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The Role of Secondary Metabolites in the Conocarpus spp. in Controlling of Plant Diseases: A Review

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Abstract: This study aimed to demonstrate the effectiveness of the conocarpus plant and its importance in several fields, including its ability to grow and survive and resist the environmental conditions to which it is exposed, as well as the aesthetic role of the plant and its use as windbreaks and erosion control and its properties in protecting plants from pathogens, which is due to its containment of secondary metabolites compounds (derivatives of primary metabolic compounds), in addition to the statement of the positive effect of conocarpus plant in reducing the plant diseases, which was confirmed by previous studies, as studies showed that aqueous and alcoholic extracts of conocarpus plant achieved a high effectiveness in reducing pathogens compared with control treatment (which represents the plant only). Also, it showed that the alcoholic extracts were the most effective in inhibiting pathogens in the laboratory experiments, reducing the infection percentage and infection severity in the field experiments and increasing the growth parameters compared with aqueous extracts.

Keywords: *Conocarpus* spp., secondary metabolic compounds, button wood

Introduction:

Nowadays, plants are of great importance as they are an important source of active ingredients that are used in many fields. These ingredients are naturally made in plants and stored. Usually, plants have a specific number of major metabolic compounds and many secondary metabolites compounds. These compounds are formed to meet all the needs for growth and reproduction or to survival, where each compound has a role for the survival and continuity of plants, they are called secondary metabolites compounds, which are derivatives of primary metabolic compounds that play a physiological role in the environment of the plant itself, other plants or living organisms, for example, they have a role in biological functions, they may be repellent, attractant or protective compounds, as these compounds work to spread pollen grains and seeds as wellas attract animals through the color, smell and chemicals taste. Also, they work as anti-pathogens and herbivores, in addition to, the secondary metabolites compounds work as signals to stimulate defenses in the plant and delay the growth of pathogens as well as they have an important role in plant symbiotic relationships (Schafer, 2009), as they are important in the competition and survival of plants. The number of secondary metabolites compounds exceeds 200,000, that are produced by plants and accumulated in small amounts, but the number of secondary metabolites diagnosed isn't much. Wink (2008) mentioned that 100,000 compounds were isolated from the plants.

Secondary metabolites compounds are produced in different partsof the plant, and the diversity of compounds and their synthesis varies according to different plant species. However, some compounds are produced in all types of plant tissues, while some compounds are produced in special tissues, cells or organs (Yazdani et al., 2011).Most of the hydrophilic secondary metabolites compounds accumulate in the vacuoles whereas the lipophilic secondary metabolites compounds are present in the epidermis or on the epidermis or lipocytes (Engelmeier and Hadacek, 2006). The compounds produced have a role in the management of plant pathogens (Salih and Al Dabagh ,2021), as these plants have proven their great role in controlling pathogens or reducing their impact, as well as being environmentally safe compounds, cheap and easy to obtain, therefore their use in controlling or reducing the impact of pathogens reduces the resulting environmental pollution about the incorrectly use of pesticides which leads to the emergence of resistan strains and contamination of the environment with chemical pesticides (Abdul-Karim , 2021 ; Hassan et al.,2021), so,studies have tended to find and study the effectiveness of secondary metabolites compounds produced by plants.Therefore, it is necessary to stop at these plants (Al-Abide, 2022), including the conocarpus plant which is known for its ability to grow in different environments and under environmental stress and currently used in many countries, and know the compounds that they form and the role that these compounds play, whether for the growth and reproduction of the plant or its role in controlling pathogens, which many studies have proven its effective and important role in inhibiting the growth of pathogens.

Conocarpus plant taxonomy

It is called dhmas and carpus, and in English it is called Button wood and Button mangrove, while the scientific name is *Conocarpus erectus* L. It belongs to the Comberataceae family, the order of Myrtales, and class of Magnoliidae (Alsharekh et al., 2022). It is cultivated in public gardens and park to cover greenery, protects the soil during storms and helps in stabilizing the soil during sand dunes.

Its branches and stems are used as animal forage, and its leaves are used in tanning leather because it contains tannins, as well as the use of wood for the manufacture of furniture, boats, ships and building houses as a result of its hardness and strength, in addition to, it is used in the production of charcoal.Also, it is used in the treatment of anemia, colds, fever, headache, diarrhea, tumors, wounds and diabetes (Raza et al., 2018; Santos, 2018) as well as its role in inhibiting bacterial and fungal pathogens such as *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsella pneumonia*, *Bacillus cereus*and *Proteus mirabilis*which makes it very important (Touqeer et al., 2014).

Description of Conocarpus

Conocarpus trees (shrubs) have an attractive appearance, evergreen, their height reaches 20 m, with an erect stem, many branches, and their secondary roots are dark brown. The phloemis thin and wrinkledand theirbranches are thin and yellow-green bearing glossy green spear-shaped leaves with a smooth edge, sharp top and short petioles, alternating on the branches.Their flowers are terminal or axillary, green or greenish-white, gathered in conical heads. The fruit is green and turns reddish-brown upon maturity and dryness (Jasim et al., 2020).It is characterized by its tolerance high and low temperatures and grows in all types of sandy, clay, loam and alkaline soils and hardpan soils that are impermeable to water. Also, it has the ability to resist salinity, as well as its rapid growth in summer season. Also, it is characterized by its resistance to ultraviolet rays and isn't affected by the gases emitted from factories and other pollutants. It is recommended to sowing it in external roads as windbreaks and green fences because it has dense leaves and intertwined branches, which makes it abundant shade and noise-reducing, but it isn't recommended to sowing it near buildings because it has a dense and water-loving root system, it grows towards water and sewage pipes and has a horizontal and rapid growth.

Spread and distribution of Conocarpus

The plant spreads in a wide range on the coasts in the tropical and subtropical regions and in the south and central Atlantic Ocean of Florida, North and South America, Brazil, Ecuador, East Africa, Eritrea, Yemen, Somalia and Djibouti. Also, it is found in the south of the Arabian Peninsula, Sudan, India, Pakistan and Australia, and its sowing was introduced to Saudi Arabia, Kuwait, UAE and Oman because they suffer from desertification and the lack of vegetation cover. Also, it has been introduced to Iraq and is cultivated all over the country (AL-Surrayai et al., 2009; von Linsingen et al., 2009).

Secondary compounds in conocarpus

Conocarpus contains many secondary metabolites compounds that are effective in inhibiting many pathogens, where it contains phenolic compounds such as flavonoids and tannins as main compounds in leaves, fruits and roots (Jasim et al., 2020), as well as Gallic acid, Ellagic acid, 3,3′-Dimethoxyellagic acid, Brevifolin carboxylic acid, Quercetin 3-O-glucuronide, Myricetin 3-O-glucuronide, Syringetin 3-O-glucuronide, Ellagitannin, Castalagin, Quercetin, Myricetin, Syringetin, 3,4,3′-Trimethoxyellagic acid and Saponins (Rehman et al., 2019).

phenolic compounds from *Conocarpus erectus*

	Compound Identity	Reference
1	Gallic acid	Nawwar et al., 1982
2	Brevifolin carboxylic acid	Nawwar et al., 1994
3	Quercetin 3-*O*-glucuronide	Nawwar et al., 1984
4	Myricetin 3-*O*-glucuronide	Nakanishi et al., 2007
5	Syringetin 3-*O*-glucuronide	Bohm et al., 1975
6	Ellagitannin, castalagin	Nonaka et al., 1985
7	Quercetin	Nawwar et al., 1984
8	Myricetin	Nakanishi et al., 2007
9	Syringetin	Yasukawa et al., 1990
10	3,4,3 -Trimethoxyellagic acid	Alam et al., 2007
11	3,3 -Dimethoxyellagic acid	Nawwar et al., 1982
12	Ellagic acid	Nawwar et al., 1982

Ayoub (2010)

Phenols

It is one of the most widespread secondary metabolites groups whichis found in the plant kingdom (Obeid and Jaber , 2018) , with its different types found in the plants, as plants synthesize several thousand different phenolic compounds.The high concentrations of phenolic compounds make the plant more resistant, but the production of these compounds in the plant is costly for the plant because of the energy consumption when production of these compounds, so they aren't available for other functions in the plant. Some types of phenolic compounds are found in most plants, while others are found in specific plants.

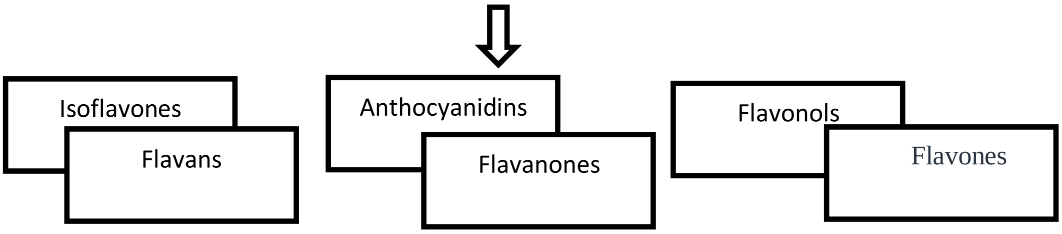
Phenol is a chemical term that represents a substance that has a hexagonal aromatic ring linked with one or more hydroxyl groups (Abdul-Karim et al., 2021), whereas the polyphenols contain at least two phenyl rings linking with one or more hydroxyl groups. These compounds have important roles in cell wall structure and the growth and survival of plants.Phenolsare compounds of low molecular weight, colorless, odorless, bitter taste, sensitive to high temperatures and dissolve in water as well as they are linking with saccharide in the form of glycosides. Phenols are found in cell walls or in cell vacuoles in liquid form. The location and number of hydroxyl groups have a relationship with the antiviral activity against pathogens. Phenols have a role in the growth and reproduction of plants and increase the plants' potential to environmental stresses such as ultraviolet rays, nutrient deficiency, heat, bacterial, fungal and insect pathogens, and they have a role in hardness plant walls, make cell walls impermeable to water and gases (Alsaloom ,2023 ; Yoysif and Hassan ,2023) . Finally,phenolic compounds are divided into several groups.

1- Simple phenols
2- Phenolic acid
3- Flvonoids
4- Coumarin
5- Isocoumarin
6- Naphtoquinone
7- Antraquinone
8- Xanthone
9- Lignane

10- Stibene
11- Tannin

Flavonoids

Flavonoids are compounds of low molecular weight that are formed of colored plant pigments responsible of the colors of flowers, fruits and leaves. Flavonoidsare spread in most plant families, especially Angiosperms, as they are found in more than 6000 plant species and are concentrated in the aerial parts of the plant. Flavonoids are formed of two phenyl rings linked with each other by a heterogeneous ring consisting of 3 carbon atomsand in total they contain 15 carbon atoms. Flavonoids are found in vacuoles and some of them are found in chromoplasts and chloroplasts or they are in the form of glycosides. Flavonoids play an important role in plant protection, as some flavonoids (such as flavones, flavans) have the property of inhibiting fungi (Sukalingam et al., 2017) by affecting the plasma membrane and mitochondria, inhibiting cell wall formationand cells division, RNA and protein synthesisand disrupting cell permeability (Al-Aboody and Mickymaray, 2020 ; Abbas et al., 2020) . Also, flavonoids have a role in inhibiting many enzymes that interfere with respiration process, such as NADH-oxidase, as well as their role in attracting insects and facilitating cross-pollination between plants. They are divided intoseveral groups (Cassidy and Minihane, 2017).



Tannins

Tannins are polyphenol chemical metabolic compounds that are free of nitrogen which are found in the bark, stems, leaves and fruits of plants and are within the vacuoles. The concentration of tannins varies according to the plant part and is often in a large concentration in the leaves, peels of plants and dead cells.Tannins are amorphous compounds that are difficult to separate, dissolve in water, alcohol and glycerine, while they don't dissolve in ether or benzene. When dissolved theTanninsin water, they form an acidic emulsion with an astringent taste and have the ability to precipitate proteins and alkaloids from their solutions, this is the process that takes place when tanning leather (Abdul- Karim et al., 2021).Tannins are an important source of energy consumed by plants and have an oxygen-attracting property. Also, tannins have an important role in inhibiting the growth of fungal and insect pathogens.

The concentration of tannins increases in the dead parts to protect them from the growth of the saprobionts organisms. Also, tannins have a distinctive role in building processes, so they are found in the developing parts such as buds, leaves and fruits, and they are divided to true tannins, which are characterized by their high molecular weight and Pseudo tannins, which are characterized by a low molecular weight (Tong et al., 2020).

The role of conocarpus in controlling the plant pathogens

Yasir (2012) reported that the ethanolic and methanolic extract achieved 100% of inhibition percentage of *Alternaria solani* fungus compared with cold and hot aqueous extractsat a concentration of 45 $mgml^{-1}$which achieved 78.3 and 77.7% respectively, where as the inhibition percentage of *Ulocladium botrytis* fungus were 100, 100, 88.8 and 86.1% respectively in for same extracts. Al-Shatti et al., (2014) showed that the use of conocarpus extract at a concentration of 10% inhibited the growth of the two fungi (*Sclerotinia* and *Rhizoctonia*), as the growth of the fungi reached 0%.Bashir et al., (2015) mentioned that the conocarpus extract achieved antagonistic activity against *Saccharomyces cerevisiae*, *Aspergillus niger* and *Penicillium notatum* fungi, as the inhibition area reached 14.3, 12.5 and 13.3 mm respectively. Al-Khafaji et al., (2016) noted the effectiveness of conocarpus extract in inhibiting *Aspergillu sflavus*, *Alternaria alternata* and *Macrophomina phaseolina* fungi, as the radius of the inhibition area reached 0.4, 2.1 and 2.5 cm respectively. Khurshid et al., (2016) observed the efficacy of methanolic extracts of conocarpus in inhibiting the biomass of *Fusarium oxysporum* f. sp. Lycopersici caused tomato wilt disease by 12-25 and 14-23%, respectively compared with control treatment (46-50%). Karim et al., (2017) indicated that the conocarpus extract at concentrations of 1000 and 2000 ppm achieved effectiveness in inhibiting the growth of the *Nattrassi Mangifera* fungus that causes branch wilt disease of apple trees (75.41 and 85.75%)respectivelyand reduced the area under the disease progression curve (16.14 and 13.32 mm^2) respectively compared with control treatment (74.56 mm^2).Gad et al., (2018) showed the effectiveness of conocarpus extract in increasing the death percentage of second-stage larvae of *Meloidogyne incognita* nematode of 24.5, 28.5 and 39.75% at concentrations of 25, 50 and 75% respectively which led to an increasing the growth parameters of plants. Kareem (2018) and Matloob (2019) reported that aqueous extract of conocarpus inhibited the growth of *Fusarium solani* isolated from tomato plants of 61.48, 78.42 and 100% at concentrations of 15, 10 and 5% respectively.Ahmed and Kareem (2020) showed that the concentrations of 250, 500, and 1000 achieved inhibition growth of *Erwinia carotovorasup* sp. Carotovorabacteria causing soft rot of potato tubers was 64.1, 77.8 and 86.1% respectively compared with control treatment which was 0%.

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