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Swietenia mahagoni Leaves Extract: Antifungal, Insecticidal, and Phytochemical Analysis

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Abstract: In this study, we investigated the antifungal properties of an acetone extract derived from the leaves of *Swietenia mahagoni* (SMAL) against two isolated fungi, *Fusarium equiseti* (OQ820153) and *Rhizoctonia solani* (OQ820152), from rice sheath. The extract was effective in inhibiting the growth of both fungi at the highest concentration tested, 3000 $\mu g \cdot mL^{-1}$. Laboratory tests on the LC_{20} of SMAL extract (49.86 $mg \cdot L^{-1}$) versus pyriproxyfen 10% EC (1.96 $mg \cdot L^{-1}$) were accomplished on *Aphis gossypii* Glover. The extract potently reduced the survival of the nymphs (49.58%) more than the other treatments. The longevity of nymphs treated with the extract had the highest prolongation at 9.67 days. The olfactory choice test exhibited the lowest aphid attraction percentage (23.33%). The HPLC of SMAL extract contained various phenolic compounds, and the most abundant found were catechin (752.64 $\mu g \cdot g^{-1}$), gallic acid, and chlorogenic acid, as well as flavonoids such as rutin (585.24 $\mu g \cdot g^{-1}$) and naringenin. A GC–MS analysis revealed *n*-hexadecanoic acid (37.1%) as the major compound, followed by oleic acid. These results suggest that SMAL extract has the potential to help plants fight against fungal and insect infections, making it a promising natural and renewable solution for long-term plant pest regulation.

Keywords: *Swietenia mahagoni*; acetone extract; antifungal; rice; *Fusarium equiseti*; pyriproxyfen; insecticidal; *Aphis gossypii*; HPLC; GC–MS

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1. Introduction

The capacity to overcome medication resistance and the unpleasant side effects associated with antibiotics has led to a rise in the popularity of medicinal plants and other natural products in the last few years for treating a wide range of pathogenic diseases. Therefore, scientists are investigating new antimicrobial substances that have been used for centuries in alternative medicine. The phytochemical components included in plant extracts make them a less risky and more cost-effective choice. The identification of chemical compounds derived from herbal plants has sparked research into the phytocompounds [1–3] responsible for their biological properties.

The *Swietenia mahagoni* (L.) belongs to the Meliaceae family, which consists mainly of evergreen blooming plants. This family, which has around 50 genera and 550 species, has been widely farmed in South Asia and the Pacific region [4]. A broad variety of diseases are treated using various species from this family's usage in traditional medicine. The bark of *S. mahagoni* is used as a spice and in spirits, while its seeds are employed for the treatment of malaria, diabetic complications, autoimmune disorders, viral infections, eating disorders, and hypertension [5]. The therapeutic properties of plants are attributed to their secondary metabolites, which can be used to produce natural antibiotics. The Meliaceae family contains various chemical compounds, including triterpenoids (limonoids), which are more abundant in this family than in others [6]. Over 300 limonoids have been extracted from this family, including seven from the extract of *S. mahagoni* seeds [7]. Different species of *Swietenia* contain in their various parts phenolic compounds, triterpenoids (limonoids), flavonoids, swiemahogins A and BC, and alkaloids [8,9].

According to the data from the United States Department of Agriculture (USDA) for the 2021–2022 marketing year, Egypt ranks as the 20th largest producer of rice in the world, with an estimated production of 4.2 million metric tons, out of a worldwide production of 513.85 million metric tons [10]. Sheath blight is an economically significant rice disease worldwide caused by the fungus *Rhizoctonia solani* and was reported in Egypt early in 2013 [11,12]. A mild pathogen in cereals, *Fusarium equiseti* is occasionally detected in association with kernels affected by *Fusarium* head blight [13]. However, recent research has suggested that the *F. incarnatum-equiseti* species complex may also be associated with the rice sheath rot disease [14]. Meanwhile, Tralamazza et al. [15] have reported that this species complex is associated with panicle infection in wild rice in Brazil. Numerous research studies have explored the effectiveness of different extracts against *R. solani*, revealing encouraging outcomes regarding their antifungal properties [16–18]. Antifungal properties towards the fungi *Aspergillus flavus*, *Candida* spp., and *A. niger* were detected using water, alcohol, ether, and chloroform-derived extracts of *S. macrophylla* leaves [19]. The methanolic extract of *S. mahagoni* leaves was shown to be more potent against *C. albicans* and *A. niger* when compared to a water-based extract and other solvent extracts [20]. Additionally, the antifungal properties of triterpenoids from *Khaya senegalensis* and *S. mahagoni* were investigated by Govindachari et al. [7].

One of the wide-ranging polyphagous insects that exhibit several sophisticated biotypes and plausible distinctions in host adaptation is the cotton aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae). Its rapid reproduction and high insecticide resistance give rise to economic and ecological problems [21]. Moreover, the susceptibility to secondary infections like sooty mold and virus diseases would be able to accrete in the infected host plants [22]. Oil of mahogany from *S. mahagoni* showed the potent toxic and repellent effects on the nymphs of the bean aphid, *Aphis craccivora* Koch (Hemiptera: Aphididae). Therefore, mahogany oil was suggested for the management of bean aphid [23]. One of the commonly used insect growth regulators in the control of piercing-sucking insects is the pyriproxyfen, which proved a superior efficacy in reducing the population of cotton aphid, *A. gossypii* Glover [24]. This study aimed to isolate and molecularly identify the pathogens responsible for rice sheath blight and rot, examine the antifungal and insecticidal properties of the acetone extract obtained from *Swietenia mahagoni* leaves (SMAL) against fungal pathogens and the cotton aphid, *Aphis gossypii* Glover, and determine the primary phytochemical constituents present in the extract through HPLC and a GC–MS analysis.

2. Materials and Methods

2.1. Source of Phytopathogens

The fungal strains used in this study were isolated from rice sheath, morphologically identified at the genus level under a light microscope according to the fungal identification manual [25] and molecularly identified by amplifying the ITS region using the universal primers ITS1 and ITS4 [26]. All the PCR conditions were previously reported [27], and then the PCR products were purified and sequenced using Sanger's method. The sequences

were annotated, a BLAST search was performed on the GenBank portal to identify the tested fungi according to the NCBI database alignment, and then the fungal sequences were deposited in the GenBank database in order to get the accession numbers.

2.2. Preparation of Swietenia Mahagoni Extract

In this study, *Swietenia mahagoni* leaves were collected in the Alexandria governorate, Egypt, and air-dried for two weeks at 25 °C. The dried leaves were then finely ground into a powder using a grinding mill. One hundred grams of the powdered sample was soaked in 400 mL of 96% acetone for a week, the resulting mixture was filtered, and the *S. mahagoni* (SMAL) extract was concentrated using a rotary vacuum evaporator. To prepare the concentrations used in the study, all extracts were diluted with dimethyl sulfoxide (DMSO) [28].

2.3. Swietenia Mahagoni Extract (SMAL) Antifungal Activity

The potential of SMAL extract to combat the tested fungi was evaluated using the poisoned food technique [29]. Different concentrations of SMAL extract (1000, 2000, and 3000 μg mL^{-1}) were mixed with potato dextrose agar (PDA) plates and compared to the negative control (PDA supplemented with DMSO). Circular disks (0.5 cm) of the fungi were placed on the PDA plates and incubated at 25 °C for 5 days. The experiment was repeated three times. The percentage of growth inhibition (%) was determined by calculating the effect of the SMAL extract on the hyphal growth of the fungi using the formula $[(P - D)/P] \times 100$, where P represents the length of the fungal growth in the control and D represents the hyphal growth length [30].

2.4. Swietenia Mahagoni Extract (SMAL) Insecticidal Activity

2.4.1. Sampling and Rearing of Cotton Aphid

Samples of cotton aphid, *Aphis gossypii* Glover individuals, were collected from different regions in Al-Behera governorate. The collected samples of individual cotton aphids were reared on cotton seedlings (variety Giza 86) based on the rearing method performed by Gaimari and Turner [31]. These seedlings were grown in plastic pots (diameter, 10 cm; height, 8 cm) covered with muslin cloth and incubated in a purpose-built growth chamber supplied with a digital thermostat, hygrometer, and automatic shut-off 24 h timer. The aphid's culture was incubated under rearing conditions of 25 ± 2 °C, 60% RH, and 16 h of light duration. Deteriorated seedlings caused by aphid feeding were replaced whenever needed by new, healthy ones. As the steady growth of aphids increased over time, sufficient quantities of seedlings were gradually introduced into the rearing space. Finally, a laboratory strain (LS) of *A. gossypii* Glover was obtained after approximately 7 successive generations.

2.4.2. Toxicity Studies

Slide dipping techniques performed by Stirbly et al. [32] were used to evaluate the toxicity of the SMAL extract and pyriproxyfen (Grendo 10% EC, a juvenile hormone analog obtained from Soltaire for Agriculture and Industrial Chemicals Co., Alexandria, Egypt) against *A. gossypii* Glover. Six gradual concentrations of each treatment were prepared in distilled water. A stereoscopic microscope and fine brush were used to transfer and fix twenty adult females on the upper side of double-faced Scotch tape. The Scotch tape was affixed to one side of a glass slide. Each concentration had three replicated slides that dipped for 10 s. In the control treatment, the slides were dipped in distilled water. The dipped slides were incubated, and the numbers of living and dead aphids were monitored at 24 h of exposure. Thereafter, mortality percentages were corrected based on Abbott's [33] formula and subjected to a probit analysis [34].

2.4.3. Biological Aspects

A laboratory test was conducted according to the susceptibility test method of the Insecticide Resistance Action Committee (IRAC) [35]. Leaf disks obtained from newly leaves of cotton seedlings were dipped in the solution of each treatment at LC_{20} as well as distilled water for the control treatment. One leaf disk was placed upon the surface of a 1% solidified agar gel poured into the base of a glass container (diameter, 7 cm; height, 2.5 cm). Twenty newly emerged adult female aphids (LS) were transferred onto the leaf disks. Each container was covered with microholed gauze and fitted with lids. Each treatment was replicated three times. The treatments were incubated under the same previous laboratory conditions. Daily monitoring for the biological aspects was accomplished using a stereomicroscope. The longevity and survival percentages of adult females exposed to the LC_{20} of each treatment were monitored every 24 h after treatment. The daily production of newly born nymphs was counted to calculate the total reproduction rate per female. On the other hand, twenty of the first 24 h born nymphs from the adult females exposed to the LC_{20} of each treatment were monitored for their longevity and survival percentage. The total life duration, comprising the longevity of the nymphal and adult stages, was calculated according to Michelotto et al. [36].

2.4.4. Olfactory Response in Triplicate Choice Test

Twenty starved adult aphids were inserted in a central chamber amidst three lateral chambers, which connected with each of them via short tubular passages, according to Jaba et al. [37]. Each lateral chamber hosted 3 g of fresh, tender leaves treated with one of the tested compounds at LC_{20} versus distilled water in the control. An air compressor was used to blow air through slime hoses attached to each lateral chamber over the hosted leaves. The three-hosted leaves were inserted at the same time. This designed set of olfactometer was replicated three times. The number of aphids attracted to each chamber was recorded each hour up to 4 h. The retention time of aphid individuals required to attain their attraction response in each chamber was calculated at the end of the 4th hr. The equation of the olfactory response was expressed by the following equation, according to Weeks et al. [38] as follows:

$$\text{Total attraction percentage} = (100 \times (T + C)/N)$$

where T is the number of aphides entering the chamber of hosted leaves; C: number of aphides entering the control chamber; N: total number of aphides in the olfactometer set.

2.5. HPLC Analysis

The HPLC instrument used in this study was an Agilent 1260 series, as noted in reference [39]. The column used had dimensions of 4.6 mm (diameter) × 250 mm (length) and a particle size of 5 µm. The mobile phase was composed of H_2O (A) and 0.05% CF_3COOH in CH_3CN (B), and the flow rate was 0.9 mL/min. A stepwise gradient program was utilized to facilitate the separation of sample components. Specifically, from 0 to 5 min, the mobile phase contained 80% solvent A and 20% solvent B; from 5 to 8 min, it changed to 60% solvent A and 40% solvent B; from 8 to 12 min, the mobile phase remained at 60% solvent A and 40% solvent B; from 12 to 16 min, it returned to the initial condition of 82% solvent A and 18% solvent B; and from 16 to 20 min, it remained at 82% solvent A and 18% solvent B. Detection was performed using a multiwavelength detector monitored at 280 nm, with an injection volume of 5 µL and a column temperature of 40 °C. The analyzed compounds (standards) included 17 common phenolic and flavonoid components: apigenin, caffeic acid, catechin, chlorogenic acid, cinnamic acid, coumaric acid, daidzein, ellagic acid, ferulic acid, gallic acid, methyl gallate, naringenin, pyrocatechol, quercetin, rutin, syringic acid, and vanillin.

2.6. Gas Chromatography–Mass Spectrometry (GC–MS) Analysis

In this study, an Agilent 7000D GC–MS (Agilent technologies, Santa Clara, CA, USA) was used with a 5% diphenyl/95% dimethylpolysiloxane column packed with an HP-5MS

capillary column. Pure helium gas (99.99%) was used as the carrier gas at a flow rate of 1 mL/min. The ionization energy was set at 70 eV, and the scan time was 0.2 s. The fragment range was set between 40 to 600 m/z. For each injection, 1 µL of the sample was used, with a split ratio of 10:1. The injector temperature was constant at 250 °C. The column oven temperature was set at 50 °C for 3 min, raised at 10 °C per min up to 280 °C, and then increased to 300 °C for 10 min. The identification of phytochemicals was based on the comparison of their retention time, peak area, and mass spectral patterns with those of authentic compounds stored in the mass spectral Wiley registry 8E, replib, and mainlib libraries.

2.7. Statistical Analyses

The obtained data were subjected to an analysis of variance (ANOVA), and means were compared using the LSD test for significance at 0.05 using SAS software [40].

3. Results

3.1. The Process of Isolating and Identifying Fungal Strains

After examining the isolation trails from the sheath of the rice plant, two pathogens were recovered. Upon initial identification using a light microscope, they were confirmed to be *Fusarium* and *Rhizoctonia* species. To further characterize these fungi, we performed a molecular analysis by sequencing the amplified ITS region. The resulting sequences were then compared to those in the Genbank portal, which revealed a homology of 100% with *Fusarium equiseti* and *Rhizoctonia solani*. To make these findings publicly available, we deposited the sequences of the two fungal organisms in the NCBI database under the accession numbers OQ820153 for *F. equiseti* and OQ820152 for *R. solani*.

3.2. Effect of the SMAL Extract on the Fungal Pathogens

Table 1 presents data on the in vitro growth inhibition percentage of two plant pathogenic fungi, *Rhizoctonia solani* and *Fusarium equiseti*, in response to different concentrations of *Swietenia mahagoni* leaf (SMAL) extract.

Table 1. In vitro growth inhibition percentage (%) of plant pathogenic fungi in response to *Swietenia mahagoni* leaf extract.

Treatments of *Swietenia mahagoni* Acetone Extract Conc. (µg·mL^{-1})	**Inhibition Percentage (%)**	
	Rhizoctonia solani	***Fusarium equiseti***
1000	18.21 c	37.86 b
2000	53.22 b	36.07 bc
3000	77.50 a	82.50 a
* Nc	0.00 d	0.00 c

* Nc = negative control (DMSO). The different letters in each column mean the data were significantly different according to the LSD test at a 0.05 level of probability.

The results show that increasing the concentration of the leaf extract led to a higher inhibition percentage for both fungal strains. At a concentration of 1000 µg·mL^{-1}, *R. solani* had an inhibition percentage of 18.21%, while *F. equiseti* had an inhibition percentage of 37.86%. At 2000 µg·mL^{-1}, *R. solani* had a higher inhibition percentage of 53.22%, while *F. equiseti* had a slightly lower inhibition percentage of 36.07%. However, at the highest concentration tested (3000 µg·mL^{-1}), both fungal strains had a high inhibition percentage of 77.50% and 82.50%, respectively. The control group (Nc, DMSO) did not show any inhibition of fungal growth, indicating that the observed effects were due to the SMAL extract and not any other factors. However, the data suggested that the SMAL extract had antifungal properties and could inhibit the growth of *R. solani* and *F. equiseti* in vitro.

3.3. Toxicity of the SMAL Extract on the Adults of Cotton Aphids

Toxicity studies were conducted to calculate the values of the LC_{20} and LC_{50} of the tested plant extracts in comparison to pyriproxyfen 10% EC, on the adult stage of *Aphis gossypii* Glover (LS) at 24 h of exposure under laboratory conditions (Table 2). Pyriproxyfen 10% EC showed the highest toxicity values of 4.18 and 1.96 mg·L^{-1}, which transcended the *Swietenia mahagoni* extract toxic values of 197.70 and 49.86 mg·L^{-1} at LC_{50} and LC_{20}, respectively.

Table 2. Toxicity of the tested compounds on adult *Aphis gossypii* Glover (LS) at 24 h of exposure.

Tested Compound	Lethal Concentration (mg·L^{-1})		Confidence Limits (mg·L^{-1})	Slope ± SE **	χ2 ***	df	N ****
Swietenia mahagoni acetone extract	LC_{20} LC_{50}	49.86 197.70	(30.57–72.21) (155.12–251.96)	0.42 ± 0.05	9.79	4	360
Pyriproxyfen10% EC	LC_{20} LC_{50}	1.96 4.18	(1.62–2.38) (3.67–4.77)	0.71 ± 0.11	7.94	4	360

** Standard error, *** chi square, **** total numbers of aphids submitted to the toxicity test.

3.4. Biological Aspects of Adult Females and Nymphal Stages of Aphis Gossypii Glover

Data of the reproduction activity of adult females and survival percentages of the developmental stages of *A. gossypii* Glover along their longevity period were evaluated under the exposure to the LC_{20} of the tested compounds (Table 3). *Swietenia mahagoni* extract had a potent effect that significantly reduced the survival percentages of the nymphal stage (49.58%), more than pyriproxyfen 10% EC (61.67%) and the control treatment (98.57%). All the tested compounds had no significant differences on the survival percentages of adult female stage. SMAL extract and pyriproxyfen 10% EC had equipollent effects that exceeded the control treatment in reducing the daily and total nymph production in addition to the reproductive period of the adult female.

Table 3. Effects of the LC_{20} of the tested compounds on the reproduction activity of the female and the survival percentages of the born nymphs of *Aphis gossypii* Glover (LS).

Treatments	Nymph Production/Female (Days) ± SD [1]		Reproductive Period (Days) ± SD	Total Mean of Survival% ± SD [1]	
	Daily	Total		Adult Stage	Nymphal Stage
Swietenia mahagoni acetone extract	0.38 ^{b} ± 0.30	1.50 ^{b} ± 0.30	2.33 ^{b} ± 0.58	62.36 ^{a} ± 13.96	49.58 ^{c} ± 3.82
Pyriproxyfen 10% EC	0.50 ^{b} ± 0.58	2.01 ^{b} ± 0.58	3.00 ^{ba} ± 0.00	67.92 ^{a} ± 4.02	61.67 ^{b} ± 1.44
Control	3.94 ^{a} ± 1.55	15.77 ^{a} ± 1.55	3.67 ^{a} ± 0.58	76.33 ^{a} ± 5.93	98.57 ^{a} ± 1.43

[1] SD = standard deviation. Means of data in each column followed by the same letters are not significantly different according to the $LSD_{0.05}$.

3.5. Longevity of Developmental Stages and Total Life Duration of Aphis Gossypii Glover (LS)

The obtained data of the tested compounds at LC_{20} showed biological effects on the longevity of the adult and nymphal stages of *A. gossypii* Glover (LS) and consequently on its total life duration (Table 4). The results of the longevity of adults had no significant differences between all treatments, whilst nymphs treated with the SMAL extract had the highest prolongation of their longevity (9.67 days), more than pyriproxyfen 10% EC (8.67 days) in comparison to the control (7.00 days). Both SMAL extract and pyriproxyfen 10% EC had an equipollent prolongation for the total life duration at 15.67 and 14.33 days, respectively, in comparison to the control at 12.67 days.

Table 4. Effects of the LC_{20} of the tested compounds on the longevity of the developmental stages and the total life duration of *Aphis gossypii* Glover (LS).

Treatments	Longevity (Days) ± SD [1]		Total Life Duration (Adult + Nymph) (Days) ± SD [1]
	Adult Stage	Nymphal Stage	
Swietenia mahagoni acetone extract	6.00 a ± 0.00	9.67 a ± 0.58	15.67 a ± 0.58
Pyriproxyfen 10% EC	5.67 a ± 0.58	8.67 b ± 0.58	14.33 a ± 1.15
Control	5.67 a ± 0.58	7.00 c ± 0.00	12.67 b ± 0.58

[1] SD = standard deviation. Means of data in each column followed by the same letters are not significantly different according to the $LSD_{0.05}$.

3.6. Olfactory Response on the Adult Stage of Aphis Gossypii Glover

The lateral chamber that hosted the leaves treated with the SMAL extract possessed the lowest attraction percentage on aphid individuals (23.33%) compared to pyriproxyfen 10% EC (35.00%), which was on a par with the response of the control (40.00%). All the treatments had no significant differences for the retention times (Rt) of the submitted aphid individuals to achieve their attraction response over 4 h of exposure (Figure 1).

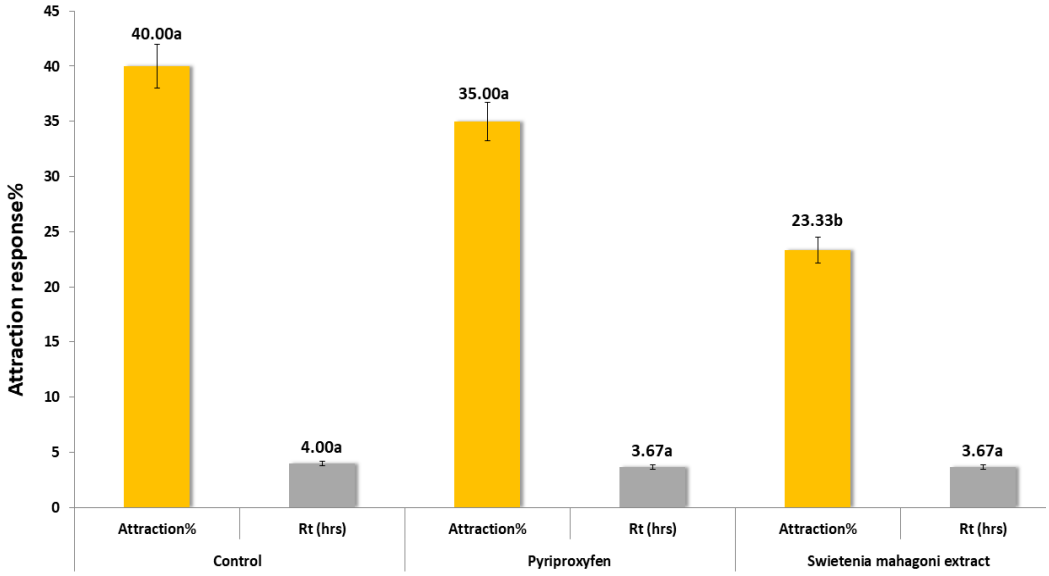

Figure 1. Attraction percentages of the adults of *Aphis gossypii* Glover (LS) at the 4th hr of exposure to the tested compounds at LC_{20} in the olfactory choice test. [1] SD = standard deviation. [2] Rt = retention time (h). Means of attraction percentages and retention times followed by the same letters are not significantly different according to the $LSD_{0.05}$.

3.7. Swietenia Mahagoni Extract's Polyphenolic Content

Table 5 provides a list of the phenolic and flavonoid components detected in the *Swietenia mahagoni* leaf (SMAL) extract, along with their respective areas and concentrations measured in $\mu g \cdot g^{-1}$ (Figure 2). Phenolic compounds are secondary metabolites widely distributed in plants that are important for their antioxidant and medicinal properties. The SMAL extract contained a variety of phenolic compounds, including gallic acid, chlorogenic acid, methyl gallate, caffeic acid, syringic acid, ellagic acid, coumaric acid, vanillin, ferulic acid, and cinnamic acid. The highest concentration of catechin was found at 752.64 $\mu g \cdot g^{-1}$, followed by gallic acid at 690.54 $\mu g \cdot g^{-1}$ and chlorogenic acid at 471.15 $\mu g \cdot g^{-1}$.

Table 5. Phenolic and flavonoid components detected in *Swietenia mahagoni* extract.

Compounds	Area	Concentration (μg·g^{-1})
Gallic acid	94.29	690.54
Chlorogenic acid	39.46	471.15
Catechin	34.57	752.64
Methyl gallate	51.39	316.17
Caffeic acid	11.08	89.01
Syringic acid	14.44	128.93
Pyro catechol	* nd	nd
Rutin	59.82	585.24
Ellagic acid	8.79	146.29
Coumaric acid	15.46	40.62
Vanillin	11.40	58.30
Ferulic acid	17.00	119.16
Naringenin	8.32	82.18
Daidzein	5.53	27.91
Querectin	nd	nd
Cinnamic acid	15.57	40.34
Apigenin	nd	nd
Kaempferol	nd	nd
Hesperetin	4.41	32.51

* nd = not detected.

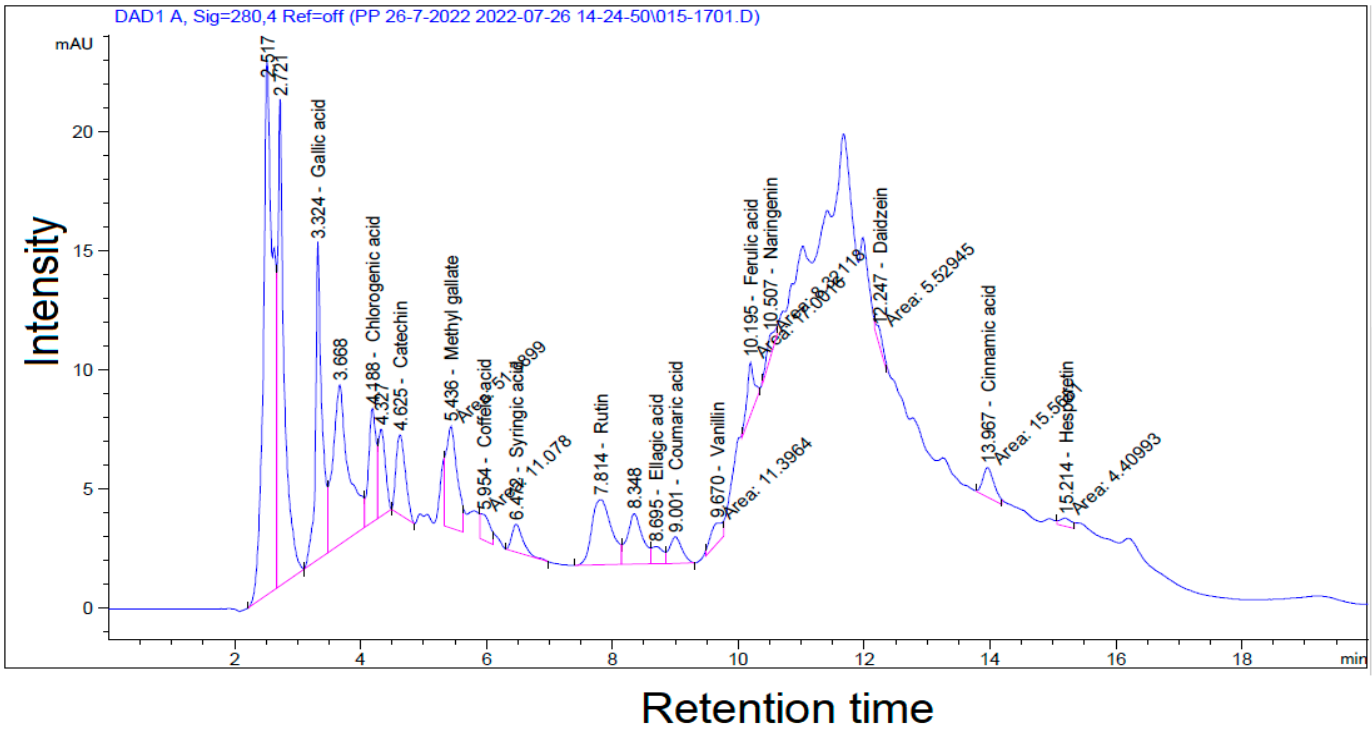

Figure 2. Polyphenolic content detected in *Swietenia mahagoni* extract.

Flavonoids are a subclass of phenolic compounds that are widely distributed in plants and have been shown to have numerous health benefits. The SMAL extract contained several flavonoids, including rutin, naringenin, daidzein, and hesperetin. The highest concentration of rutin was found at 585.24 μg·g^{-1}, followed by naringenin at 82.18 μg·g^{-1} (Table 5). Notably, some compounds such as pyro catechol, querectin, apigenin, and kaempferol were not detected in the extract. It is possible that these compounds were present in concentrations below the detection limit of the instrument used in this analysis.

3.8. Swietenia Mahagoni (SMAL) Extract's GC–MS Content

The GC–MS chromatogram of the acetone leaf extract of *Swietenia mahagoni* (SMAL) recorded a total of 14 peaks corresponding to the bioactive compounds that were recognized by relating their peak retention time, relative abundance area (%), and compound class to that of the known compounds described by different mass spectral libraries (Figure 3). Overall, all the phytocompounds identified in the SMAL extract are presented in Table 6. The GC–MS analysis of the SMAL extract revealed the presence of several classes of compounds, including fatty acid derivatives, epoxy fatty acid esters, saturated and unsaturated fatty acids, triterpenoids, alkaloid derivatives, and a triacylglycerol. The major compounds identified were n-hexadecanoic acid, which accounted for 37.1% of the total area, and oleic acid, which accounted for 19.05% of the total area. 9,12-octadecadienoic acid and friedelan-3-one were also present in significant amounts, accounting for 6.24%, and 8.08% of the total area, respectively (Table 6).

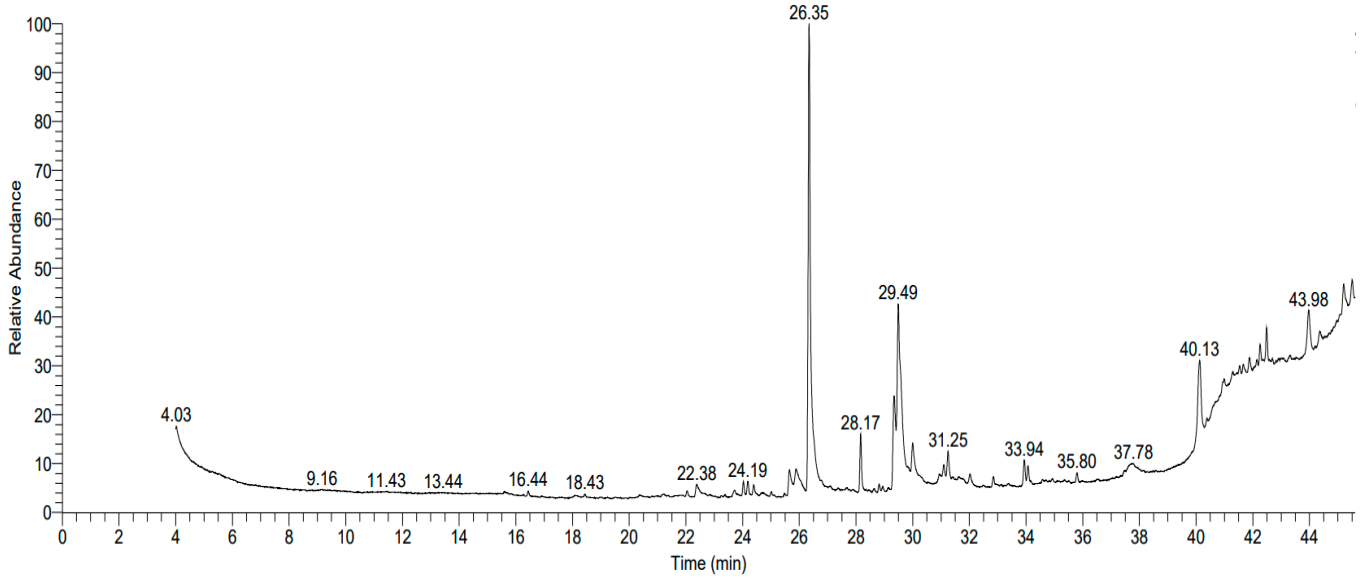

Figure 3. Phytoconstituents detected in the acetone leaf extract of *Swietenia mahagoni* using gas chromatography–mass spectrometry.

Table 6. GC–MS analysis of the acetone leaf extract of *Swietenia mahagoni*.

* RT (min)	Relative Abundance %	Compound	Compound Class
24.03	1.01	Methyl 11,14-eicosadienoate	Fatty acid derivative
25.64	2.35	Oxiraneundecanoic acid, 3-pentyl-,methyl ester	Epoxy fatty acid ester
26.35	37.1	n-Hexadecanoic acid	Saturated fatty acid
28.16	4.4	Palmitic acid	Saturated fatty acid
29.34	6.24	9,12-Octadecadienoic acid	Polyunsaturated fatty acid
29.49	19.05	Oleic acid	Monounsaturated fatty acid
31.24	2.24	Glycidyl oleate	Epoxy fatty acid ester
33.93	2.31	α-N-Normethadol	Opioid derivative
34.07	1.94	Oleic anhydride	Fatty acid derivative
40.13	8.08	Friedelan-3-one	Triterpenoid
43.97	4.65	Strychane 1-acetyl-20α-hydroxy-16-methylene	Alkaloid derivative
45.21	3.22	Trilinolein	Triacylglycerol
45.51	2.08	Lupeol	Triterpenoid

* RT = Retention time.

4. Discussion

In recognition of their reliability, strength, ecological nature, and sustainable impact on the ecosystem, plant-based substances, particularly medicinal plants, have been introduced

in the environmental field to treat various plant diseases. In addition, such substances may mitigate the negative effects of synthetic antimicrobials [41]. In the present investigation, qualitative evaluations of the bioactive substances in the acetone extract of *Swietenia mahagoni* leaves (SMAL) were performed using a variety of conventional assays, displaying the presence of a vast array of phytochemical components. The most significant biologically active substances were rutin, gallic acid, catechin, hexadecanionic acid, oleic acid, and triterpenes. These results are consistent with those of other investigators [42,43], and these molecules play a major role in the treatment of various plant pathogens. Chen et al. [9] explored the association among the botanical compound substances in the plant extract and its biological capability.

A study was conducted to investigate the antifungal properties of the methanolic extract obtained from the leaves of *S. mahagoni* (methSM). The study showed that fungal strains such as *Candida albicans*, *Aspergillus flavus*, and *A. niger* were highly susceptible to the extract at concentrations of 25 and 50 mg·mL^{-1}, with inhibition zones (IZ) ranging from 12.0 to 22.1 mm. However, less activity was observed at a concentration of 15 mg·mL^{-1}, with IZ ranging from 9.5 to 13.1 mm. Conversely, no antifungal activity was observed against *A. fumigatus* and *C. glabrata* [44]. However, our promising antifungal results are consistent with those obtained by previous studies, which showed that the methSM extract was effective against *C. albicans* and *A. niger* at a concentration of 100 mg·mL^{-1}, with IZ ranging from 16 to 20 mm [20]. Other studies have also reported the antifungal properties of *S. mahagoni* and *macrophylla* methanol seed extract against *C. albicans, Rhizopus* spp., *Fusarium*, and *Alternaria* species [45,46].

The most potent molecules found in our SMAL-HPLC and GC–MS analyses, such as catechin, gallic acid, ferulic acid, and hexadecanoic acid have been studied for their antibacterial and antifungal properties [47–49]. The SMAL extract's detected molecules (e.g., coumaric, caffeic, and ferulic acids) were found to have antifungal activity against *Alternaria alternata* when applied alone or synergistically [47]. Moreover, in contrast, the second constituent in SMAL's GC–MS, oleic acid (monoene fatty acid), did not have a significant effect on the growth of *R. solani* or *Pythium avenae* but did reduce the mycelial growth of *P. ultimum* [50].

However, a sublethal concentration (LC_{20}) of SMAL extract significantly decreased the survival percentages of *A. gossypii* Glover nymphs, with no discernible influence on the adult survival percentages. Certain HPLC–MS phytochemical components of *Swietenia mahagoni* extract, such as derivatives of dihydro-p-coumaric, cinnamic acid, and 7-hydroxycoumarin, may be one of the primary sources of toxic effects and viable insecticidal activities [51–53]. In addition, the SMAL extract was distinguished by derivatives of quercetin, in which it attained a good affinity on the active site of acetylcholinesterase but with a lower binding energy compared to chlorpyrifos against insect pests of the Hemiptera, Diptera, and Lepidoptera. On the contrary, quercetin was almost safe for natural enemies of Coleoptera and pollinators of Hymenoptera [54,55]. Moreover, the SMAL extract in this study featured derivatives of caffeic acid. Sequential binding of multiple molecules of caffeic acid was shown to possess a potent inhibitor of *Helicoverpa armigera* Hubner gut proteases' activity and gene expression [56]. Ultimately, some of the moieties of the SMAL extract might share only a synergistic action, for instance, the synergistic effects of the derivatives of chlorogenic acid on quercetin [55], vanillin mixtures with imidacloprid or α-cypermethrin [57], and daidzein on the baculovirus biopesticide [58]. Moreover, the hesperidin–Mg complex was found to be a trigger for the insecticide's potential against the adults of *Bemisia tabaci* Gennadius and *Spodoptera frugiperda* (J.E. Smith) [59]. On the other hand, the unsaturated free carboxylic fatty acids detected by GC–MS in the SMAL extract, exemplified in oleic acid, n-hexadecanoic acid, 9,12-octadecadienoic acid (*Z*,*Z*), and *trans*-13-octadecenoic acid, were thought to attain an insecticidal activity against *A. gossypii* Glover. These findings are in accordance with the investigations on the insecticidal activity of corresponding fatty acids on lepidopteran pests, such as *S. littoralis* Boisd. [60,61], *Earias insulana* Boisd. [62], and the hemipteran, *A. gossypii* Glover [63]. This phenomenon

could be elucidated by the inferences of Eldesouky et al. [60] and Khamis et al. [61] stating that the ascendancy of the larvicidal activity against *S. littoralis* Boisd was correlated with the increases in the double-bond quantities in the fatty acid chains. Furthermore, the free carboxylic fatty acids could accomplish more toxicity than their methylated ones, as the free carboxyl group had a high tendency to obstruct the systemic constancy of target cells [61,64].

In this study, both the SMAL extract and pyriproxyfen realized equally prolonging effects on the longevity of the nymphal stages of *A. gossypii* Glover and its whole life duration. The LC_{20} of the SMAL extract and pyriproxyfen had equipollent effects on reducing the reproductive activity of the adult female more than the control. The biological aspects of the SMAL extract on cotton aphids may be attributed to particular HPLC–MS components that were investigated in several research studies. For instance, in polyphenols, gallic acid was found to exhibit antifeeding effects via jasmonic acid signals, which induced astragalin, naringenin, and epigallocatechin-3-gallate [65]. In addition, ellagic acid adversely increased larval mortality, reduced pupation, and prolonged the development of the immature stages of *S. litura* Fabricius [66]. Moreover, naringenin and quercetin increased the developmental duration, the pre-reproductive period, and mortality, while decreasing fecundity and the reproduction rate of the pea aphid, *Acyrthosiphon pisum* Harris.

In our study, the SMAL extract possessed a repellent response on the adult stage of *A. gossypii* compared to pyriproxyfen and the control treatment. The explication of these findings may be associated with the presence of specific HPLC–MS phytochemical moieties in the SMAL extract represented in pyrocatechol, catechin, and gallic acid [65,67,68]. The repellency and insecticidal activity of 1,2-benzenediol (pyrocatechol) were observed on insects due to the presence of two hydroxyl groups in the *ortho*-position [68]. Flavonoid derivatives, (+)-catechin, showed no fatal effects but potent repellency and antifeedant activity against *Coptotermes curvignathus* Holmgren (Isoptera: Rhinotermitidae) [67]. Gallic acid could induce the direct defense of *Camellia sinensis* against the larvae of *Ectropis oblique*, via stimulating the signals of jasmonic acid and the pathways of phenylpropanoid [65].

Overall, our data suggest that the tested compound has potential as a natural fungicide against *R. solani* and *F. equiseti*. Moreover, an insecticide could be used to kill cotton aphids. However, further studies are needed to determine the mechanism of action and potential applications of the tested extract in agriculture.

5. Conclusions

In summary, this study evaluated the antifungal and insecticidal properties of an acetone extract of *Swietenia mahagoni* leaves (SMAL). The extract showed a partial activity against the fungal growth of *Rhizoctonia solani* and was more potent toward *Fusarium equiseti* in vitro. The SMAL extract possessed plausible toxic effects on *Aphis gossypii* Glover. This extract potently reduced the survival percentages of the nymphs. It had obvious reductions in the nymph production and the reproductive period of the adult females. Additionally, the SMAL extract could attain the highest prolongation in the longevity of nymphs and the total life duration. Moreover, it exhibited the lowest attraction percentage in the olfactory choice test on the adult aphids. Therefore, the SMAL extract may be rationally included as part of the cotton aphid control programs. According to the HPLC and GC–MS analyses, the SMAL extract was found to contain high levels of catechin, gallic acid, rutin, n-hexadecanoic acid, and oleic acid. The results suggest that the SMAL extract could be a potential natural and renewable product to regulate plant infestation by fungi and *A. gossypii* Glover and could be used as a long-term approach instead of insecticides that negatively affect human health and the environment.

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References

1. Duraipandiyan, V.; Ayyanar, M.; Ignacimuthu, S. Antimicrobial activity of some ethnomedicinal plants used by Paliyar tribe from Tamil Nadu, India. *BMC Complement. Altern. Med.* **2006**, *6*, 35. [CrossRef] [PubMed]
2. Jothy, S.L.; Torey, A.; Darah, I.; Choong, Y.S.; Saravanan, D.; Chen, Y.; Latha, L.Y.; Deivanai, S.; Sasidharan, S. Cassia spectabilis (DC) Irwin et Barn: A promising traditional herb in health improvement. *Molecules* **2012**, *17*, 10292–10305. [CrossRef] [PubMed]
3. Mazumder, P.M.; Percha, V.; Farswan, M.; Upaganlawar, A. Cassia: A wonder gift to medical sciences. *Int. J. Clin. Pharm.* **2008**, *1*, 16–38.
4. Arora, D.S.; Kaur, G.J. Antibacterial activity of some Indian medicinal plants. *J. Nat. Med.* **2007**, *61*, 313–317. [CrossRef]
5. Naveen, Y.P.; Rupini, G.D.; Ahmed, F.; Urooj, A. Pharmacological effects and active phytoconstituents of Swietenia mahagoni: A review. *J. Integr. Med.* **2014**, *12*, 86–93. [CrossRef] [PubMed]
6. Nweze, E.I.; Okafor, J.I.; Njoku, O. Antimicrobial activities of methanolic extracts of *Trema guineensis* (Schumm and Thorn) and Morinda lucida benth used in Nigerian. *Bio-Research* **2004**, *2*, 39–46. [CrossRef]
7. Govindachari, T.R.; Suresh, G.; Banumathy, B.; Masilamani, S.; Gopalakrishnan, G.; Krishna Kumari, G.N. Antifungal activity of some B, D-seco limonoids from two meliaceous plants. *J. Chem. Ecol.* **1999**, *25*, 923–933. [CrossRef]
8. Ervina, M. The recent use of *Swietenia mahagoni* (L.) Jacq. as antidiabetes type 2 phytomedicine: A systematic review. *Heliyon* **2020**, *6*, e03536.
9. Chen, J.-J.; Huang, S.-S.; Liao, C.-H.; Wei, D.-C.; Sung, P.-J.; Wang, T.-C.; Cheng, M.-J. A new phragmalin-type limonoid and anti-inflammatory constituents from the fruits of Swietenia macrophylla. *Food Chem.* **2010**, *120*, 379–384. [CrossRef]
10. U.S. Department of Agriculture The Agricultural Research Service. *USDA Composition Database*; U.S. Department of Agriculture The Agricultural Research Service: Washington, DC, USA, 2019.
11. Singh, R.; Sunder, S.; Kumar, P. Sheath blight of rice: Current status and perspectives. *Indian Phytopathol.* **2016**, *69*, 340–351.
12. El-Shafey, R.A.S.; Elamawi, R.M.; Saleh, M.M.; Tahoon, A.M.; Emeran, A.A. Morphological, pathological and molecular characterisation of rice sheath blight disease causal organism *Rhizoctonia solani* AG-1 IA in Egypt. *Arch. Phytopathol. Plant Prot.* **2019**, *52*, 507–529. [CrossRef]
13. Goswami, R.S.; Kistler, H.C. Heading for disaster: *Fusarium graminearum* on cereal crops. *Mol. Plant Pathol.* **2004**, *5*, 515–525. [CrossRef] [PubMed]
14. Imran, M.; Khanal, S.; Zhou, X.-G.; Antony-Babu, S.; Atiq, M. First Report of Fusarium Sheath Rot of Rice Caused by *Fusarium incarnatum-equiseti* Species Complex in the United States. *Plant Dis.* **2022**, *106*, 3206. [CrossRef]
15. Tralamazza, S.M.; Piacentini, K.C.; Savi, G.D.; Carnielli-Queiroz, L.; de Carvalho Fontes, L.; Martins, C.S.; Corrêa, B.; Rocha, L.O. Wild rice (*O. latifolia*) from natural ecosystems in the Pantanal region of Brazil: Host to *Fusarium incarnatum-equiseti* species complex and highly contaminated by zearalenone. *Int. J. Food Microbiol.* **2021**, *345*, 109127. [CrossRef] [PubMed]
16. Behiry, S.I.; Soliman, S.A.; Al-Mansori, A.-N.A.; Al-Askar, A.A.; Arishi, A.A.; Elsharkawy, M.M.; Abdelkhalek, A.; Heflish, A.A. Chorisia speciosa Extract Induces Systemic Resistance against Tomato Root Rot Disease Caused by *Rhizoctonia solani*. *Agronomy* **2022**, *12*, 2309. [CrossRef]
17. Behiry, S.I.; Soliman, S.A.; Al-Askar, A.A.; Alotibi, F.O.; Basile, A.; Abdelkhalek, A.; Elsharkawy, M.M.; Salem, M.Z.M.; Hafez, E.E.; Heflish, A.A. *Plantago lagopus* extract as a green fungicide induces systemic resistance against *Rhizoctonia* root rot disease in tomato plants. *Front. Plant Sci.* **2022**, *13*, 2818. [CrossRef]
18. Derbalah, A.; Shebl, A.M.; Elgobashy, S.F.; Ahmad, A.A.; Ramadan, N.E.; Behiry, S.I.; Abdelkhalek, A.; Saleem, M.H.; Al-Askar, A.A.; Kamran, M. Resistance Induction and Direct Antifungal Activity of Some Monoterpenes against *Rhizoctonia solani*, the Causal of Root Rot in Common Bean. *Life* **2022**, *12*, 1040. [CrossRef]
19. Ayyappadhas, R.; Jestin, C.; Kenneth, N.; Dayana, N.; Dhanalekshmi, U.M. Preliminary studies on antimicrobial activity of *Swietenia macrophylla* leaf extract. *Int. J. Pharm. Sci. Rev. Res* **2012**, *16*, 1–4.
20. Chiranjib, B.; Laxmaiah, C.; Srikanth, V.; Gouda, T.S.; Kumar, C.S.; Debnath, S. Antimicrobial activity of *Swietenia mahagoni* L. (leaf) against various human pathogenic microbes. *Indo Am. J. Pharm. Res* **2011**, *1*, 257–261.

21. Quan, Q.; Hu, X.; Pan, B.; Zeng, B.; Wu, N.; Fang, G.; Cao, Y.; Chen, X.; Li, X.; Huang, Y. Draft genome of the cotton aphid *Aphis gossypii*. *Insect Biochem. Mol. Biol.* **2019**, *105*, 25–32. [CrossRef]
22. Morando, R.; da Silva, I.F.; da Silva Santana, A.; Sampaio, G.S.L.; Lourenção, A.L.; Baldin, E.L.L. Assessing cotton genotypes for resistance to *Aphis gossypii* (Hemiptera: Aphididae). *J. Econ. Entomol.* **2021**, *114*, 387–396. [CrossRef]
23. Hossain, M.A.; Yasmin, M.S.; Bachchu, M.A.A.; Alim, M.A. Potency of Three Botanical Oils Against the *Aphis Craccivora Koch* (Homoptera: Aphididae) Nymphs Under Laboratory Conditions. *SAARC J. Agric.* **2021**, *19*, 139–154. [CrossRef]
24. Kamble, B.; Bhalkare, S.K.; Bhonde, A.; Dabhade, P.; Undirwade, D.B. Efficacy of Insect Growth Regulators against Aphids and Thrips on BT Cotton. *Indian J. Entomol.* **2022**, *84*, 920–922. [CrossRef]
25. Dugan, F.M.; Dugan, F.M. *The Identification of Fungi: An Illustrated Introduction with Keys, Glossary, and Guide to Literature*; The American Phytopathological Society: St. Paul, MN, USA, 2006.
26. White, T.J.; Bruns, T.; Lee, S.; Taylor, J. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. *PCR Protoc. Guide Methods Appl.* **1990**, *18*, 315–322.
27. Sobhy, S.; Al-Askar, A.A.; Bakhiet, E.K.; Elsharkawy, M.M.; Arishi, A.A.; Behiry, S.I.; Abdelkhalek, A. Phytochemical Characterization and Antifungal Efficacy of Camphor (*Cinnamomum camphora* L.) Extract against Phytopathogenic Fungi. *Separations* **2023**, *10*, 189. [CrossRef]
28. Abdelkhalek, A.; Al-Askar, A.A.; Alsubaie, M.M.; Behiry, S.I. First Report of Protective Activity of *Paronychia argentea* Extract against Tobacco Mosaic Virus Infection. *Plants* **2021**, *10*, 2435. [CrossRef]
29. Kumar, A.; Shukla, R.; Singh, P.; Prasad, C.S.; Dubey, N.K. Assessment of *Thymus vulgaris* L. essential oil as a safe botanical preservative against post harvest fungal infestation of food commodities. *Innov. Food Sci. Emerg. Technol.* **2008**, *9*, 575–580. [CrossRef]
30. Dissanayake, M. Inhibitory effect of selected medicinal plant extracts on phytopathogenic fungus *Fusarium oxysporum* (Nectriaceae) Schlecht. Emend. Snyder and Hansen. *Annu. Res. Rev. Biol.* **2014**, *4*, 133–142. [CrossRef]
31. Gaimari, S.D.; Turner, W.J. Methods for rearing *Aphidophagous Leucopis* spp.(Diptera: Chamaemyiidae). *J. Kansas Entomol. Soc.* **1996**, *69*, 363–369.
32. Stribley, M.F.; Moores, G.D.; Devonshire, A.L.; Sawicki, R.M. Application of the FAO-recommended method for detecting insecticide resistance in *Aphis jabae Scopoli*, *Sitobion avenae* (F.), *Metopolophium dirhodum* (Walker) and *Rhopalosiphum padi* (L.) (Hemiptera: Aphididae). *Bull. Entomol. Res.* **1983**, *73*, 107–115. [CrossRef]
33. Abbott, W.S. A method of computing the effectiveness of an insecticide. *J. Econ. Entomol.* **1925**, *18*, 265–267. [CrossRef]
34. Finney, D.J. *Probit Analysis*; Cambridge University Press: Cambridge, UK, 1971.
35. Insecticide Resistance Action Committee (IRAC). Susceptibility Test Methods Series: Method 026. 2011. Available online: https://irac-online.org/methods/musca-domestica-adults/ (accessed on 23 July 2020).
36. Michelotto, M.D.; Busoli, A.C. Aspectos biológicos de *Aphis gossypii* Glover, 1877 (Hemiptera: Aphididae) em três cultivares de algodoeiro e em três espécies de plantas daninhas. *Ciência Rural* **2003**, *33*, 999–1004. [CrossRef]
37. Jaba, J.; Haseena, B.; Tripathy, S.; Hosamani, A.C.; Amaresh, Y.S. Olfactory response of cowpea aphid, *Aphis craccivora Koch*, to host odours and population of conspecifics. *J. Biopestic.* **2010**, *3*, 405.
38. Weeks, E.N.I.; Logan, J.G.; Gezan, S.A.; Woodcock, C.M.; Birkett, M.A.; Pickett, J.A.; Cameron, M. A bioassay for studying behavioural responses of the common bed bug, *Cimex lectularius* (Hemiptera: Cimicidae) to bed bug-derived volatiles. *Bull. Entomol. Res.* **2011**, *101*, 1–8. [CrossRef] [PubMed]
39. Abdelkhalek, A.; Király, L.; Al-Mansori, A.N.A.; Younes, H.A.; Zeid, A.; Elsharkawy, M.M.; Behiry, S.I. Defense Responses and Metabolic Changes Involving Phenylpropanoid Pathway and PR Genes in Squash (*Cucurbita pepo* L.) following Cucumber mosaic virus Infection. *Plants* **2022**, *11*, 1908. [CrossRef] [PubMed]
40. SAS Institute. *(SAS) PC-SAS User Guide, Version 8*; SAS Inc.: Cary, NC, USA, 2002.
41. Cantrell, C.L.; Dayan, F.E.; Duke, S.O. Natural products as sources for new pesticides. *J. Nat. Prod.* **2012**, *75*, 1231–1242. [CrossRef]
42. Ekimoto, H.; Irie, Y.; Araki, Y.; Han, G.-Q.; Kadota, S.; Kikuchi, T. Platelet aggregation inhibitors from the seeds of *Swietenia mahagoni*: Inhibition of in vitro and in vivo platelet-activating factor-induced effects of tetranortriterpenoids related to swietenine and swietenolide. *Planta Med.* **1991**, *57*, 56–58. [CrossRef]
43. Nakatani, M.; Abdelgaleil, S.A.M.; Kurawaki, J.; Okamura, H.; Iwagawa, T.; Doe, M. Antifeedant Rings B and D Opened Limonoids from *Khaya senegalensis*. *J. Nat. Prod.* **2001**, *64*, 1261–1265. [CrossRef]
44. Syame, S.M.; Mohamed, S.M.; Elgabry, E.A.; Darwish, Y.A.A.; Mansour, A.S. Chemical characterization, antimicrobial, antioxidant, and cytotoxic potentials of *Swietenia mahagoni*. *AMB Express* **2022**, *12*, 77. [CrossRef]
45. Sahgal, G.; Ramanathan, S.; Sasidharan, S.; Mordi, M.N.; Ismail, S.; Mansor, S.M. Phytochemical and antimicrobial activity of *Swietenia mahagoni* crude methanolic seed extract. *Trop. Biomed.* **2009**, *26*, 274–279.
46. Durai, M.V.; Balamuniappan, G.; Geetha, S. Phytochemical screening and antimicrobial activity of leaf, seed and central-fruit-axis crude extract of *Swietenia macrophylla* King. *J. Pharmacogn. Phytochem.* **2016**, *5*, 181–186.
47. Behiry, S.I.; Philip, B.; Salem, M.Z.M.; Amer, M.A.; El-Samra, I.A.; Abdelkhalek, A.; Heflish, A. *Urtica dioica* and *Dodonaea viscosa* leaf extracts as eco-friendly bioagents against Alternaria alternata isolate TAA-05 from tomato plant. *Sci. Rep.* **2022**, *12*, 16468. [CrossRef] [PubMed]
48. Huang, C.B.; Alimova, Y.; Myers, T.M.; Ebersole, J.L. Short-and medium-chain fatty acids exhibit antimicrobial activity for oral microorganisms. *Arch. Oral Biol.* **2011**, *56*, 650–654. [CrossRef] [PubMed]

49. Borges, A.; Ferreira, C.; Saavedra, M.J.; Simões, M. Antibacterial activity and mode of action of ferulic and gallic acids against pathogenic bacteria. *Microb. Drug Resist.* **2013**, *19*, 256–265. [CrossRef] [PubMed]
50. Walters, D.; Raynor, L.; Mitchell, A.; Walker, R.; Walker, K. Antifungal activities of four fatty acids against plant pathogenic fungi. *Mycopathologia* **2004**, *157*, 87–90.
51. Wang, X.; Wei, X.; Huang, X.; Shen, L.; Tian, Y.; Xu, H. Insecticidal constructure and bioactivities of compounds from *Ficus sarmentosa* var. henryi. *Agric. Sci. China* **2011**, *10*, 1402–1409. [CrossRef]
52. Huang, G.-Y.; Cui, C.; Wang, Z.-P.; Li, Y.-Q.; Xiong, L.-X.; Wang, L.-Z.; Yu, S.-J.; Li, Z.-M.; Zhao, W.-G. Synthesis and characteristics of (Hydrogenated) ferulic acid derivatives as potential antiviral agents with insecticidal activity. *Chem. Cent. J.* **2013**, *7*, 33. [CrossRef]
53. Devi, T.B.; Jena, S.; Patra, B.; Singh, K.D.; Chawla, S.; Raina, V.; Koijam, A.S.; Parida, A.; Rajashekar, Y. Acute and sub-acute toxicity evaluation of dihydro-p-coumaric acid isolated from leaves of Tithonia diversifolia Hemsl. A. Gray in BALB/c mice. *Front. Pharmacol.* **2022**, *13*, 1055765. [CrossRef]
54. Riddick, E.W. Potential of quercetin to reduce herbivory without disrupting natural enemies and pollinators. *Agriculture* **2021**, *11*, 476. [CrossRef]
55. Herrera-Mayorga, V.; Guerrero-Sánchez, J.A.; Méndez-Álvarez, D.; Paredes-Sánchez, F.A.; Rodríguez-Duran, L.V.; Niño-García, N.; Paz-González, A.D.; Rivera, G. Insecticidal Activity of Organic Extracts of *Solidago graminifolia* and Its Main Metabolites (Quercetin and Chlorogenic Acid) against *Spodoptera frugiperda*: An In Vitro and In Silico Approach. *Molecules* **2022**, *27*, 3325. [CrossRef]
56. Joshi, R.S.; Wagh, T.P.; Sharma, N.; Mulani, F.A.; Sonavane, U.; Thulasiram, H.V.; Joshi, R.; Gupta, V.S.; Giri, A.P. Way toward "dietary pesticides": Molecular investigation of insecticidal action of caffeic acid against *Helicoverpa armigera*. *J. Agric. Food Chem.* **2014**, *62*, 10847–10854. [CrossRef] [PubMed]
57. Kletskov, A.V.; Potkin, V.I.; Dikusar, E.A.; Zolotar, R.M. New Data on Vanillin-Based Isothiazolic Insecticide Synergists. *Nat. Prod. Commun.* **2017**, *12*, 105–106. [CrossRef]
58. Hay, W.T.; Behle, R.W.; Berhow, M.A.; Miller, A.C.; Selling, G.W. Biopesticide synergy when combining plant flavonoids and entomopathogenic baculovirus. *Sci. Rep.* **2020**, *10*, 6806. [CrossRef]
59. Da Silva, D.F.; Bomfim, J.; Marchi, R.C.; Amaral, J.C.; Pinto, L.S.; Carlos, R.M.; Ferreira, A.G.; Forim, M.R.; Fernandes, J.B.; da Silva, M.F.G.F. Valorization of hesperidin from citrus residues: Evaluation of microwave-assisted synthesis of hesperidin-Mg complex and their insecticidal activity. *J. Braz. Chem. Soc.* **2022**, *33*, 772–782.
60. Eldesouky, S.E.; Khamis, W.M.; Hassan, S.M. Joint action of certain fatty acids with selected insecticides against cotton leafworm, *Spodoptera littoralis* and their effects on biological aspects. *J. Basic Environ. Sci.* **2019**, *6*, 23–32.
61. Khamis, W.M.; El-Desouky, S.E.; Gad, A.A. Toxicity and Antifeedant Effects of Apricot Kernel Extract and Its Main Components against Cotton Leaf Worm, *Spodoptera littoralis* (Lepidoptera: Noctuidae) Larvae With Reference To Some Physiological Effects. *Alex. Sci. Exch. J.* **2016**, *37*, 637–646.
62. Moustafa, H.Z.; Yousef, H.; EL-lakwah, S.F. Toxicological and biochemical activities of fatty acids against *Earias insulana* (boisd.)(lepidoptera: Noctuidae). *Egypt. J. Agric. Res.* **2018**, *96*, 503–515. [CrossRef]
63. Abdullah, R.R. Insecticidal activity of secondary metabolites of locally isolated fungal strains against some cotton insect pests. *J. Plant Prot. Pathol.* **2019**, *10*, 647–653. [CrossRef]
64. Maia, M.R.G.; Chaudhary, L.C.; Bestwick, C.S.; Richardson, A.J.; McKain, N.; Larson, T.R.; Graham, I.A.; Wallace, R.J. Toxicity of unsaturated fatty acids to the biohydrogenating ruminal bacterium, *Butyrivibrio fibrisolvens*. *BMC Microbiol.* **2010**, *10*, 52. [CrossRef]
65. Zhang, X.; Ran, W.; Li, X.; Zhang, J.; Ye, M.; Lin, S.; Liu, M.; Sun, X. Exogenous Application of Gallic Acid Induces the Direct Defense of Tea Plant Against *Ectropis obliqua* Caterpillars. *Front. Plant Sci.* **2022**, *13*, 833489. [CrossRef]
66. Punia, A.; Chauhan, N.S.; Kaur, S.; Sohal, S.K. Effect of ellagic acid on the larvae of *Spodoptera litura* (Lepidoptera: Noctuidae) and its parasitoid *Bracon hebetor* (Hymenoptera: Braconidae). *J. Asia. Pac. Entomol.* **2020**, *23*, 660–665. [CrossRef]
67. Adfa, M.; Kusnanda, A.J.; Livandri, F.; Rahmad, R.; Darwis, W.; Efdi, M.; Ninomiya, M.; Koketsu, M. Insecticidal activity of *Toona sinensis* against *Coptotermes curvignathus Holmgren*. *Rasayan J. Chem* **2017**, *10*, 153–159.
68. Chuang, K.-J.; Chen, Z.-J.; Cheng, C.-L.; Hong, G.-B. Investigation of the antioxidant capacity, insecticidal ability and oxidation stability of *Chenopodium formosanum* seed extract. *Int. J. Mol. Sci.* **2018**, *19*, 2726. [CrossRef] [PubMed]