Characterization of Phytoconstituents from Alcoholic Extracts of Four Woody Species and Their Potential Uses for Management of Six *Fusarium oxysporum* Isolates Identified from Some Plant Hosts

Mohamed Z. M. Salem 1,*. Abeer A. Mohamed 2, Hayssam M. Ali 3,4,* and Dunia A. Al Farraj 3

1 Forestry and Wood Technology Department, Faculty of Agriculture (El-Shatby), Alexandria University, Alexandria 21545, Egypt; zidan_forest@yahoo.com
2 Plant Pathology Institute, Agriculture Research Center (ARC), Alexandria 21616, Egypt; abeer_pcr@yahoo.com
3 Botany and Microbiology Department, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia; dfarraj@ksu.edu.sa

* Correspondence: hayhassan@ksu.edu.sa

Abstract: Background: Trees are good sources of bioactive compounds as antifungal and antioxidant activities. Methods: Management of six molecularly identified *Fusarium oxysporum* isolates (F. oxy 1, F. oxy 2, F. oxy 3, F. oxy 4, F. oxy 5 and F. oxy 6, under the accession numbers MW854648, MW854649, MW854650, MW854651, and MW854652, respectively) was assayed using four extracts from *Conium maculatum* leaves, *Acacia saligna* bark, *Schinus terebinthifolius* wood and *Ficus eriobotryoides* leaves. All the extracts were analyzed using HPLC-VWD for phenolic and flavonoid compounds and the antioxidant activity was evaluated using 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging and β-carotene-linoleic acid (BCB) bleaching assays. Results: In mg/kg extract, the highest amounts of polyphenolic compounds p-hydroxy benzoic, benzoic, gallic, and rosmarinic acids, with 444.37, 342.16, 311.32 and 117.87, respectively, were observed in *C. maculatum* leaf extract; gallic and benzoic acids with 2551.02, 1580.32, respectively, in *A. saligna* bark extract; quinol, naringenin, rutin, catechol, and benzoic acid with 2530.22, 1224.904, 798.29, 732.28, and 697.73, respectively, in *S. terebinthifolius* wood extract; and rutin, o-coumaric acid, p-hydroxy benzoic acid, resveratrol, and rosmarinic acid with 9168.03, 2016.93, 1156.99, and 574.907, respectively, in *F. eriobotryoides* leaf extract. At the extract concentration of 1250 mg/L, the antifungal activity against the growth of *F. oxysporum* strains showed that *A. saligna* bark followed by *C. maculatum* leaf extracts had the highest inhibition percentage of fungal growth (IPFG%) against F. oxy 1 with 80% and 79.5%, F. oxy 2 with 86.44% and 78.9%, F. oxy 3 with 86.4% and 84.2%, F. oxy 4 with 84.2, and 82.1%, F. oxy 5 with 88.4% and 86.9%, and F. oxy 6 with 88.9, and 87.1%, respectively. For the antioxidant activity, ethanolic extract from *C. maculatum* leaves showed the lowest concentration that inhibited 50% of DPPH free radical (3.4 µg/mL). Additionally, the same extract observed the lowest concentration (4.5 µg/mL) that inhibited BCB bleaching. Conclusions: Extracts from *A. saligna* bark and *C. maculatum* leaves are considered potential candidates against the growth of *F. oxysporum* isolates—a wilt pathogen—and *C. maculatum* leaf as a potent antioxidant agent.

Keywords: plant extracts; *Fusarium oxysporum* isolates; *Acacia saligna*; *Conium maculatum*; *Schinus terebinthifolius*; *Ficus eriobotryoides*; antifungal; antioxidant; HPLC

1. Introduction

Trees and shrubs produce a broad range of bioactive compounds called secondary metabolism. These compounds have a long range of different effects as antimicrobials, antioxidants or insecticidal properties dependent on plant species and the type of bioactive compounds [1–8]. Medicinal and aromatic plants are often characterized as medicinal...
Plants 2021, 10, 1325

2 of 17

and poisonous depending on the presence of bioactive chemicals such as simple phenols, phenolic acids and flavonoid compounds [3,9,10]. However, in the literature regarding the bioactivity of flavonoids and polyphenols on antifungal activity, some results found that flavonoids were not associated with antifungal activity [11,12], while other works reported that the inhibition of fungal growth was mainly due to flavonoids [13,14].

*Conium maculatum* L., an umbelliferous weed, is known worldwide for its acute toxicity to humans and domestic animals [15]. Flavones (apigenin, luteolin, chrysoeriol), flavonols (kaempferol, quercetin, isorhamnetin), and anthocyanidins (cyanidin) have been detected in *C. maculatum* [16–18]. Other compounds furanocoumarins (psoralen, xanthotoxin and bergapten) were isolated from *C. maculatum* [19]. In addition, furocoumarins, polyynes, prenylated coumarins and elemicin were isolated from root dichloromethane extract of *C. maculatum* [20]. Coniine (eight times more toxic than γ-coniceine) and γ-coniceine are the most abundant alkaloids with chronic toxicity found in *C. maculatum* extracts [21]. The leaf essential oil has only observed potential antifungal activity against *Aspergillus parasiticus* [22]. *C. maculatum* leaf extract exhibited maximum inhibition (100%) of *Verticillium fungicola* mycelial growth at a 1.5% concentration [23]. Meanwhile, in the study of Yanar et al. [24], *C. maculatum* leaf extract did not show any activity against the mycelial growth of *Alternaria solani*. *C. maculatum* showed significant relative antibacterial activity against *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumonia*, *Proteus vulgaris* and *Pseudomonas aeruginosa* [25]. In addition, the extract from *C. maculatum* as an herb presented good antibacterial activity against *S. aureus*, *B. subtilis*, *P. aeruginosa*, and *E. coli*, except against *C. albicans* according to measured MIC values [26].

*Acacia saligna* (Labill.) H. L.Wendl. is considered a fast-growing tree [27], and its extracts from different parts have shown some biologically active compounds as well antioxidant [3,28,29]. *Melia azedarach* wood treated with *A. saligna* flower extract showed good inhibition to *Penicillium chrysogenum* and moderate activity against *Fusarium culmorum* and *Rhizoctonia solani* but weak activity was reported [3]. Ethyl acetate extract of leaves was more effective as an antimicrobial than methanolic and water extracts [28]. The *A. cyanophylla* leaf ethanol extract showed potent antifungal activity against some species of *Aspergillus* [30].

*Schinus terebinthifolius* Raddi belongs to the family Anacardiaceae, and is a medicinal plant widely used for the treatment of various diseases as well for its own antimicrobial bioactive compounds [31–34]. Stem bark extract, which contains catechin, tannins, terpenes, flavonoids, and saponins, has shown a topical anti-inflammatory agent with potential antioxidant properties related to flavonoids [35]. Naringenin and gallic acid were identified in fruit extract with potent antioxidants and inhibit oxidative stress [36].

*Ficus* comprises about 800 species including shrubs, woody trees, and vines in the family Moraceae [37]. Extracts from different parts of *Ficus* species showed the presence of phenolic and flavonoid compounds with bioactivity properties such as antioxidant, antibacterial, antifungal and antiviral [38–41]. To the best of our knowledge, there are no studies in the literature considering the identification and characterization of the phenolic and flavonoid compounds as well other phytochemicals from *Ficus eriobotryoides* extracts.

Phytopathogenic fungi are posing major problems in agriculture. *Fusarium oxysporum* is a devastating wilt pathogen on almost 150 plant species. Fusarium with its toxic fumonisins mycotoxins has been shown to cause maize ear rot disease by contaminating its grains, which are major problems in pre- or post-harvest losses [42,43]. *F. oxysporum* is a causal pathogen for Panama wilt disease in *Musa paradisiaca* [44]. *F. oxysporum* is capable of causing vascular wilt, root rot and damping off diseases in over one hundred agronomically important plant species [45–48]. This pathogen is a soil-borne fungus and can survive in soil for more than ten years [49,50]. The plant extracts containing anti-fungal compounds have been gaining importance over the last three decades against a wide range of plant pathogenic microbes [51–53].

Trees and shrubs are renewable sources for raw materials, rich in valuable bioactive compounds including phenolic and flavonoid compounds [54,55]. The antioxidant activ-
ities of plant-derived phenolic compounds measured by 1,1-diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging and beta-carotene bleaching (BCB) methods have been studied from extracts from several parts of trees like fruits, leaves, bark, seeds, flowers, and roots [56–66]. The antioxidant activity was well-correlated with the concentrations of phenolic, flavonoid and tannin contents [67,68]. Thus, in the present study, the plant extracts are tested for the inhibitory effect on the growth of the \( F. \) oxysporum pathogen.

The aim of the present study was to evaluate the biological activity of ethanol extracts four extracts of four plant species to control the wilt pathogen—\( Fusarium \) oxysporum. Phenolic and flavonoid compounds were also identified using HPLC-VWD, and the antioxidant activity was also reported.

2. Materials and Methods

2.1. Extraction of Plant Materials

Leaves of \( Conium \) maculatum L. were collected from the Garden of the Faculty of Agriculture, Alexandria University, Alexandria, Egypt, while \( Acacia \) saligna (Labill.) H.L.Wendl. (bark), \( Schinus \) terebinthifolius Raddi wood and \( Ficus \) eriobotryoides leaves collected from Antoniadis Gardens, Alexandria, Egypt, during June 2019, were used in the present study [8,27]. All the plant materials were identified by coauthor Dr. Mohamed Z.M. Salem at the Department of Forestry and Wood Technology, Faculty of Agriculture, Alexandria University. The plant materials were air-dried at room temperature until each of them could be transferred to powder using a small laboratory mill. After obtaining the powdered of all materials, 50 g from each plant material was extracted by soaking method [69,70], in 80% ethanol (150 mL) for one week, and then filtrated through cotton plug followed by filter paper (Whatman no. 1). The extracts were concentrated with evaporating the solvent using a rotary evaporator and poured in Petri dishes to complete the dryness. Three replicates for each extract were carried out. The afforded quantities of extracts were \( 4.45 \pm 0.57, 9.57 \pm 0.51, 7.06 \pm 0.58, \) and \( 5.5 \pm 0.81 \) g/100 g dry weigh from \( C. \) maculatum leaves, \( A. \) saligna bark, \( S. \) terebinthifolius wood, and \( F. \) eriobotryoides leaves, respectively.

After that, the extracts were separately prepared in a stock solution of 200 mL as dissolved in 10% dimethyl sulfoxide (DMSO) and the following concentrations 500, 750, 1000 and 1250 mg/L were prepared.

2.2. Phenolic and Flavonoid Compositions of Plant Extracts by HPLC Analysis

The phytochemical compounds of the ethanolic extracts from \( C. \) maculatum (leaves), \( A. \) saligna (bark), \( S. \) terebinthifolius wood and \( F. \) eriobotryoides (leaves) were injected and analyzed for their phytochemicals using An Agilent 1260 Infinity HPLC Series (Agilent, Santa Clara, CA, USA), equipped with a Quaternary pump and a Zorbax Eclipse plus C18 column (100 mm × 4.6 mm i.d.) (Agilent Technologies, Santa Clara, CA, USA) [3,9,71–73], with the injection volume of 20 \( \mu \)L and operated at 30 °C with the following ternary linear elution gradient;

(A) HPLC grade water 0.2% \( H_3PO_4 \) (v/v)
(B) methanol
(C) acetonitrile

Standard HPLC-grade phenolic and flavonoid compounds pyrogallol, quinol, gallic acid, catechol, \( p \)-hydroxy benzoic acid, chlorogenic acid, vanillic acid, caffeic acid, syringic acid, vanillin, \( p \)-coumaric acid, ferulic acid, benzoic acid, rutin, ellagic acid, \( o \)-coumaric acid, salicylic acid, resveratrol, cinnamic acid, myricetin, quercetin, rosmarinic acid, naringenin and kaempferol as well as caffeine, were used for the HPLC analysis. The detection was set at 284 nm to identify the phenolic compounds.

2.3. Antifungal Activity and Minimum Inhibitory Concentration (MIC) Assays of Four Plant Extracts

The antifungal activity of four plant extracts was assessed against six fungal isolates of \( Fusarium \) oxysporum F. oxy 1, F. oxy 2, F. oxy 3, F. oxy 4, F. oxy 5 and F. oxy 6, collected from
different plant hosts of Peas (*Pisum sativum* L.), Zucchini (*Cucurbita pepo* L.), Egyptian Rice (*Oryza sativa* L.), Pepper (*Capsicum annuum* L.), Cape gooseberry (*Physalis peruviana* L.), and Bean (*vicia faba* L.) with their sequencing ITS regions submitted and registered to GenBank under the accession numbers MW854648, MW854649, MW854650, MW854651, MW854652, and MW854653, respectively. The plant extracts were prepared as mentioned above at the concentrations of 500, 750, 1000 and 1250 mg/L [74]. Carbendazim (reference chemical fungicide) prepared at concentrations of 200 mg/L were assessed using the broth dilution method according to Clinical and Laboratory Standards Institute (CLSI) [75]. *F. oxysporum* isolates were cultivated on a PDA medium. Then, a single 0.5 cm culture disk was taken from actively growing cultures and placed in the middle of the Petri dishes were with the different concentrations of plant extracts. The plates were incubated for 6 days at 28 °C, and three replications were used for each isolate [53,76,77]. The fungal inhibition percentage was calculated with the formula of inhibition percentage of fungal growth (IPFG) (%) = \[\frac{DC-DT}{DC}\] × 100, where DC and DT are the average diameters (mm) of fungal colonies under the control and experimental treatments, respectively. Three replicates were carried out for all of the treatments [52]. The minimum inhibitory concentrations (MIC) of the plant extracts prepared at concentrations of 64 to 1250 mg/L were assessed according to CLSI [75].

### 2.4. Antioxidant Activity of the Extracts

Free radical scavenging activity of the obtained four extracts was measured using 2,2-diphenyl-1-picrylhydrazyl (DPPH) method (absorbance at 517 nm), along with the β-carotene-linoleic acid (BCB) bleaching assay [71,78,79]. The DPPH is a stable free radical alcohol soluble and the assay is based on its scavenging by the active principles of the extracts, while BCB assay is based on the bleaching inhibition of this system by the extract biocompounds. The concentration of extract or the references compounds ascorbic acid (AA) and butylated hydroxyl toluene (BHT)) responsible for 50% of inhibition of DPPH radical or BCB bleaching inhibition after 24 h of incubation was determined [80–82].

### 2.5. Statistical Analysis

The results of the percentages of the fungal linear inhibition of six isolates of *Fusarium oxysporum* as affected by four concentrations (500, 750, 1000 and 1250 mg/L) of the ethanol extract of *C. maculatum* leaves, *A. saligna* bark, *S. terebinthifolius* wood and *Ficus eriobotryoides* leaves were statistically analyzed with two-way analysis of variance (ANOVA) using SAS software (SAS Institute, Release 8.02, Cary, North Carolina State University, Raleigh, NC, USA) [83]. The means were compared against the control treatment according to Duncan’s Multiple Range Test at a 0.05 level of probability.

## 3. Results

### 3.1. Phytochemical Analysis of Extracts by HPLC

Table 1 presents the chemical compounds of the phenolic and flavonoid compounds as well as caffeine identified in the 80% ethanolic extracts from *Conium maculatum* leaves, *Acacia saligna* bark, *Schinus terebinthifolius* wood, and *Ficus eriobotryoides* leaves. Figure 1 shows the HPLC chromatograms of the identified compounds from studied extracts. The highest amounts (mg/kg extract) of chemical compounds *p*-hydroxy benzoic acid (444.37), benzoic acid (342.16), gallic acid (311.32), rosmarinic acid (117.87), vanillic acid (95.21) and *p*-coumaric acid (81.86) were observed in *C. maculatum* leaf extract. *A. saligna* bark extract showed the presence of gallic acid (2551.02), benzoic acid (1580.32), caffeine (106.73), and chlorogenic acid (103.50) followed by vanillin (69.46), caffeic acid (53.55), rosmarinic acid (49.57) and ferulic acid (42.17) as main compounds in mg/kg extract. The compounds quinol (2530.22), naringenin (1224.904), catechol (732.28), benzoic acid (697.73), quercetin (315.44), caffeic acid (302.27), caffeine (267.62), *p*-hydroxy benzoic acid (233.27), rosmarinic acid (187.66), chlorogenic acid (174.65), kaempferol (175.06) and *o*-coumaric acid (139.04) were observed as the highest amounts (mg/kg extract) identified
in *S. terebinthifolius* wood extract. In the ethanol extract of *F. eriobotryoides* leaves, the highest peaks (mg/kg extract) observed were rutin (9168.03), *o*-coumaric acid (2016.93), *p*-hydroxy benzoic acid (1009.20), resveratrol (1156.99), and rosmarinic acid (574.907).

Table 1. Phytochemical compounds of extracts by HPLC analysis.

| Compound                  | Amount (mg/kg Extract) | C. maculatum Leaves | A. saligna Bark | S. terebinthifolius Wood | F. eriobotryoides Leaves |
|---------------------------|------------------------|---------------------|-----------------|--------------------------|-------------------------|
|                           | RT *                   | Amount              | RT              | Amount                   | RT                      | Amount                   |
| Pyrogallol                | 3.165                  | 20.57               | -               | ND                       | -                       | ND                       |
| Quinol                    | 3.384                  | 23.27               | -               | ND                       | 3.384                   | 2530.22                  | -                       | ND                       |
| Gallic acid               | 3.762                  | 311.32              | 3.304           | 2551.02                  | 3.783                   | 67.87                    | -                       | ND                       |
| Catechol                  | -                      | ND                  | -               | ND                       | 5.944                   | 732.28                   | -                       | ND                       |
| *p*-Hydroxy benzoic acid  | 8.433                  | 444.37              | -               | ND                       | 8.389                   | 233.27                   | 7.861                   | 1009.20                  |
| Caffeine                  | 9.327                  | 50.63               | 9.204           | 106.73                   | 9.389                   | 267.62                   | -                       | ND                       |
| Chlorogenic acid          | 9.536                  | 30.99               | 9.506           | 103.50                   | 9.583                   | 174.65                   | -                       | ND                       |
| Vanillic acid             | 9.946                  | 95.21               | -               | ND                       | 10.059                  | 33.97                    | -                       | ND                       |
| Caffeic acid              | -                      | ND                  | 10.401          | 53.55                    | 10.544                  | 302.27                   | 10.102                  | 157.48                   |
| Syringic acid             | 10.931                 | 18.87               | -               | ND                       | 10.888                  | 109.28                   | 10.336                  | 5.90                     |
| Vanillin                  | 11.454                 | 5.71                | 11.883          | 69.46                    | 11.841                  | 23.92                    | -                       | ND                       |
| *p*-Coumaric acid         | 13.940                 | 81.86               | 13.832          | 8.27                     | 13.837                  | 3.58                     | 13.193                  | 0.0935                   |
| Ferulic acid              | 14.851                 | 15.15               | 15.060          | 42.17                    | 14.855                  | 12.94                    | 15.176                  | 145.45                   |
| Benzoic acid              | 15.074                 | 342.16              | 15.212          | 1580.32                  | 15.218                  | 697.73                   | -                       | ND                       |
| Rutin                     | 16.316                 | 19.93               | 16.757          | 16.15                    | 16.678                  | 798.29                   | 16.365                  | 9168.03                  |
| Ellagic acid              | 17.511                 | 5.74                | -               | ND                       | 17.109                  | 116.32                   | -                       | ND                       |
| *o*-Coumaric acid         | 17.964                 | 5.82                | 17.652          | 11.44                    | 18.164                  | 139.04                   | 17.791                  | 2016.93                  |
| Salicylic acid            | -                      | ND                  | -               | ND                       | 19.256                  | 78.35                    | -                       | ND                       |
| Resveratrol               | -                      | ND                  | -               | ND                       | -                       | ND                       | 19.925                  | 1156.99                  |
| Cinnamic acid             | -                      | ND                  | -               | ND                       | 20.483                  | 7.16                     | -                       | ND                       |
| Quercetin                 | -                      | ND                  | 21.572          | 37.36                    | 21.622                  | 315.44                   | 21.600                  | 314.85                   |
| Rosmarinic acid           | 22.033                 | 117.87              | 21.731          | 49.57                    | 22.040                  | 187.66                   | 22.069                  | 574.907                  |
| Naringenin                | -                      | ND                  | -               | ND                       | 22.667                  | 1224.904                 | -                       | ND                       |
| Myricetin                 | -                      | ND                  | -               | ND                       | -                       | ND                       | 23.904                  | 65.23                    |
| Kaempferol                | 24.332                 | 16.41               | 23.923          | 10.73                    | 24.372                  | 175.06                   | 24.325                  | 10.95                    |

*: RT: Retention time (min); ND: not detected
Figure 1. Cont.
3.2. Antifungal Activity of Extracts

Figure 2 shows the visual observation of the activity of four plant extracts (C. maculatum leaves, A. saligna bark, S. terebinthifolius wood and F. eriobotryoides leaves against six isolates of F. oxysporum. It can be seen that with the increase in the extract’s concentration, the mycelial inhibition percentage of fungi is increased.
Table 2 presents the antifungal activity of extracts against the growth of six isolates of *F. oxysporum*. The highest inhibition percentage of fungal growth (IPFG%) against the growth of *F. oxy 1* was observed with extracts from *A. saligna* bark followed by *C. maculatum* leaves at 1250 mg/L with IPFG of 80%, and 79.5%, respectively, while *F. eriobotryoides* leaf extract showed good activity with IPFG of 73.1% at 1250 mg/L. However, these values are lower than the value from carbendazim (88.89%). Extract from *A. saligna* bark showed the potent antifungal activity against isolate *F. oxy 2* with IPFG of 86.4% at 1250 mg/L, which higher than the values from carbendazim (85.2%). Furthermore, extracts from *C. maculatum* leaves, *S. terebinthifolius* wood and *F. eriobotryoides* leaves showed good activity against the growth of *F. oxy 2* with IPFG values of 78.9, 73.5, and 66.6%, respectively, at the concentration of 1250 mg/L. Extracts from *A. saligna* bark (IPFG 86.4%), and *C. maculatum* leaves (IPFG 84.2%) showed the highest activity against the growth of *F. oxy 3*, which higher than the IPFG from carbendazim (79.2%). In addition, *F. eriobotryoides* leaf extract at the concentration of 1250 mg/L observed IPFG value of 86.4% against *F. oxy 3*. At concentration of 1250 mg/L, extract from *A. saligna* bark, *C. maculatum* leaves, and *F. eriobotryoides* leaves showed the highest activity against the growth of *F. oxy 4* with IPFG values of 84.2, 82.1, and 76.6, respectively, and were higher than the values from carbendazim (75.8%). Extracts from *A. saligna* bark and *C. maculatum* leaves observed the highest activity against *F. oxy 5* with IPFG values of 88.4% and 86.9%, respectively, and those values were higher than the reported from carbendazim (84.81%). In addition, *F. eriobotryoides* leaves extract at the concentration of 1250 mg/L showed good activity against *F. oxy 5* with an IPFG value of 82.9%. Extracts from *A. saligna* bark and *C. maculatum* leaves showed a significant effect against *F. oxy 6* with values of IPFG 88.9, and 87.1%, respectively.
and these values were highest than the value of carbendazim (82.6%). The MIC values (mg/L) measured against the growth of six isolates from *F. oxysporum* are shown in Table 3. The range of these values were 32–125, 64–125, 125–250, and 125–250 mg/L, as the extracts from *C. maculatum*, *A. saligna*, *S. terebinthifolius* and *F. eriobotryoides*, respectively, were measured. Nevertheless, these values were lower than the reported from carbendazim (5–10 mg/L).

### Table 2. Antifungal activity of plant extracts against six isolates of *F. oxysporum*.

| Plant Extracts | Conc. (mg/L) | Inhibition Percentage of Fungal Growth (%) |
|----------------|-------------|------------------------------------------|
|                |             | F. oxy 1       | F. oxy 2       | F. oxy 3       | F. oxy 4       | F. oxy 5       | F. oxy 6       |
| Control a      | 0           | 0.00           | 0.00           | 0.00           | 0.00           | 0.00           | 0.00           |
| Positive control b | 200     | 88.9 ± 1.1     | 85.2 ± 0.6     | 79.2 ± 1.7     | 75.8 ± 1.1     | 84.8 ± 0.6     | 82.6 ± 0.6     |
|                | 500         | 27.9 ± 1.8     | 12.6 ± 1.1     | 13.7 ± 0.7     | 34.8 ± 1.4     | 40.2 ± 1       | 8.6 ± 1.7      |
| *C. maculatum* leaves | 750     | 41.5 ± 3.4     | 48.4 ± 1.6     | 40.4 ± 0.7     | 44.5 ± 0.9     | 47.5 ± 0.7     | 30.4 ± 2.7     |
| 1000           | 62.1 ± 2.6  | 57.1 ± 1.4     | 60.2 ± 1       | 68.7 ± 0.5     | 66.9 ± 1       | 58.2 ± 1.7     |
| 1250           | 79.5 ± 0.3  | 78.1 ± 1       | 84.2 ± 1.4     | 82.1 ± 0.5     | 86.9 ± 0.7     | 87.1 ± 0.4     |
| 500            | 9.4 ± 0.5   | 11.3 ± 2       | 15.3 ± 1.7     | 9.4 ± 0.5      | 13.1 ± 0.4     | 6.2 ± 1.4      |
| 750            | 27.3 ± 0.9  | 33.1 ± 0.4     | 31.7 ± 1.6     | 44.8 ± 1.1     | 29.7 ± 3.1     | 32.6 ± 0.6     |
| *A. saligna* bark | 1000   | 49.4 ± 3.4     | 58.2 ± 1.6     | 46.6 ± 1.3     | 56.6 ± 1.9     | 62.7 ± 1.9     | 47.3 ± 0.6     |
| 1250           | 80 ± 1.5    | 86.4 ± 0.4     | 86.4 ± 0.4     | 84.2 ± 2.1     | 88.4 ± 1.5     | 88.8 ± 0.8     |
| 500            | 12.6 ± 0.6  | 46.8 ± 1       | 53.5 ± 1       | 30 ± 0.7       | 49.4 ± 0.6     | 49.5 ± 1.7     |
| 750            | 30 ± 3.1    | 52.8 ± 0.4     | 54.8 ± 1.4     | 50.7 ± 2.7     | 55.8 ± 0.3     | 54.6 ± 1.3     |
| *S. terebinthifolius* wood | 1000  | 40 ± 0.6       | 59.3 ± 0.6     | 57.3 ± 0.6     | 60.5 ± 0.9     | 62.7 ± 0.9     | 60 ± 0.6      |
| 1250           | 54.6 ± 1.3  | 73.5 ± 1       | 57.1 ± 0.4     | 61.8 ± 0.4     | 68.7 ± 0.6     | 60.2 ± 0.4     |
| 500            | 30 ± 2.9    | 46.6 ± 0.6     | 41.1 ± 1       | 53.1 ± 0.7     | 54.8 ± 1.3     | 46.6 ± 0.6     |
| 750            | 36.4 ± 3.1  | 52.8 ± 0.4     | 53.3 ± 0.6     | 61.3 ± 0.4     | 60.6 ± 1.9     | 56.4 ± 3.1     |
| *F. eriobotryoides* leaves | 1000  | 52.6 ± 0.6     | 58.4 ± 1.6     | 60.2 ± 1       | 67 94 ± 1.2    | 63.9 ± 1.6     | 59.3 ± 0.6     |
| 1250           | 73.1 ± 1.9  | 66.6 ± 0.6     | 66.6 ± 0.6     | 76.6 ± 0.4     | 82.9 ± 1.6     | 71.5 ± 1.7     |

**p-Value**

\[**\]: Positive control (DMSO); \[**\]: Positive control (Carbendazim); \[**\]: Highly significant effect at 0.01 level of probability.

### Table 3. Minimum inhibitory concentrations (MICs) of the plant extracts and reference fungicide.

| Plant Extracts             | Minimum Inhibitory Concentration (MIC mg/L) against *F. oxysporum* Isolates |
|----------------------------|--------------------------------------------------------------------------------|
|                            | F. oxy 1 | F. oxy 2 | F. oxy 3 | F. oxy 4 | F. oxy 5 | F. oxy 6 |
| *C. maculatum* leaves      | 125      | 125      | 64       | 32       | 64       | 64       |
| *Acacia saligna* bark      | 125      | 125      | 64       | 64       | 64       | 64       |
| *Schinus terebinthifolius* wood | 125    | 250      | 250      | 125      | 250      | 250      |
| *Ficus eriobotryoides* leaves | 125  | 250      | 250      | 125      | 250      | 250      |
| Carbendazim *              | 10       | 10       | 5        | 5        | 10       | 10       |

\[*\]: Reference fungicide.

### 3.3. Antioxidant Activity of Extracts

Table 4 presents the antioxidant activity of extracts from *C. maculatum* leaves, *A. saligna* bark, *S. terebinthifolius* wood and *F. eriobotryoides* leaves compared with those reported from the standards ascorbic acid (AA) and butylated hydroxyl toluene (BHT) as measured by 2,2-Diphenyl-1-picrylhydrazyl (DPPH) free radical scavengers and \(\beta\)-Carotene-linoleic acid bleaching (BCB) assays. The lowest concentrations that inhibited 50% of DPPH free radicals were 3.4 µg/mL (*C. maculatum* leaves) and 5.12 µg/mL (*S. terebinthifolius* fruits) where they were lower than the value from AA (7.66 µg/mL) but higher than from BHT (2.4 µg/mL). Comparing with the other method, BCB, the lower values were reported as *C. maculatum* extract (4.5 µg/mL) was tested, which was lower than the value reported from AA (5.12 µg/mL) and higher than as found be BHT (2.78 µg/mL). It can be observed that
the extract from *A. saligna* bark had weakened antioxidant activity as measured by DPPH and BCB methods.

**Table 4. Antioxidant activity of four extracts measured by DPPH and β-carotene-linoleic acid assays.**

| Extract                             | Concentration (µg/mL) * | DPPH     | BCB       |
|-------------------------------------|-------------------------|----------|-----------|
| Conium maculatum leaves             | 3.4 ± 0.1 c**           | 4.5 ± 0.1 d |
| Acacia saligna bark                 | 10.2 ± 0.1 a            | 14.3 ± 0.1 a |
| Schinus terebinthifolius wood       | 5.12 ± 0.4 c            | 6 ± 0.12 b  |
| Ficus eriobotryoides leaves         | 4.22 ± 0.12 d           | 6.07 ± 0.33 b |
| **Positive controls**               |                         |          |           |
| AA                                  | 7.66 ± 0.5 b            | 5.12 ± 0.1 c |
| BHT                                 | 2.4 ± 0.2 f             | 2.78 ± 0.1 c |

*: The lowest concentration that caused a 50% inhibition of free radical by DPPH method or by 50% BCB bleaching inhibition compared with control. AA: Ascorbic acid. BCB: β-Carotene-linoleic acid. BHT: Butylated hydroxytoluene. DPPH: 2,2-Diphenyl-1-picrylhydrazyl. All the values are mean ± SD. SD: standard deviation. The lowest values are the most active. ** Means with the same superscript letter within the same column are not significantly different according to LSD (*p* < 0.05).

4. Discussion

The results of the present work show that the extracts of *C. maculatum* leaves, *A. saligna* bark, *S. terebinthifolius* wood and *F. eriobotryoides* leaves possessed a remarkable and potential antifungal activity against the six *F. oxysporum* isolates as well as antioxidant properties. These activities could be related to the presence of the identified several phenolic and flavonoid compounds in their extracts.

*p*-Hydroxy benzoic acid, benzoic acid, gallic acid, rosmarinic acid, vanillic acid and p-coumaric acid were observed as the abundant compounds in *C. maculatum* leaf ethanolic extract. Previously, total phenolic compounds were presented in *C. maculatum* 33.28 mg GAE/g DW [84]. Coumarins, umbelliferone and scopoletin compounds isolated from *C. maculatum* extract showed inhibitory effects on *Alternaria*, and *Bipolaris* species spore germination, which were greater than those of xanthotoxin, furanocoumarins, bergapten and angelcin [85]. The tested furanocoumarins were most effective for inhibiting mycelial growth of *Fusarium* spp. than *Alternaria* and *Bipolaris* [85]. Leaf extract of *C. maculatum* showed weak activity against *Phytophthora infestans* [86]. At the concentration of 50%, *C. maculatum* roots ethanolic extract showed the maximum inhibition of mycelia growth and conidial germination of the *Fusarium pallidoroseum* [87].

In the present study, bark extract from *Acacia saligna* showed the presence of gallic acid, benzoic acid, caffeine, chlorogenic acid, vanillin, caffeic acid, rosmarinic acid and ferulic acid as main compounds. Polyphenolic and tannins compounds are the most abundant compounds in leaves, fruits, stems, pods, petiole, and roots of *Acacia* [88,89]. Previous work showed that benzoic acid, caffeine, o-coumaric acid, naringenin, quercetin, and kaempferol were identified as the main compounds from water extract of *A. saligna* flower analyzed using HPLC, but in total, the extract showed weak antioxidant activity as measured by the DPPH method [3]. *A. saligna* leaf extracts qualitatively showed the presence of polyphenolic compounds, e.g., quercetin, quercitrin, apigenin, apigenin-7-glucoside, myricetin 3-O-glucoside, astragalin, gallic acid, taurine, myricetin, myricitrin, 7-galloylcatetechin, (+)-catechin and kaempferol [28,90,91]. Myricetin-3-O-rhamnoside (C7-O-C7) myricetin-3-O-rhamnoside was isolated from leaves while myricetin-3-O-a-L-rhamnoside and quercetin-3-O-a-L-rhamnoside were isolated from leaves and flowers of *A. saligna* [92].

Acacia extracts were observed to exhibit potent bioactivity against a wide range of fungal species including *Pythium aphanidermatum*, *Alternaria brassicae*, *Rhyzoctonia solani*, *Microsporum gypseum*, *Epidermophyton floccosum*, *Trichophyton rubrum* and *Fusarium oxysporum* ciceris, *F. culmorum*, *Candida albicans* and *Penicillium chrysogenum* [3,93–97]. In the present study, the illustration of the fungicidal bioactivity of *A. saligna* bark ex-
tract against six isolates of F. oxysporum is shown for the first time. Recently, strong antifungal activity was observed with methanolic extract of leaves, which were associated with specific polyphenols gallic acid, quercetin 3-glucuronide, rutoside, hyperoside, and p-coumaric acid [98]. Leaf ethanol extract of A. saligna showed remarkable antifungal activity against Aspergillus flavus, A. fumigatus, A. niger, and Candida albicans, where phenolic acid gallic, protocatechuic, chlorogenic, p-hydroxy benzoic, p-coumaric, syringic, vanillic and salicylic were reported as main compounds [29]. From other species of Acacia, methanol extract from Acacia amplexipes bark showed significant to moderate inhibition against Trichoderma spp., Rhizopus and Acremonium spp. and less activity against Aspergillus niger [99]. Fruits and bark ethyl acetate extracts of A. nilotica (L.) Willd. ex Del subsp. nilotica, tomentosa and astringens showed the highest molluscicidal activity against Bulinus truncatus and Biomphalaria pfeifferi. The activity was mainly due to (-)-epigallocatechin-7-gallate and (-)-epigallocatechin-5,7-digallate or (-)-epigallocatechin derivatives [100]. Quercetin 3-O-(4’-O-acetyl)-rhamnopyranoside and ferulic acid was isolated from leaves and bark extract from A. arabica [101]. The whole plant extract from A. plicosepalus showed the presence of rutin [102].

Wood extract of S. terebinthifolius showed the present quinol, naringenin, rutin, catechol, benzoic acid, quercetin, and caffic acid as the main abundant polyphenolic compounds. Gallic acid, methyl and ethyl gallates, (+)-catechin, myricetin, kaempferol, quercetin, afzelin, myricetrin were isolated from the leaf extract with cytotoxic and antiradical activities [103]. Naringenin with gallic acid were identified in fruits extract from S. terebinthifolius [36]. Wood extract showed the presence of fatty acids in form of methyl esters such as myristic, 14-pentadecenoic acid, and pentadecanoic acid [104]. Phenolic compounds ferulic acid, caffeic acid, romarinic acid, chlorogenic acid, gallic acid and quercetin were identified in S. terebinthifolius extracts [105].

Phenolic compound of S. terebinthifolius might be useful in the control of Paracoccidioides brasiliensis, the pathogenic fungi [106]. Gallotannins, gallic acid and flavonoids were isolated from fruit of S. terebinthifolius with potential antibacterial activity [107]. Gallic acid and its derivatives have been isolated from leaves and fruits of S. terebinthifolius [108,109]. Additionally, leaf extract from S. terebinthifolius showed the presence of two gallic acid derivatives, methyl gallate and 1,2,3,4,6-penta-0-galloyl-β-glucopyranoside, and four flavonoids (robustaflavone, quercetin, quercitrin, and luteolin), where they exhibited considerable antioxidant activity [110]. Numerous bioactive compounds were identified from the aerial parts extract of S. terebinthifolius such as coumarins, 2,8-dihydroxyadenine, gallic acid and tannins [111,112].

In the present study and for the first time, we identified the polyphenolic compounds from Ficus eriobotryoides leaves, where rutin, o-coumaric acid, p-hydroxy benzoic acid, resveratrol, and rosmarinic acid were identified as the main compounds in the ethanol extract. Phenolic compounds such as furanocoumarins (psoralen and bergapten), ferulic acid, gallic acid, chlorogenic acid, and flavonoids like rutin identified from some Ficus plants have been recognized for their pharmacological properties [41,113–115]. The strong antioxidant and antibacterial activities of F. microcarpa bark extract have been attributed to its high level of phenolic compounds such as catechol, vanillin, syringaldehyde, p-propylphenol, p-vinylguaiacol, and syringol [116]. Rutin, and chlorogenic acid, present in F. carica, and F. elastica extracts have been promised as potent antioxidant activity [117].

Phenolic and flavonoid compounds found in plants with different quantities depending on the plant part and the extraction process have great effects as antimicrobials and antioxidants [3,71,118]. Dihydroquercetin isolated from barley showed to suppress the growth of Fusarium spp. [119], while naringenin and its derivatives were displayed potential antimicrobial activities [120]. The methanol extract with its main compound rutin extracted from peels of Musa paradiisaca showed potential wood-biofungicide against the growth of Fusarium culmorum and Rhizoctonia solani [9]. Flower extract of A. saligna flower extract with its main phenolic and flavonoid compounds (o-coumaric acid, benzoic acid, quercetin, naringenin, and kaempferol) showed good antifungal activity against
Penicillium chrysogenum [3]. Rutin from Polygala paniculata possessed good activity against Sporothrix schenckii and Cryptococcus gattii [121], while the extract from Phaleria macrocarpa fruit showed the presence of myricetin, naringin, and rutin, which could responsible for the bioactivity [122,123]. Quercetin, which was identified in S. terebinthifolius wood and F. eriobotryoides leaves, has shown antifungal and antioxidant activities [124]. Three flavonoids and two esters of gallic acid isolated from S. terebinthifolius leaves were observed for their antiradical potential [103].

5. Conclusions

This study provides the potential use of four extracts from Conium maculatum leaves, Acacia saligna bark, Schinus terebinthifolius wood and Ficus eriobotryoides leaves for the antifungal and antioxidant properties. Phytochemical investigations of the ethanolic extracts identified several phenolic and flavonoid compounds, where the most abundant compounds were p-hydroxy benzoic acid, benzoic acid, and gallic acid in C. maculatum leaf, gallic and benzoic acids in A. saligna bark, quinol, naringenin, rutin, catechol, benzoic acid, and quercetin in S. terebinthifolius wood, and rutin, o-coumaric acid, p-hydroxy benzoic acid, resveratrol, and rosmarinic acid in F. eriobotryoides leaves. The extracts showed promising antifungal and antioxidant properties. Extracts from A. saligna and C. maculatum showed the highest activity against all the studied six isolates from F. oxysporum. Among the four extracts, C. maculatum leaf extract showed promising antioxidant activity compared to standard antioxidant compounds. Therefore, the phenolic and flavonoid compounds as well as caffeine present in the four plants were identified as a promising natural source to control and manage the growth of Fusarium oxysporum isolates as well as for antioxidant activity.

Author Contributions: Conceptualization, M.Z.M.S. and A.A.M.; data curation, M.Z.M.S. and A.A.M.; funding acquisition, D.A.A.F. and H.M.A.; investigation, M.Z.M.S. and A.A.M.; methodology, M.Z.M.S. and A.A.M.; resources M.Z.M.S., A.A.M., H.M.A. and D.A.A.F.; software, M.Z.M.S., A.A.M., H.M.A. and D.A.A.F.; validation, M.Z.M.S., A.A.M., H.M.A. and D.A.A.F.; Writing—original draft, M.Z.M.S., A.A.M., H.M.A. and D.A.A.F.; Writing—review and editing, M.Z.M.S., A.A.M., H.M.A. and D.A.A.F. All co-authors contributed to writing and revising the article. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by the Deanship of Scientific Research at King Saud University for funding this work through Research group no. RG 1435-011.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The authors would like to extend their sincere appreciation to the Deanship of Scientific Research at King Saud University for funding this work through Research group no. RG 1435-011.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Mansour, M.M.A.; Abdel-Megeed, A.; Nasser, R.A.; Salem, M.Z.M. Comparative evaluation of some woody tree methanolic extracts and Paraloid B-72 against phytopathogenic mold fungi Alternaria tenuissima and Fusarium culmorum. BioResources 2015, 10, 2570–2584. [CrossRef]

2. Mansour, M.M.A.; Salem, M.Z.M. Evaluation of wood treated with some natural extracts and Paraloid B-72 against the fungus Trichoderma harzianum: Wood elemental composition, in-vitro and application evidence. Int. Biodeterior. Biodegrad. 2015, 100, 62–69. [CrossRef]

3. Al-Huqail, A.A.; Behiry, S.I.; Salem, M.Z.M.; Ali, H.M.; Siddiqui, M.H.; Salem, A.Z.M. Antifungal, antibacterial, and antioxidant activities of Acacia saligna (Labill.) HL Wendl. flower extract: HPLC analysis of phenolic and flavonoid compounds. Molecules 2019, 24, 700. [CrossRef] [PubMed]

4. Ashmawy, N.A.; Salem, M.Z.M.; El Shanhoury, N.; Al-Huqail, A.A.; Ali, H.M.; Behiry, S.I. Eco-friendly wood-biofungicidal and antibacterial activities of various Coccoloba uvifera L. leaf extracts: HPLC analysis of phenolic and flavonoid compounds. BioResources 2020, 15, 4165–4187.
5. Salem, M.Z.M.; Mervat, E.-H.; Nasser, R.A.; Ali, H.M.; El-Shanhoury, N.A.; Elansary, H.O. Medicinal and biological values of *Callistemon viminalis* extracts: History, current situation and prospects. *Asian Pac. J. Trop. Med.* 2017, 10, 229–237. [CrossRef]

6. Ashmawey, N.A.; Al Farraj, D.A.; Salem, M.Z.M.; Elshikh, M.S.; Al-Kufaidy, R.; Alshammari, M.k.; Salem, A.Z.M. Potential impacts of *Punica halensis* Miller trees as a source of phytochemical compounds: Antibacterial activity of the cones essential oil and n-butanol extract. *Agroforeys. Syst.* 2020, 94, 1403–1413. [CrossRef]

7. Abdelsalam, N.R.; Salem, M.Z.M.; Ali, H.M.; Mackled, M.I.; EL-Hefny, M.; Elshikh, M.S.; Hatamleh, A.A. Morphological, biochemical, molecular, and oil toxicity properties of *Taxodium trees* from different locations. *Ind. Crop. Prod.* 2019, 139, 111515. [CrossRef]

8. El-Sabrout, A.M.; Salem, M.Z.M.; Bin-Jumah, M.; Allam, A.A. Toxicological activity of some plant essential oils against *Tribolium castaneum* and *Culex pipiens* larvae. *Processes* 2019, 7, 933. [CrossRef]

9. Behiry, S.I.; Okla, M.K.; Alamri, S.A.; EL-Hefny, M.; Salem, M.Z.M.; Alaraidh, I.A.; Ali, H.M.; Al-Ghtani, S.M.; Monroy, J.C.; Salem, A.Z.M. Antifungal and antibacterial activities of *Musa paradisiaca* L. peel extract: HPLC analysis of phenolic and flavonoid contents. *Processes* 2019, 7, 215. [CrossRef]

10. EL-Hefny, M.; Salem, M.Z.M.; Behiry, S.I.; Ali, H.M. The Potential Antibacterial and Antifungal Activities of Wood Treated with *Withania somnifera* Fruit Extract, and the Phenolic, Caffeine, and Flavonoid Composition of the Extract According to HPLC. *Processes* 2020, 8, 113. [CrossRef]

11. Stanković, M.S.; Stefanović, O.; Čomić, L.; Topuzović, M.; Radojević, I.; Solujić, S. Antimicrobial activity, total phenolic content and flavonoid concentrations of *Teucrium* species. *Cent. Eur. J. Biol.* 2012, 7, 664–671. [CrossRef]

12. Ruan, Y.; Kotraiah, V.; Straney, D.C. Flavonoids stimulate spore germination in *Fusarium solani* pathogenic on legumes in a manner sensitive to inhibitors of cAMP-dependent protein kinase. *Mol. Plant Microb. Interact.* 1995, 8, 929–938. [CrossRef]

13. Rhouma, A.; Daoud, H.B.; Ghanmi, S.; Salah, H.B.; Romdhane, M.; Demak, M. Antimicrobial activity of leaf extracts of *Pistacia* and *Schinus* species against some plant pathogenic fungi and bacteria. *J. Plant Path.* 2009, 91, 339–345.

14. El Hadrami, A.; Adam, L.R.; Daayf, F. Biocontrol treatments confer protection against *Verticillium dahliae* infection in potato by inducing anti-microbial metabolites. *Mol. Plant Microbe Interact.* 2011, 24, 328–335. [CrossRef]

15. Panter, K.E.; Gardner, D.R.; Shea, R.E.; Molyneux, R.J.; James, L.F. Toxic and teratogenic piperidine alkaloids from *Lupinus*, *Conium* and *Nicotiana* species. In *Toxic Plants and Other Natural Toxicants*; Chapman and Hall, New York, 1998.

16. Gebhardt, Y.; Witte, S.; Forkmann, G.; Lukačin, R.; Matern, U.; Martens, S. Molecular evolution of flavonoid dioxygenases in the family Apiceae. *Phytochemistry* 2005, 66, 1273–1284. [CrossRef]

17. Harborne, J.B.; Williams, C.A. Flavonoid pattern in the fruits of the Umbelliferae. *Phytochemistry* 1978, 17, 1741–1750. [CrossRef]

18. Teubert, H.; Herrmann, K. Flavonol glycosides of leaves and fruits of *dill* (*Anethum graveolens* L.). Phenolics and spices. *Z. Lebensm. Unters. Forsch.* 1978, 167, 101–104. [CrossRef]

19. Meier, P.; Hotti, H.; Rischer, H. Elicitation of furanocoumarins in poison hemlock (*Conium maculatum* L.) cell culture. *Plant Cell Tissue Organ Cult. (PCTOC)* 2015, 123, 443–453. [CrossRef]

20. Chizzola, R.; Lohwasser, U. Diversity of Secondary Metabolites in Roots from *Conium maculatum* L. *Plants* 2020, 9, 939. [CrossRef]

21. López, T.N.; Cid, M.S.; Bianchini, M.L. Biochemistry of the hemlock (*Conium maculatum* L.) alkaloids and their acute and chronic toxicity in livestock. *Toxicon* 1999, 37, 841–865. [CrossRef]

22. Razzaghi-Abyaneh, M.; Shams-Ghahfarokhi, M.; Rezaee, M.B.; Jaimand, K.; Alinezhad, S.; Saberi, R.; Yoshinari, T. Chemical composition and antiaflatoxigenic activity of *Citrus aurantifolia* and *C. limetta* essential oils. *Food Control* 2019, 20, 1018–1024. [CrossRef]

23. Kousar, S.; Rasool, F.; Aafia, S.; Mushthaq, N.; Nazim, N. Evaluation of different botanicals against *Verticillium fungicola* causal pathogen of dry bubble disease of button mushroom. *Pharma Innov. J.* 2018, 7, 34–36.

24. Yanar, Y.; Gökçe, A.; Kadioglu, I.; Çam, H.; Whalon, M. In vitro antifungal evaluation of various plant extracts against early blight disease (*Alternaria solani*) of potato. *Afr. J. Biotechnol.* 2011, 10, 8291–8295.

25. Ali-Shtayeh, M.S.; Al-Assali, A.A.; Jamous, R.M. Antimicrobial activity of Palestinian medicinal plants against acne-inducing bacteria. *Afr. J. Microbiol. Res.* 2013, 7, 2560–2573.

26. Ozçelik, B.; Kusmenoglu, Ş.; Turkoz, S.; Abbasoglu, U. Antimicrobial activities of plants from the *Apicaceae.* *Pharm. Biol.* 2004, 42, 526–528. [CrossRef]

27. Abdelsalam, N.R.; Ali, H.M.; Salem, M.Z.M.; El-Wakil, H.E. Quantitative and Qualitative Genetic Studies of Some *Acacia* Species Grown in Egypt. *Plants* 2020, 9, 243. [CrossRef]

28. El-Toumy, S.A.; Salib, J.Y.; Mohamed, W.M.; Morsy, F.A. Phytochemical and antimicrobial studies on *Acacia saligna* leaves. *Egypt J. Chem.* 2010, 53, 705–717.

29. Gumgumjee, N.M.; Hajar, A.S. Antimicrobial efficacy of *Acacia saligna* (Labill.) H.L. Wendl. and *Cordia sinensis* Lam. leaves extracts against some pathogenic microorganisms. *Int. J. Microbiol. Immunol. Res.* 2015, 3, 51–57.

30. Saleem, A.; Ahotupa, M.; Pihlaja, K. Total phenolics concentration and antioxidant potential of extracts of medicinal plants of Pakistan. *Z. Naturforsch.* 2001, 56, 973–978. [CrossRef]

31. Rocha, P.D.S.D.; Paula, V.M.B.; Olinto, S.C.F.; dos Santos, E.L.; de Picoli Souza, K.; Estevinho, I.M. Diversity, Chemical Constituents and Biological Activities of Endophytic Fungi Isolated from *Schinus terebinthifolius* Raddi. *Microorganisms* 2020, 8, 859. [CrossRef]
32. Salem, M.Z.M.; EL-Hefny, M.; Ali, H.M.; Elansary, H.O.; Nasser, R.A.; El-Settawy, A.A.A.; El Shanhorey, N.; Ashmawy, N.A.; Salem, A.Z.M. Antibacterial activity of extracted bioactive molecules of Schinus terebinthifolius ripened fruits against some pathogenic bacteria. Microb. Pathog. 2018, 120, 119–127. [CrossRef] [PubMed]

33. Hussein, H.S.; Salem, M.Z.M.; Soliman, A.M. Repellent, attractive, and insecticidal effects of essential oils from Schinus terebinthifolius fruits and Cymbopogon citratus leaves on two whitefly species, Bemisia tabaci and Trialeurodes vaporariorum. Sci. Hortic. 2017, 216, 111–119. [CrossRef]

34. Salem, M.Z.M.; El-Shikh, M.S.; Ali, H.M. Antibacterial activity of extract from the stem bark of Schinus terebinthifolius. J. Pure Appl. Microbiol. 2014, 8, 3865–3870.

35. De Carvalho, M.C.R.D.; Barca, F.N.T.V.; Agnez-Lima, L.F.; de Medeiros, S.R.B. Evaluation of mutagenic activity in an extract of pepper tree stem bark (Schinus terebinthifolius Raddi). Environ. Mol. Mutagenesis 2003, 42, 185–191. [CrossRef]

36. De Lima Glória, L.; Barreto de Souza Arantes, M.; Menezes de Faria Pereira, S.; de Souza Vieira, G.; Xavier Martins, C.; Ribeiro de Carvalho Junior, A.; Antunes, F.; Braz-Filho, R.; José Cuncino Vieira, I.; Leandro da Cruz, L.; et al. Phenolic compounds present Schinus terebinthifolius Raddi influence the lowering of blood pressure in rats. Molecules 2017, 22, 1792. [CrossRef]

37. Salem, M.Z.M.; Salem, A.Z.M.; Camacho, L.M.; Ali, H.M. Antimicrobial activities and phytochemical composition of extracts of Ficus species: An overview. Afr. J. Microbiol. Res. 2013, 7, 4207–4219.

38. Hansson, A.; Zelada, J.C.; Noriega, H.P. Reevaluation of risks with the use of Ficus insipida latex as a traditional anthelmintic remedy in the Amazon. J. Ethnopharmacol. 2005, 98, 251–257. [CrossRef]

39. Manian, R.; Anusuya, N.; Siddhuraju, P.; Manian, S. The antioxidant activity and free radical scavenging potential of two different solvent extracts of Camellia sinensis (L.) O. Kuntz, Ficus bengalensis L. and Ficus racemosa L. Food Chem. 2008, 107, 1000–1007. [CrossRef]

40. Adeshina, G.O.; Okeke, C.-L.E.; Osuagwu, N.O.; Ehinmidu, J.O. Preliminary in-vitro antibacterial activities of ethanolic extracts of Ficus sycomorus Linn. and Ficus platypylla Del. (Moraceae). Afr. J. Microbiol. Res. 2010, 4, 598–601.

41. Abdel-Hameed, E.S.S. Total phenolic contents and free radical scavenging activity of certain Egyptian Ficus species leaf samples. Food Chem. 2009, 114, 1271–1277. [CrossRef]

42. Atanasonova-Penichon, V.; Bernillon, S.; Marchegay, G.; Lornac, A.; Pinson-Gadais, L.; Ponts, N.; Zehraoui, E.; Barreau, C.; Richard-Forget, F. Bioguided isolation, characterization, and biotransformation by Fusarium verticillioides of Maize Kernel compounds that inhibit Fumonisins production. Mol. Plant Microbe Interact. 2014, 27, 1148–1158. [CrossRef]

43. Xing, F.; Hua, H.; Selvaraj, J.N.; Yuan, Y.; Zhao, Y.; Zhou, L.; Liu, Y. Degradation of fumonisin B1 by cinnamon essential oil. Food Control 2014, 38, 37–40. [CrossRef]

44. Ploetz, R.C. Fusarium Wilt of Banana. Phytopathology 2015, 105, 1512–1521. [CrossRef]

45. Postma, J.; Rattink, H. Biological control of Fusarium wilt of Carnation with non-pathogenic isolate of Fusarium oxysporum. Can. J. Botany 1992, 70, 1199–1205. [CrossRef]

46. Saremi, H. Ecology and Taxonomy of Fusarium species. Ph.D. Thesis, Sydney University, Camperdown, NSW, Australia, 1996.

47. Tawfik, A.A.; Allam, A.D.A. Improving cumin production under soil infestation with Fusarium wilt pathogen: I-Screening of biocontrol agents. Assit. Univ. Bull. Environ. Mol. Mutagenesis 2004, 4, 95–101. [CrossRef]

48. Sabrina, P.; Chohan, S.; Parveen, R. Physiological studies on Lasiodiplodia theobromae and Fusarium solani, the cause of Shesham decline. Mycopathologia 2009, 75, 35–38.

49. Windels, C.E. Fusarium species stored in silica gel and soil for ten years. Mycologia 1993, 25, 21–23. [CrossRef]

50. Vakalounakis, D.J.; Chalkias, J. Survival of Fusarium Wilt of Banana. Mol. Plant Microbe Interact. 2014, 27, 1148–1158. [CrossRef]

51. Tamuli, P.; Das, J.; Boruah, P. Antifungal Activity of Polygonum hydropiper and Solanum melongena against Plant Pathogenic Fungi. Plant Arch. 2014, 14, 15–17.

52. Mohamed, A.A.; Behiry, S.I.; Ali, H.M.; EL-Hefny, M.; Salem, M.Z.M.; Ashmawy, N.A. Phytochemical Compounds of Branches from P. halphenisi Oily Liquid Extract and S. terebinthifolius Essential Oil and Their Potential Antifungal Activity. Processes 2020, 8, 330. [CrossRef]

53. Mohamed, A.A.; EL-Hefny, M.; EL-Shanhoure, N.A.; Ali, H.M. Foliar Application of Bio-Stimulants Enhancing the Production and the Toxicity of Oryzium majorana Essential Oils Against Four Rice Seed-Borne Fungi. Molecules 2020, 25, 2363. [CrossRef]

54. Martin, S.; Mussatto, S.I.; Martínez-Avila, G.; Montañez-Saenz, J.; Aguilar, C.N.; Teixeira, J.A. Bioactive phenolic compounds: Production and extraction by solid-state fermentation. A review. Biotechnol. Adv. 2011, 29, 365–373. [CrossRef]

55. Salem, M.Z.M.; Mansour, M.M.A.; Elansary, H.O. Evaluation of the effect of inner and outer bark extracts of Sugar Maple (Acer saccharum var. saccharum) in combination with citric acid against the growth of three common molds. J. Wood Chem. Technol. 2019, 39, 136–147. [CrossRef]

56. Singh, R.; Kumari, N.; Nath, G. Free radicals scavenging activity and antimicrobial potential of leaf and fruit extracts of Sapindus mukorossi Gaertn. against clinical pathogen. Int. J. Phytomed. 2016, 8, 22–28.

57. Rice-Evans, C.; Miller, N.; Paganga, G. Antioxidant properties of phenolic compounds. Trends Plant Sci. 1997, 2, 152–159. [CrossRef]

58. Latté, K.P.; Kolodziej, H. Antioxidant properties of phenolic compounds from Pelargonium reniforme. J. Agric. Food Chem. 2004, 52, 4899–4902. [CrossRef]
Plants 2021, 10, 1325

10. Salem, M.Z.M.; Zayed, M.Z.; Ali, H.M.; Abd El-Kareem, M.S.M. Chemical composition, antioxidant capacity and antibacterial activities of extracts from Schinus molle L. wood branch growing in Egypt. J. Wood Sci. 2016, 62, 548–561. [CrossRef]

11. El-Hefny, M.; Moustafa, N.Y. Screening and total phenolic content of extracts from three genders of carob tree barks growing in Morocco. Arab. J. Chem. 2013, 4, 321–324. [CrossRef]

12. Zhang, X.X.; Shi, Q.Q.; Ji, D.; Niu, L.X.; Zhang, Y.L. Determination of the phenolic content, profile, and antioxidant activity of seeds from nine tree peony (Paonia section Moutan DC.) species native to China. Food Res. Int. 2017, 97, 141–148. [CrossRef]

13. Salem, M.Z.M.; Abdel-Megeed, A.; Ali, H.M. Stem wood and bark extracts of Delonix regia (Boj. Ex. Hook): Chemical analysis, antibacterial, antifungal, and antioxidant properties. BioResources 2014, 9, 2382–2395. [CrossRef]

14. Salem, M.Z.M.; Ali, H.M.; Mansour, M.M.A. Fatty acid methyl esters from air-dried wood, bark, and leaves of Brachychiton diversifolius R. Br. Antibacterial, antifungal, and antioxidant activities. BioResources 2014, 9, 3835–3845. [CrossRef]

15. Amarante, C.V.T.D.; Souza, A.G.D.; Benincà, T.D.T.; Steffens, C.A. Phenolic content and antioxidant activity of fruit of Brazilian genotypes of feijoa. Pesqui. Agropecu. Bras. 2017, 52, 1223–1230. [CrossRef]

16. EL-Hefny, M.; Mohamed, A.A.; Salem, M.Z.M.; Abd El-Kareem, M.S.M.; Ali, H.M. Chemical composition, antioxidant capacity and antibacterial activity against some potato bacterial pathogens of fruit extracts from Phytolacca dioica and Ziziphus spina-christi grown in Egypt. Sci. Hortic. 2018, 233, 225–232. [CrossRef]

17. Abdel-Megeed, A.; Salem, M.Z.M.; Ali, H.M.; Gohar, Y.M. Antioxidant and antibacterial evaluation of the extracts of wood branches. J. Pure Appl. Microbiol. 2013, 7, 1843–1850.

18. Ali, H.M.; Salem, M.Z.M.; Al Sahli, A.A. Performance of antibacterial activity of methanolic extracts from different parts of some tree species using DPPH radical-scavenging assay. J. Pure Appl. Microbiol. 2013, 7, 131–137.

19. Salem, M.Z.M.; Ali, H.M.; El-Shanhorey, N.A.; Abdel-Megeed, A. Evaluation of extracts and essential oil from Callistemon viminalis leaves: Antibacterial and antioxidant activities, total phenolic and flavonoid contents. Asian Pac. J. Trop. Med. 2013, 6, 785–791. [CrossRef]

20. Hosseinihashemi, S.K.; Anooshei, H.; Aghajani, H.; Salem, M.Z.M. Chemical composition and antioxidant activity of extracts from inner bark of Berberis vulgaris stem. BioResources 2015, 10, 7958–7969. [CrossRef]

21. Abdelkhalek, A.; Salem, M.Z.M.; Kordy, A.M. Salem, A.Z.M.; Behiry, S.I. Antiviral, antifungal, and insecticidal activities of Eucalyptus bark extract: HPLC analysis of polyphenolic compounds. Microb. Pathog. 2020, 147, 104383. [CrossRef]

22. Salem, M.Z.M.; Ibrahim, I.H.M.; Ali, H.M.; Helmy, H.M. Assessment the using of natural extracted dyes and pancreatin enzyme for dyeing of four natural textiles: HPLC analysis of polyphenolcs. Processes 2020, 8, 59. [CrossRef]

23. Mansour, M.M.A.; EL-Hefny, M.; Salem, M.Z.M.; Ali, H.M. The Biofungicide Activity of Some Plant Essential Oils for the Cleaner Production of Model Linen Fibers Similar to Those Used in Ancient Egyptian Mummification. Processes 2020, 8, 79. [CrossRef]

24. Clinical and Laboratory Standards Institute (CLSI). Reference Method for Broth Dilution Antifungal Susceptibility Testing of Filamentous Fungi, Approved Standard, 2nd ed.; CLSI document M38-A2; Clinical and Laboratory Standards Institute: Wayne, PA, USA, 2001.

25. El-Mougy, N.S. Effect of some essential oils for limiting early blight (Alternaria solani) development in potato field. J. Plant Prot. Res. 2009, 49, 57–61. [CrossRef]

26. Rahman, M.; Begum, M.; Alam, M. Screening of Trichoderma isolates as a biological control agent against Ceratocystis paradoxa causing pineapple disease of sugarcane. Mycobiology 2009, 37, 277–285. [CrossRef]

27. Elansary, H.O.; Norrie, J.; Ali, H.M.; Salem, M.Z.M.; Mahmoud, E.A.; Yessoufou, K. Enhancement of Calibrachoa cultivars antioxidant, antifungal, and antibacterial activities using seaweed extracts: Total phenolic, flavonoids and tannins contents. BMC Complement. Altern. Med. 2016, 16, 341. [CrossRef]

28. Elansary, H.O.; Norrie, J.; Ali, H.M.; Salem, M.Z.M.; Mahmoud, E.A.; Yessoufou, K. Enhancement of Calibrachoa cultivars antioxidant, antifungal, and antibacterial activities using seaweed extracts: Total phenolic, flavonoids and tannins contents. BMC Complement. Altern. Med. 2016, 16, 341. [CrossRef]

29. Salem, M.Z.M.; Ashmawy, N.A.; Elansary, H.O.; El-Settawy, A.A. Chemotyping of diverse Eucalyptus species grown in Egypt and antioxidant and antibacterial activities of its respective essential oils. Nat. Prod. Res. 2015, 29, 681–685. [CrossRef]

30. Formaggio, A.S.N.; Volobuff, C.R.F.; Santiago, M.; Cardoso, C.A.L.; Vieira, M.D.C.; Valdevina Pereira, Z. Evaluation of antioxidant activity, total flavonoids, tannins and phenolic compounds in Psychotria leaf extracts. Antioxidants 2014, 3, 745–757. [CrossRef]

31. DJenidi, H.; Khennouf, S.; Bouaziz, A. Antioxidant activity and phenolic content of commonly consumed fruits and vegetables in Algeria. Prog. Nutr. 2020, 22, 224–235. [CrossRef]

32. Amidri, H. Chemical Composition and Essential Activity of Essential Oil and Methanolic Extracts of Ferula microcolea (Boiss.) Boiss (Apiaceae). Int. J. Food Prop. 2014, 17, 722–730. [CrossRef]

33. SAS. Users Guide: Statistics (Release 8.02); SAS Institute Inc.: Cary, NC, USA, 2001.

34. Rongai, D.; Pulcini, P.; Pesce, B.; Milan, F. Antifungal activity of some botanical extracts on Fusarium oxysporum. Open Life Sci. 2015, 10, 409–416. [CrossRef]

35. Al-Barwani, F.M.; Eltayeb, E.A. Antifungal compounds from induced Conium maculatum L. plants. Biochem. Syst. Ecol. 2004, 32, 1097–1108. [CrossRef]
112. Queires, L.C.S.; Fauvel-Lafèeve, F.; Terry, S.; De la Taille, A.; Kouyoumdjian, J.C.; Chopin, D.K.; Vacherot, F.; Rodrigues, L.E.A.; Crepin, M. Polyphenols purified from the Brazilian aroeira plant (Schinus terebinthifolius, Raddi) induce apoptotic and autophagic cell death of DU145 cells. *Anticancer Res.* 2006, 26, 379–387.

113. Teixeira, D.M.; Patão, R.F.; Coelho, A.V.; da Costa, C.T. Comparison between sample disruption methods and solid–liquid extraction (SLE) to extract phenolic compounds from Ficus carica leaves. *J. Chromatogr. A* 2006, 1103, 22–28. [CrossRef]

114. Qin, H.; Zhou, G.; Peng, G.; Li, J.; Chen, J. Application of ionic liquid-based ultrasound-assisted extraction of five phenolic compounds from Fig (Ficus carica L.) for HPLC-UV. *Food Anal. Methods* 2015, 8, 1673–1681. [CrossRef]

115. Pande, G.; Akoh, C.C. Organic acids, antioxidant capacity, phenolic content and lipid characterization of Georgia-grown underutilized fruit crops. *Food Chem.* 2010, 120, 1067–1075. [CrossRef]

116. Ao, C.; Li, A.; Elzaawely, A.A.; Xuan, T.D.; Tawata, S. Evaluation of antioxidant and antibacterial activities of *Ficus microcarpa* L. fil. extract. *Food Control* 2008, 19, 940–948. [CrossRef]

117. Teixeira, D.M.; Canelas, V.C.; do Canto, A.M.; Teixeira, J.M.G.; Dias, C.B. HPLC-DAD quantification of phenolic compounds contributing to the antioxidant activity of *Maclura pomifera*, *Ficus carica* and *Ficus elastica* extracts. *Anal. Lett.* 2009, 42, 2986–3003. [CrossRef]

118. Baldan, V.; Sut, S.; Faggian, M.; Gassa, E.D.; Ferrari, S.; De Nadai, G.; Francescato, S.; Baratto, G.; Dall’Acqua, S. *Larix decidua* bark as a source of phytoconstituents: An LC-MS study. *Molecules* 2017, 22, 1974. [CrossRef]

119. Mierziak, J.; Kostyn, K.; Kulma, A. Flavonoids as important molecules of plant interactions with the environment. *Molecules* 2014, 19, 16240–16265. [CrossRef]

120. Orhan, D.D.; Özçelik, B.; Özgen, S.; Ergun, F. Antibacterial, antifungal, and antiviral activities of some flavonoids. *Microbiol. Res.* 2010, 165, 496–504. [CrossRef]

121. Johann, S.; Mendes, B.G.; Missau, F.C.; de Resende, M.A.; Pizzolatti, M.G. Antifungal activity of five species of Polygala. *Braz. J. Microbiol.* 2011, 42, 1065–1075. [CrossRef]

122. Cushnie, T.P.; Lamb, A.J. Antimicrobial activity of flavonoids. *Int. J. Antimicrob. Agents* 2005, 26, 343–356. [CrossRef]

123. Hendra, R.; Ahmad, S.; Sukari, A.; Shukor, M.Y.; Oskouei, E. Flavonoid analyses and antimicrobial Activity of various parts of *Phaleria macrocarpa* (Sche.) Boerl Fruit. *Int. J. Mol. Sci.* 2011, 12, 3422–3431. [CrossRef]

124. Rocha, M.F.G.; Sales, J.A.; da Rocha, M.G.; Galdino, L.M.; de Aguiar, L.; Pereira-Neto, W.D.A.; de Aguiar Cordeiro, R.; Castelo-Branco, D.D.S.C.M.; Sidrim, J.J.C.; Brilhante, R.S.N. Antifungal effects of the flavonoids kaempferol and quercetin: A possible alternative for the control of fungal biofilms. *Biofouling* 2019, 35, 320–328. [CrossRef] [PubMed]