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PLANTS AS NATURAL DEFENDERS AGAINST MYCOTOXINS CONTAMINATION IN AGRICULTURE

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Abstract

Through a variety of biological and chemical processes, plants play a significant role in preventing mycotoxin contamination in agriculture. Some plants produce natural antifungal compounds, such as phytoalexins, which inhibit the growth of pathogenic fungi responsible for mycotoxins. Also, certain plants help control fungi by changing the growing environment, influencing factors such as soil pH, humidity, and temperature, conditions that can prevent their development. The antifungal qualities of cultivated, aromatic, or medicinal plants like oregano (*Origanum vulgare*), thyme (*Thymus vulgaris*), and rosemary (*Rosmarinus officinalis*) are frequently researched. In addition, plant-fungus interactions in the soil can reduce fungal infections and, by implication, mycotoxin contamination. In practice, plants can be used in agricultural management strategies to minimize contamination risks, such as crop rotation or choosing plants that are more resistant to fungal attack. Therefore, by incorporating them into ecological practices and sustainable farming systems, plants can help lower the exposure of humans and animals to mycotoxins in addition to aiding in the control of fungi.

Introduction

Contamination of food and feed with toxic fungi can have serious health consequences. Toxic fungi, such as *Aspergillus* or *Fusarium*, produce mycotoxins that can negatively affect humans and animals. These toxic substances can become present in foods such as cereals or their by-products due to appropriate growing conditions, such as humidity and temperature. Approximately 60-80% of crops worldwide are susceptible to mycotoxin contamination, causing significant economic losses. In the agricultural industry, mycotoxins can reduce animal growth rate, immunity and fertility, as well as egg, meat and milk production. Monitoring and controlling these toxic fungi is important to ensure global food safety. Plants are considered environmentally friendly and safe sources of bioagents for the control of fungi and mycotoxins in food and feed. They offer a synergistic approach to protect against fungal contamination and to stimulate the natural defense systems of plants. Plants have bioactive compounds with the ability to combat the toxic and genotoxic effects of mycotoxins, reducing the risks of mutagenicity and carcinogenicity.

Aromatic and medicinal plants have been used throughout history not only for their aroma and taste, but also for their healing properties. Many of them contain active compounds that give them antifungal properties, offering natural solutions in combating pathogenic fungi that can affect crops or food products. The following table highlights the antifungal properties of various aromatic and medicinal plants, details their active compounds and common uses.



Table 1. Antifungal Properties of Aromatic and Medicinal Plants

Table 2. Antifungal effects of plant extracts, their compounds and nanoformulations against mycotoxigenic fungi

Plant	Scientific Name	Active Compounds	Antifungal Properties	Uses
Oregano	<i>Origanum vulgare</i>	Carvacrol, Thymol	Inhibits growth of pathogenic fungi like <i>Candida</i>	Food preservation, herbal treatments
Thyme	<i>Thymus vulgaris</i>	Thymol, Carvacrol	Strong antifungal activity against <i>Aspergillus</i>	Food protection, antiseptic in natural remedies
Rosemary	<i>Rosmarinus officinalis</i>	Rosmarinic acid, Carnosic acid	Reduces risks of contamination with mycotoxins	Culinary uses, cosmetics, aromatherapy
Garlic	<i>Allium sativum</i>	Allicin	Broad-spectrum antifungal effects	Food flavoring, natural antifungal treatments
Sage	<i>Salvia officinalis</i>	Camphor, Thujone	Antifungal properties against several fungi species	Culinary uses, traditional medicine
Peppermint	<i>Mentha × piperita</i>	Menthol, Menthone	Effective against certain fungal strains	Herbal teas, natural remedies
Clove	<i>Syzygium aromaticum</i>	Eugenol	Potent antifungal activity	Culinary spice, natural preservative
Lavender	<i>Lavandula angustifolia</i>	Linalool, Linalyl acetate	Antifungal effects, particularly against mold	Aromatherapy, cosmetics, natural cleaning
Basil	<i>Ocimum basilicum</i>	Eugenol, Linalool	Inhibits growth of various fungi	Culinary uses, pest deterrent

Plant/Compound	Antifungal Effect	Target Mycotoxic Fungi	Application Form
Garlic (<i>Allium sativum</i>)	Inhibits fungal growth	<i>Aspergillus</i> , <i>Penicillium</i>	Extract, essential oil
Thyme (<i>Thymus vulgaris</i>)	Strong antifungal activity	<i>Aspergillus flavus</i> , <i>Fusarium spp.</i>	Extract, essential oil
Field Thyme (<i>Thymus serpyllum</i>)	Moderate antifungal effects	<i>Fusarium</i> , <i>Penicillium</i>	Extract, powder
Peppermint (<i>Mentha piperita</i>)	Antifungal activity	<i>Aspergillus</i> , <i>Fusarium spp.</i>	Extract, essential oil
Oregano Oil (<i>Origanum vulgare</i>)	Effective against fungi	<i>Aspergillus</i> , <i>Candida</i>	Essential oil
Propolis Extract	Variable antifungal effect	<i>Aspergillus</i> , <i>Penicillium</i>	Extract
Nanoformulations with Essential Oils	Enhanced antifungal efficacy	<i>Aspergillus</i> , <i>Fusarium spp.</i>	Nanoparticles with oils
Chicory (<i>Cichorium intybus</i>)	Moderate antifungal activity	<i>Aspergillus flavus</i>	Extract

Many plant species have been investigated for their antifungal activities, with many essential oils inhibiting post-harvest fungal contamination and extending the shelf life of many crops under storage conditions. Essential oils also inhibit the production of mycotoxins by several fungal species. Some plants can protect themselves against various phytopathogens, and these plants produce a variety of antimicrobials (e.g., phytoalexins and phytoanticipins). They differ in a) molecular weight, b) structure, c) functionality, and d) class (e.g., alkaloids, flavonoids, terpenoids, phenolics, glycosides, tannins, fatty acids). The advantage of plant extracts is that they often contain a mixture of chemicals that can work synergistically to inhibit the growth of phytopathogenic fungi. Many plant extracts also contain more than one antifungal compound. If these compounds have different mechanisms of action, this may lead to a decrease in the development of resistance. Therefore, the use of plant extracts can reduce the development of resistance against antimicrobial compounds.

Conclusions

In conclusion, the use of plant extracts and their compounds as natural defenders against mycotoxin contamination in agriculture presents a promising strategy for improving crop protection and food safety. Various plants, such as garlic, thyme, and oregano, have demonstrated significant antifungal properties against common mycotoxigenic fungi, such as *Aspergillus* and *Fusarium*. These natural alternatives not only reduce the dependence on synthetic fungicides but also contribute to sustainable agriculture. Incorporating plant-derived antifungal agents into agricultural management can help mitigate the risks of mycotoxin contamination in food and feed, protecting both human and animal health. Furthermore, innovative approaches, such as nanoformulations, can enhance the efficacy of these plant extracts, providing more robust solutions to combat fungal threats. Overall, harnessing the natural antifungal properties of plants can serve as an effective and environmentally friendly strategy in the ongoing fight against mycotoxins in agriculture.