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Herbs and Spices: Plants Protecting Plants

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Sustainable agriculture ushers the utilization of herbs and spices for protecting crops in the fields for safer food and environment. Plants produce active ingredients that can also protect other plants and can be used for organic agriculture. This paper reviews the utilization of commercial herbs and spices as green biopesticides, their phytochemical profile and modes of actions as well as their formulations as biocontrol in the Philippines. Meta-analysis revealed that most studies worked on essential oils, crude extracts and aqueous solutions of spices, and assays for flavanoids alkaloids, cardiac glycosides, saponins, tannins, and terpenoids. Results of studies accountedfor the biopesticidal properties to their phenolic content.Review also revealed that studies found that that modes of actions associated with antimicrobial actions of these spices are loss of cytoplasmic components due to leakage associated with disruption of cell walls and membranes and changes in the chemical composition and metabolism of fats and nucleic acids. There are limited investigation on influence of herbs on their effect on plant pathogens and pests. However, the limited studies revealed that the spices and herbs are effective biopesticides.

Keywords: herbs and spices, antimicrobial; essential oils, biopesticides, phytochemicals

Introduction

In nature, plants have great strategies of protecting themselves. Man through centuries have utilized plants as food to keep him healthy and harness their bountiful potent chemicals to protect himself from diseases. In return, man protected plants through use of non-organic and syntheticchemicalsthat brought about health and environmental issues. Man has to look back and study that plants can protect themselves and use this insight and knowledge to develop organic pesticides from plantsfor safer health and environment.

Herbs and spices spike up flavor and aroma of food. Spice is more of a culinary term that refers to extracts from parts of plants, maybe roots, leaves, blooms, skin or skin, that are added to food to enhance flavor and smell of

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food (Farrel, 1990). Today, the American Spice Trade Association considers spices as "any dried plant product used primarily for seasoning purposes covering a wide range of plants like herbs, spice seeds and even dehydrated vegetables and spice blends.The list is numerous and used more commonly as food additives in oriental cuisines. The spices are also known for their medicinal properties.

This review gives another perspective to role and use of herbs and spices outside the culinary world and into the world of sustainable agriculture. This paper reviews researches conducted on the phytochemical profiles of common spices, their uses as biopesticides and as antimicrobials.

Phytochemical Profile of Common Spices

Plants synthesize secondary metabolites and in agricultural studies, thesecompounds have broad-spectrum activities against fungi, nematodes, and insects(Lee *et al.* 1997; Wilson *et al.* 1997 and Calvet 2001). Phytochemicals are bioactive and non-nutrient substances which are naturally found abundant in spices.There are a numberof plant-based antimicrobial constituents, including many essential oils, tannins, glycosides,and resins, that can be found in certain spices. Specific examples includeeugenol in cloves, allicin in garlic, cinnamic aldehyde and eugenol in cinnamon, allylisothiocyanate in mustard, eugenol and thymol in sage, and carvacrol (isothymol)and thymol in oregano (Jay 2000). Table 1 shows a summary table of phytochemical profile of some common spices from work of Sibi *et al*, (2013); Harsha *et al*., (2013); Nwinuka *et al*., (2005);Otunola (2010)and Ramya and Ganesh (2012).

Table1. Phytochemical profile of some spices

Spices	GLYCOSIDES	STEROIDS	ALKALOIDS	FLAVANOIS	SAPPONINS	TANNINS	TERPENOIDS	ANTHOCYANIN	COUMARINE
*Allium sativum*Garlic clovers	P		P	P			P		
Allium cepa var. cepa (onion)	P				P	P			
Caparis spinose(Caper)	P	P	P	P			P		
Capsicum frutescens(chili)			P	P	P	P			
Cinnamommumverum(Cinnamon),	P	P	P	P	P	P	P	P	P
Cinnamomumzeylanicum(Cinnamon)	P		P	P	P	P	P		
Cucurma longa(turmeric powder)		P			P			P	
Illiciumverum(Star anise)				P		P		P	
Piper nigrum(black pepper)	P		P	P	P	P	P		
Pimpinellaanisum(star anise)	P		P	P	P	P	P		
Piper guineense Ashanti pepper	P				P	P			
Zingiberofficinale (ginger)	P		P	P	P	P			
*Laurusnobilis(*Bay leaf)	P	P	P	P		P	P		
Carumcarvi(Caraway)	P	P		P		P	P		
*Elettariacardamomum (*Cardamom)	P	P		P			P		
*Syzygiumaromaticum (*Clove)	P	P	P	P	P	P	P		
*Coriandrumsativum*Coriander	P	P		P			P		
*Cuminumcyminum (*Cumin)	P	P		P	P	P	P		
*Foeniculum vulgare (*Fennel)	P	P		P			P		
*Papaver somniferum (*Poppy)	P	P					P		
*Parmeliaperlata (*Stone flower)	P	P	P			P	P		

*Summarized from Sibietal , 2013; Harsha *et al.*, 2013;Nwinuka *et al.*, 2005;Otunola *et al.*, 2010 ; Ramya and Ganesh, 2012

The antimicrobial properties of spices have been associated with the presence of phytochemicals in spices bacteriostatic and bactericidal activity such as included tannins, alkaloids, terpenoids, flavanoids, cardiac glycosides and saponins (Simões*et al*. 1999);Okarter et al., 2009; Harsha,2010)

One of these phytochemicals is alkaloids, a varied group of secondary metabolitesfound in almost all plants. Theyare known to be pharmcologically valuable because they disrupt the integrity of bio-membrane, potent inhibitors of ion channel and impair the function of microtubules or microfilaments; and are "mutagenic and carcinogenic due to their properties to bind DNA and acts at DNA and RNA polymerase level and act as antibiotics and inhibits the translation process in various organisms."(Mahajan *et al.* 2013).

Spices as GreenBiopesticides

Researches in the recent years have focused on the use of organic and green pesticides. The spices have not been overlooked in this aspects. Several researches have reported that the spices can be used as different forms of protecting plants and saving valuable crops in more sustainable way. Investigations used crude extracts with different solvents as well as essential oils.

Koul and colleagues (2006) reported that essential oils of some common spices act in varied ways to control plant pests- as insecticides and growth inhibitors, fumigants, antifeedant,repellants, oviposition inhibition and ovicides, attractants, antifungal and antiviral agents. They further stated that the "move toward green chemistry processes and the continuing need for developing new crop protection tools with novel modes of action makes discovery and commercialization of natural products as green pesticides an attractive and profitable pursuit …"Spices offer a promising alternativefor food safety and plant protection. Inhibitory activity of spices and theirderivatives on the growth of bacteria, yeasts, fungi and microbial toxin synthesishas been reported (Notermans and Hoogenboon-Verdegaal 1992; Sagdiç*et al*. 2003).

Koul's review cited *Eugenia cryophyllus, Eucalyptus globules*, *Cymbopogonnardus*; *Menthapulegium*, and *Thymus vulgaris* are among the spices that produce active ingredients against insects ((Lee *et al.,* 1997; Hummelbrunner and Isman, 2001). Pure constituentsof citronellal, eugenol, menthol, pulegone, and thymol are cited tobe moderately active against various mites (Calderone and Spivak, 1995; Perrucci*et al*., 1995; Ellis and Baxendale, 1997).Pulegone, linalool and limonene and*Menthacitrata oil* are known effective fumigants against rice weevil (Singh *et al.,* 1989). thymol, citronellal and α-terpineol against tobacco cutworm, *S. litura*(Hummelbrunner and Isman,

2001); cineole against *T. castaneum*(Tripathi *et al.*, 2001.) Chowdhury *et al*., (1999) and Agarwal and Walia (2003) isolated insect antifeedant products from from*Curcuma longa* (turmeric) and *Zingiberofficinale*(ginger) whileKoschier and Sedy, (200) from essential oils of majoram androsemary oil (*Rosemarinum officinalis*) against onion thrips.Moreoer, alkaloids are involved in plant-herbivore interaction, plant-plant interaction and plant-microbial interaction and may act as potent feeding deterrents in lepidopteran insects suggest alkaloids as novel candidates in designing suitable strategies for crop protection from insect pests (Mahajan *et al*. 2013; Shields *et al.*, 2015).

Spices as Antimicrobials

Spices offer a promising alternativefor food safety and plant protection. Inhibitory activity of spices and theirderivatives on the growth of bacteria, yeasts, fungi and microbial toxin synthesishas been reported (Notermans and Hoogenboon-Verdegaal 1992; Sagdiç *et al*. 2003).

A number of studies have reported a high correlation between antimicrobial efficacy and thelevel of phenolic components present in certain herb and spice preparations. Indeed, compounds such as eugenol,carvacrol and carnosic acid present in clove, oregano and rosemary; respectively, have been identified as beingresponsible for antimicrobial activity (Dorman & Deans, 2000; Moreno, Scheyer, Romano, &Vojnov, 2006; Kim *et al*. 1995).

Antifungal studies are not as many as antibacterial properties of spices However, with limited studies, thymol and carvacrol are active against most fungal species tested (Kurita *et al.*, 1981; Muller-Riebau *et al*., 1995; Tsao and Zhou, 2000). El Moughy and compnay (2007) demonstrated that spice extracts show superior reducing effect on damping-offdisease incidence at pre-emergence growth stage to that of powder treatments. The mechanism of action of these compounds against fungi is unknown but may be related to their general ability to dissolve or otherwise disrupt the integrity of cell walls and membranes (Isman and Machial, 2006; El Moughy *et al*, 2007).Juven *et al*. (1994) hypothesized that the inhibition caused by spices involves phenolic compounds that sensitize the phospholipid bilayer of the microbial cytoplasmicmembrane causing increased permeability and unavailability of vital intracellularconstituents.

With the wide variety of modes of actions of the active ingredients and secondary metabolites present in spices, it may be a worthy consideration for their development as products that will protect crops for safer food and environment.

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