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Review Paper

An alternative approach for management of fungal plants diseases using Tunisian medicinal plants

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Abstract

The efficiency of some Tunisian medicinal plants was tested against some plant diseases caused by fungi. Obtained results proved that plants such Plantago afra exhibited an antifungal activity against various micro-organisms. Other plants belonging to Opuntia species revealed efficient against the development of gram-positive and negative bacteria. Salsola vermiculata oils exhibited moderate an antifungal activity against Candid spp. Also, Chenopodiaceae spp. showed an antifungal activity against species from the genus Botrytis, Fusarium, Phytophthora, Rhizoctonia and Nattrassia. In addition, the butanolic extract of the plant Chenopodiaceae spp. generated a strong activity against F. oxysporum. Essential oils obtained from Tetraclinis articulate (Vahl.) Masters showed an antifungal activity against fungi from the genus Botrytis and Fusarium. A. roseum var. grandiflorum bulbs exhibit antimicrobial effect against Candida albicans and gram-negative bacteria. Citharexylum quadrangulare Jacq., aqueous and organic extracts, was proved efficient against Fusarium spp. and Aspergillus spp. Thus, the use of these medicinal plants in plants disease management should be taking into consideration.

Keywords: Antifungal activities, plants diseases, Tunisian medicinal plants.

Introduction

Some variety of plants have a medicinal property[1], and developing countries have a history of their use in medicine[2]. Recently, plants medicinal properties were investigated due to their potent therapeutic efficacy, antioxidant activities, biological and economic viability[3]. As consequence, the demand of herbal based medicine, are increasing worldwide. Moreover, these plants produce definite physiological action on the human body[4]. Thus, medicinal plants were used to in controlling human diseases[5].

In agricultural field, crop diseases caused by fungal infections are one of the serious problems[6]. To control the causal agents of these diseases, the majority of farmers use chemical. However, these applications increase the pollution, the occurrence of pathogens resistant and pressure[7]. As alternative, the biological control is considered as safe and economic method to be used in plant pathogens management. This has intensified the research to the fabrication of biological fungicides based on the secondary metabolites of medicinal plants. Thus, these medicinal plants could be used to control fungal plant diseases[8].

Some Tunisian medicinal plants were subject to determine their antifungal activities[9]. Plants therapeutic efficacy is due to the existence of organic compounds metabolites[3]. These plants substances are proved to be useful in controlling the growth of microorganisms and also are non-phytotoxic, systemic, and biodegradable[10-12]. For examples, species of the plants of the genera *Euphorbia* such as *E. geniculate*, *E. hirta*, *E. paralias* revealed the suppression of root infecting fungi caused by *Eupenicillium brefeldianum*, *Penicillium echinulatum*, *Alternaria phragmospora*, *A. alternata*, *Fusarium oxysporum* and *F. verticilloid*[13-16]. Furthermore, secondary metabolites of *Plantago* have an antimicrobial properties[17].

In addition, researchers found that medicinal plants compounds such as *β*-amyrin[18], two flavonoids 7-O-glucoside[19], and methyl gallate[21] have a potential antifungal activity. Also, a high antifungal activity against some bacterial (like *Pasteurella multocida*, *Escherichia coli* and *Bacillus subtilis*) and fungal species (*A. alternata*, *Ganoderma lucidum*) was proved using the plants *Callistemon viminalis*[21]. Furthermore, many plants such as *Atriplex leucoclada* were found to be active against the genus *Bacillus* sp.[22]. Also, *A. halimus* seemed to reduce the development of *F. oxy sporum* and *A. alternata*[23], and *Salicornia brachiata* exhibited activity against *Aspergill us niger*[24]. The existence of active compounds, extracted from plants, and which have an antimicrobial effect could lead to the synthesis of nature-based fungicides in the future[1]. Previous studies revealed that some Tunisian medicinal plants have antifungal effect. In the present paper, we analyze the Tunisian medicinal plants, as potential antimicrobial against phytopathogens, that can be used as an alternative approach for management of fungal plants diseases.

History of Tunisian medicinal plants

Tunisia is rich of a diverse plant with more than 2 163 varieties of medicinal plants species, from which 149 were claimed to have medicinal properties, and the majority are found in arid and semiarid conditions[25]. For example, the oil of *P. afra*, which is growing in many regions in Tunisia, are used in medicine[26, 27]. Besides, this plant was reported as important in nutraceutical, pharmaceutical and cosmetic industries[28,29]. Also, *Hibiscus cannabinus* essential oil found in Tunisia are rich in phytol, phytol, n-nonanal, benzene acetaldehyde, hexanal and methylfurfural and their antifungal activities against phytopathogens such as *Colletotrichum fragaria, C. gloeosporioides* and *C. acutatum* has been proved in Italy[30]. In addition, the plants *Eryngium maritimum* largely widespread in Tunisia[25], contain a non-terpenic compounds, which have an antioxidant, antimicrobial activities against phytopathogens such as *Pseudomonas aeruginosa*, and *A. flavus*[31,32].

Chemical composition of some Tunisian medicinal plants

Chemical composition of volatiles compounds of *Opuntia* species: The chemical composition of volatiles compounds isolated from *Opuntia* species gathered in the Cap Bon region in Tunisia were studied[33]. Results demonstrated the existence of glycosylated-flavonol sin *O. engelmannii* (0.45µg/g of dry weight) and *O. indica* (2.86µg/g of dry weight). Isorhamnetin-O-(dideoxyhexosyl-hexoside) was signaled in case of *O. ficus indica* (1.84µg/g of dry weight), and *O. engelmannii* (0.5 µg/g of dry weight); while catechol phenolic compound was noted in *O. Humifusa* (1.88µg/g of dry weight). However, among the flavones, the compound myricitrin was found in *O. engelmannii*, and the epicatechin-3-O-gallate was found in *O. humifusa.* In addition, ellagic acid compound was present in *O. humifusa*.

Chemical composition of *Allium roseum* var. *grandiflorum*: *Allium*genus includes a wild species which have been used in medicine[34]. Results of the identification of the volatile compounds in the *A. roseum* var. *grandiflorum* essential oil collected in Tunisia showed the existence of more than twenty identified compounds. *A. roseum* oil was characterized by of the existence of sulphurous compounds, classified into disulfides, disulfides, tetrasulfides. The major constituents of the sulfur-containing compounds were methyl methaneth-iosulfinate, 3-vinyl-1,2-dithiacyclohex-5-ene, diallyl trisulfide disulfide, methyl 2-propenyldisul-phid, 3-vinyl-1,2-dithiacyclohex-4-en, and diallyldisulfide. Carbonyl compound was the second major component of the *A. roseum*, followed by the heterocyclic, alcohol, alkane, and fatty acid[35,36].

Chemical composition of *Citharexylum quadrangulare*: This plant is native to Caribbean[37]. *C. quadrangulare* has been introduced to Tunisia many years ago and now it's largely cultivated[6]. The importance of this plant reports on their phytochemical constituents. In fact, the aerial parts of *C. quadrangulare* contain three flavone glycosides[38], one iridoid and two iridoid glucosides[39]. Also, 10 compounds were isolated from *C. spinosum*[38].

Chemical composition of *Tetraclinis articulate*: The chemical composition of *T. articulata*, growing in Tunisia, was identified[40]. Results indicate that the essential oil yield of fresh leaves of *T. articulata* was 0.93%, with 1.47 of refractive index. More than 30 compounds were identified in this plant, and accounted for 91% of the total oil. Also, the monoterpenes hydrocarbons displayed the highest amount (62.80%), with α-pinene and β-myrcene as the most abundant. *T. articulata* oxygenated monoterpenes represented 18.98% of the total oil, with 1,8-cineole as the major component.

In another study, 50 compounds representing 96% of *T. articulata* oil were notice. The major compounds include α-cedrene and thymol[41]. Also, 20 compounds extracted from the essential oil of woody terminal branches, and *T. articulate* roots were noted. In this report, the nonan-1-ol was the main constituent, while the monoterpene hydrocarbons were the main compounds[42].

Chemical composition of *Plantago afra*: A hydro-distillation of *P. afra* dry aerial parts demonstrated the fabrication of essential oil, with 2.5 $x10^{-2}$ yield. The highest percent of the total oil composition (92.4%) included 45 components. These components are the phenyl derivatives, and a long chain hydrocarbon, with the main components are thymol [17].

Chemical composition of *Chenopodiaceae* wild extracts: Chemical composition of *Chenopodium botrys* essential oil affirmed the existence of seventy-five compounds with a big amount of sesquiterpene comprising: elemolacetat, seline-11-en-4α-ol, selina-3,11-dien-6α-ol and elemol, in addition to α-eudesmolacetat, α-chenopodiol, botrydiol, and α-chenopodiol-6-acetat[43]. In addition, twenty compounds were also identified from *Dysphania ambrosioides* (L.) Mosyakin & Clemants. In this plant, the monoterpenes are the main constituents, and cis-piperitone oxide, *p*-cymene, trans-isoascaridole and α-terpinene are the main constituents[44].

Antifungal activity of some Tunisian medicinal plants

Antifungal activity of *Opuntia* species volatile extracts: Antimicrobial activity of *Opuntia* species growing in Tunisia has been reported against some phytopathogens[33]. In fact, a high growth inhibition of *A. alternata* was noted using leaves and flowers volatiles extracts of *O. macrorhiza, O. lindheimeri var. linguiformis*, and *O. microdasys*. In the same study, a moderately growth inhibition of *F. oxysporum* and *R. solani* were reported using flowers volatile extract of *O. lindheimeri var. linguiformis* and *O. macrorhiza leaves*[33]. Also, results of

another study indicated that *O. ficus*, *O. engelmannii* and *O. humifusa* was effective against bacteria.

Antifungal activity of *A. roseum* var. *grandiflorum*: Antifungal activities of *A. roseum* bulbs essential oil against microorganisms, such as *Klebsiella pneumoniae, E. coli, Shewanella putrefaciens, Proteus mirabilis, Vibrio* spp., *P. aeruginosa, Staphylococcus* spp., *Serratia marcescens, S. anatum* and *S. enteritidis*, was studied[35]. Results revealed that essential oil of *A. roseum* have an antibacterial activity against these microorganisms. The highest activity of this oil was observed against *C. albicans*, followed by Gram-bacteria. However, the lowest activity was signaled against Gram+ bacteria.

In another study, the essential oils antifungal activity of *A. roseum* var. *grandiflorum* against plants pathogens were proved. In fact, this plant was able to reduce the percent of mycelium growth of *F. solani* (from 28 to 56%), *B. cinerea* (from 30.43 to 52.17%), *A. solani* (from 30.00 to 48.00%), *Pythium ultimum* (from 40.38% to 42.31%), *R. solani* and *F. oxysporum* f. sp. *niveum* (from 42.00% to 52.00%)[45].

Furthermore, another study showed that 7 extracts of *A. roseum* have an antibacterial activity against some strains which have been reported as the causative agents of some the food diseases, and suggested that this plant could be used in the food industry[46]. According to their antibacterial activity, *A. roseum* compounds were classed as follow: the essential oil as the strongly active compounds; chloroform as the second most active extract; petroleum ether in the third position; the ethyl acetate extract in the fourth position.

Antifungal activities of *Citharexylum quadrangulare* Jacq.: The organic aqueous extracts from fruits, leaves, roots, and stems of *C. quadrangulare* Jacq., were investigated for their antifungal potentialities against 5 phytopathogens causing serious damage in agriculture in Tunisia[6]. In this study, *C. quadrangulare* Jacq. extracts were able to inhibit the development of *A. niger* (from 43.3 to 50.9%), *A. flavus* (from 22.8% to 65.4%) and *F. graminearum* (from 14.1 to 49.0%), *F. culmorum* (from 14.4 to 12.8%). This mycelial growth inhibition may be attributed to the existence of allelochemicals[47]. Differences between extracts in this fungi toxic test could be due to the solubility of active compound in water, or to the existence of inhibitors to the fungi toxic principle[48,49]. The antimicrobial activity of this plant extracts might be due to a synergistic effect of several compounds [50]. The *C. quadrangul are* flavonoids have the ability to inhibit spore germination and growth of plant phytopathogens[51,52, 53]. Furthermore, the iridoids and the iridoid glucosides were proved to have an antifungal activity[54,55].

Antifungal activity of essential oils from *T. articulate* (Vahl.) Masters: The antifungal activity of *T. articulate* oil collected from the region of Nabeul, North Tunisia, was assessed towards 5 phytopathogenic fungi[56]. Results of this study affirmed the existence of a strongest antifungal activity of this plant against *B. cinerea* with 71.17% of inhibition growth, while variable inhibition percent was noted for the 5 phytopathogens, i.e., *F. avenaceum, F. oxysporum, F. solani, F. culmorum,* and *B. cinerea*. In addition, *T. articulata* essential oil exhibited an inhibitory effect against *Enterococcus faecalis, E. coli, Klebsiella pneumoniae* and *Streptococcus* D[41]. Moreover, a strongest antifungal activity was notified against *Fusarium*species[57]. Essential oils of terminal woody branches of *T. articulate* give a high antifungal activity against *A. solani* (29.8mm) and *B. cinerea* (25.0mm) and *F. oxysporum niveum* (16.7mm). Also, *T. articulate* roots essential oils demonstrated an antifungal activity against *A. solani* (26.0mm), *B. cinerea* (24.8mm)[42].

Antifungal activity of *Plantago afra* aerial parts: Some investigations demonstrated that volatile components extracted from aerial parts of *P. afra* (flohsamen, spanish psyllium) collected from the area of Jendouba, north-western of Tunisia exhibited an antibacterial activity against *E. coli, S. enterica, P. aeruginosa, S. aureus*, and *B. subtilis*. In fact, the minimum inhibitory concentrations and minimum bactericidal/fungicidal values of these phytopathogens, using *P. afra* were ranging from 312.5 to 1250µg/ml[17]. The antimicrobial activities of this plant were assessed against 5 bacterial strains. This antifungal activity could be due to some terpenic components, which are the main constituents of the oils[58], or to (Z) and (E)-phytol, n-nonanal, benzene acetaldehyde, 2-hexenal and 5-methylfurfural[59].

Antifungal activity of some *Chenopodiaceae* wild extracts: *Salsola vermiculata* L., is an important perennial species in Mediterranean arid area. *S. vermiculate* leaves, roots and stems extracts collected from the region of Monastir in Tunisia were evaluated toward *S. aureus, Enterococcus faecalis, E. coli, P. aeruginosa* and *Acinetobacter baumanii*. Results showed that the ethanolic extracted from & roots were the most active against *S. aureus* with a minimum inhibitory concentration value of 0.28mg/ml. Also, the antifungal activity of this plant was tested against *Candida species and* showed an inhibition zone ranging from 6 to 9.5 mm[9].

Conclusion

We conclude that the Tunisian medicinal plants tested here showed effective antifungal potential for plants diseases control, and also antioxidants activity of plants. Tunisian medicinal herbs are cheap to produce, safe to use, and environmentally nonhazardous. Due to their antioxidant properties, these plants could be exploited as a source for the health and for the nutrition. Additionally, some plants have compounds that may be used in agriculture as alternative for chemical for the management of plant diseases. The potential for developing preparations from those plants to be use as an alternative to synthetic fungicides should be considered in the future.

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