *Fusarium* sp., *Penicillium* sp., *Aspergillus* spp.	Sengut-tuvan et al. (2013)
Lavandulastoechas	*Penicillium* sp., *Aspergillus candidus*, *Fusarium culmorum*, *Aspergillus niger*	Magro et al. (2006)
Menthaarvensis	*Aspergillus niger*, *Fusarium oxysporum*, *Rhizopus stolonifer*, *Penicillium* sp.	Taskeen-Un-Nisa (2010, 2011)
Menthacordifolia	*Colletotrichum gloeosporioides*	Bussaman et al. (2012)
Menthapiperita	*Penicillium* sp., *Aspergillus candidus*, *Fusarium* spp, *Aspergillus niger*	Hadi and Kashefi (2013)
Ocimumgratissimum	*Botryodiplodia theobromae*, *Fusarium oxysporum*, *Aspergillus niger*, *Rhizopus oryzae*	Amandioha (2001), Okigbo and Ogbonnaya (2006)
Orobanchecrenata	Identical to the pathogens of Boragoofficinalis	Gatto et al. (2011)
Piper sarmentosum	*Colletotrichum gloeosporioides* (anthracnose disease)	Bussaman et al. (2012)
Plantagolanceolata	Identical to the pathogens of *Artemisia absinthium*	Parveen et al. (2013, 2014)
Tageteserecta	*Colletotrichum gloeosporioides* (anthracnose diseases of fruits)	Imtiaj et al. (2005)
Warioniasaharae	*Alternaria alternata* (Alternariarot), *Penicillium expansum* (Penicillium rot), Rhizopus stolonifer (Rhizopusrot)	Znini et al. (2013)

Gatto et al. (2011) studied the *in vitro* and *in vivo* activity of extracts from nine herbaceous species, viz. *Borago officinalis*, *Orobanche crenata*, *Plantago lanceolata*, *Plantagocoro- nopus*, *Sanguisorba minor*, *Silene vulgaris*, *Sonchusasper*, *Sonchus oleraceus* and *Taraxacum officinale*, against some postharvest fungal rot causing pathogens (*Monilinialaxa*, *Botrytis cinerea*, *Penicillium expansum*, *Penicillium digitatum*, *Penicillium italicum*, *Aspergillus carbonarius* and *Aspergillus niger*) and reported that the extract of *Sanguisorba minor* completely inhibited the spore germination of *Monilinia laxa, Penicillium digitatum*, *Penicillium italicum* and *Aspergillus niger*. Parveen et al. (2013, 2014) reported the antifungal activity of five different plant extracts, viz. *Artemisia absinthium*, *Rumex obtusifolius*, *Taraxacum officinale*, *Plantago lanceolata* and *Malva sylvestris*, against some rot-causing fungal pathogens, *Alternaria alternata*, *Penicillium expansum*, *Aspergillus niger* and *Mucor piriformis.*

Essential oilshave been extracted from various plants and evaluated for their efficacy againsta number of pathogenic fungi causing postharvest rots of rosaceous fruits(Pandey et al., 1982; Edris and Farrag, 2003; Nakamura et al., 2004; Chuang et al., 2007; Tzortzakis and Economakis, 2007; Soylu et al., 2010; Znini et al., 2011). Znini et al. (2013) extracted an essential oil from the plant *Warioniasaharae* and reported its antifungal activity against three apple phytopathogenic fungi, viz. *Alternaria* species (*Alternaria*rot), *Penicillium expansum* (blue mould), and *Rhizopus stolonifer* (*Rhizopus*rot). The extracts of these plants used by different researchers against pathogenic fungi show promising antifungal activity which indicates that these plants can act as a good biological resource for producing safe biofungicides.

4. Conclusion

At present, lots of research is taking place to isolate, characterize and identify the plant products having antimicrobial properties. To have better identification of antimicrobial compounds, it is necessary to standardize the extraction methods, as well as designing a systemic approach to test the antimicrobial compounds against a wide range of post harvest pathogens. It is important to carry out more research studies on less known aspects of biological control including the development of novel formulations from bioagents of plant origin reported by several researchers.

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