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Phytochemical Screening and Assessment of Antioxidant and Antimicrobial Potentialities of Two Egyptian Medicinal Plants

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ABSTRACT

Methanolic extracts of *Aerva javanica* and *Ochradenus baccatus* shoots were assessed for their phytoconstituents, antioxidant and antimicrobial activities. Both tested plants displayed potent antioxidant activities evaluated by the DPPH (2, 2-diphenyl-1-picrylhydrazyl), total antioxidant capacity (TAC) and reducing power (EC_{50}) which strongly correlate with their phenolic and flavonoid contents. The antimicrobial study revealed that the methanolic extract of the tested plants exhibited different extents of activities against selected bacterial and fungal strains; moreover, *A. javanica* was most effective against *Pseudomonas aeruginosa*. GC-MS analysis of methanolic extracts showed the presence of many compounds in the areal parts of *A. javanica* like L-Rhamnose; 4TMS derivative, Glycolic acid; TMS derivative, 3-Decen-1-ol, (E)- and 2-Hydroxyisocaproic acid used as antimicrobial agents. On the other hand, for *O. baccatus* compounds like phosphorodifluoridous hydrazide, trimethyl, palmitic acid and 2-Hydroxyisocaproic acid; TMS derivative which have biological properties as anti-inflammatory and antimicrobial agents were detected. Hence, methanolic extract of *A. javanica* and *O. baccatus* shoots have comparatively rich phytochemicals and antioxidants suggesting their desirable use to cure some diseases and disorders. Nevertheless, further isolation and biological screening will elucidate the mechanism of therapeutic potential of these compounds.

1. Introduction

Wild plant species provide humanity with various significant economic, social and ecological values [1,2]. Particularly those with prospective medicinal activity have recently come to be treated as a priority of scientists and researchers because of their phytochemical constituents as alkaloids, steroids, flavonoids, phenolics, etc. [3]. Therefore, phytochemical screening of such plants is the demand of the hour in order to realize and develop natural therapeutic agents with improved value. Unfortunately, some of such medicinal plants were declined in their abundance as result of human impacts [4].

As well, habitat loss due to land use changes can push native populations to regional extinction and enable invasion of strange species [5]. In this respect, the vegetation of Eastern Desert of Egypt is under a huge human activity (mining, housing and industry) reflected in species status as mentioned by Abdelaal [6] on *Ochradenus baccatus* in Wadi Hagul. Highlighting the medicinal importance of such plants may contribute in preserving and benefiting from them.

Ochradenus baccatus and *Aerva javanica* are two growing species at the Eastern Desert of Egypt. Both are medicinal plants used in the traditional medicine [7].

Aerva javanica (Burm.f.) Shult. (Family: Amaranthaceae) is a perennial herb distributed in tropical and subtropical dry areas of the world [8]. It is native to the region from North Africa to South West Asia, in Egypt, *A. javanica* plants grown in Sinai, the Red Sea coastal strip, Gebel Elba and the surrounding mountainous region, the Eastern desert and western oases. Various *Aerva* species are usually utilized in the traditional medicine as anti-inflammatory agent [9], diuretic and treatment of urinary disorders [10], antidiabetic [11], rheumatism [12] and recently as an anticancer agent [13]. The aerial parts of *A. javanica* comprise numerous important biomolecules, which comprise phenolics and flavonoids, which might explore novel and safe bioactive compounds for the treatment of oxidative stress-related disorders [14]. The diversity has encouraged the scientific validation of their extracts for antimicrobial properties which aims to the detection of many new drugs of plant origin.

Ochradenus baccatus Delile (family Resedaceae) is a dioecious or bisexual shrub, it is the most common species of the genus [15]. *O. baccatus* demonstrates therapeutic importance as it can reduce blood cholesterol levels [16]. It is used in traditional medicine as an antimicrobial agent (*Plasmodium falciparum*) [16], in addition to its high contents of antioxidants and anti-inflammatory properties [17]. However, this plant has not yet been studied regarding its detailed chemical composition. Therefore, the present study was undertaken to examine the chemical constituents of the methanolic extracts of *A. javanica* and *O. baccatus*. Antioxidant and antimicrobial activities were further carried out.

2. Material and methods

2.1 Study area and plant collection

The Eastern Desert of Egypt represents 22.30% of the total area of Egypt, covering of approximately 223 sq. km. It extends from Nile Valley eastward to the Red Sea. *Aerva javanica* (Burm.f.) samples were collected from the Cairo-Suez road at the Eastern Desert at 29˚58´N - 32˚08´ E. *Ochradenus baccatus* samples were collected from Wadi Hagul (bounded by latitudes 29°41´ –30°01´ N and longitudes 32°08´ –32°24´ E) during February 2020.

2.2 Plant extraction

Plant material were picked up as shoot system, healthy mature plants were selected in 3 replicates for each species. 1.5 g of each sample were ground into powder, using a ceramic mortar and pestle, and dissolved in 30 mL of 80% methanol at 40 °C for 24 h. The methanolic extracts were then centrifuged at 3000 g (Universal 2S, Hettich Zentrifugen, Tuttlingen, Germany) for 15 min at room temperature (26–29 °C); filtered using a 0.2 µm pore size acrodisc syringe filters (Sigma-Aldrich). The extracts were then kept in the dark and stored at −4°C for phytochemical screening.

2.3 Determination of total phenolic content

The total phenolic content was determined according to the methods described by **Makkar et al.** [18] and expressed as mg gallic acid equivalents/g dw.

2.4 Determination of flavonoids content

Flavonoids in the methanolic extract of plant were determined by aluminum chloride colorimetric method [19]. Methanolic extract of sample (0.5 ml) was diluted in distilled water (1.5 ml) and mixed with 10% aluminum chloride (0.5 ml). Quantification of total flavonoids was done on the basis of standard curve of quercetin prepared in 80% (v/v) methanol. Results were expressed in mg quercetin equivalent (QE)/g dw.

2.5 Determination of total antioxidant capacity

The total antioxidant activity of the extract was determined using the phosphomolybdenum method as described by **Prieto et al.** [20] The results were expressed as mg of gallic acid equivalents (GAE)/g dw.

2.6 DPPH radical scavenging assay

The measurement of 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity was carried out according to the method of **Hatano et al.** [21]. The DPPH radical scavenging activity was calculated as [(A0 - A1)/A0] x 100 where A0 is the absorbance of the DPPH solution and A1 is the absorbance of the sample. Ascorbic acid was used for the standard curve and the DPPH scavenging activity was expressed as mM Ascorbic acid equivalents (ASAE)/g dw.

2.7 Determination of reducing power

The reducing power was determined according to the method of **Oktay et al.** [22]. EC_{50} value (mg/mL) is the effective concentration at which absorbance was 50% of the original amount.

2.8 Gas Chromatography-Mass Spectrometry (GC-MS) analysis

Sterilized fine powder, 2g dw was taken from each plant, mixed with 20 ml of methanol and kept in boiling water bath at 60°C for 1h. The extracts were filtered with Whatman No. 1 filter paper, then used for screening of bioactive compounds by chromatographic analysis (GC–MS; Agilent Technologies 7890B GC Systems combined with 5977A Mass Selective Detector). Capillary column was used (HP-5MS Capillary; 30.0 m × 0.25 mm ID × 0.25 µm film) and the carrier gas was helium at a rate of flow of 1.8 ml/min with 1 µl injection. The sample was analyzed with the column held initially for 3 min at 40 °C after injection, then the temperature was increased to 300 °C with a 20 °C/min heating ramp, with a 3.0 min hold. Injection was carried out in splitless mode at 300 °C. MS scan range was (m/z): 40–550 atomic mass units (AMU) under electron impact (EI) ionization (70 eV). Many compounds are difficult to vaporize like polyhydroxylated alkaloids. Their capacities to vaporize were improved by replacing the hydroxyl group by other chemical groups like trimethylsilyl groups before injection onto the GC-MS (Silylation). The constituents were determined by mass fragmentations with The NIST mass spectral search program for the NIST/EPA/NIH mass spectral library Version 2.2 at the central lab of faculty of science, Ain Shams University.

2.9 Antimicrobial Bioassay

The methanolic extracts of *A. javanica* and *O. baccatus* were tested against three fungal strains (*Aspergillus flavus*, *Candida tropicalis* and *Penicillium expansum*), three Gram positive bacteria (*Staphylococcus aureus, Bacillus subtilis* and *Bacillus cereus*) and three Gram negative bacteria (*Escherichia coli, Klebsiella pneumonia* and *Pseudomonas aeruginosa*). Filter paper discs (5 mm in diameter) are prepared before use and sterilized in an autoclave for 20-30 minutes. A sterile paper disc is taken by sterile forceps, wetted in the solution of the studied antibiotic and then placed over the surface of the inoculated potato dextrose agar in antifungal assay and nutrient agar in antibacterial assay as described by **Cappuccino and Sherman** [23]. Culture plates were incubated at 28 °C for 3-4 days for fungi and bacteria at 37 °C for 24 h. After incubation, the antibacterial and antifungal activities were recorded by measuring the diameter inhibition zones using a zone reader (mm).

2.10 Statistical analysis

Statistical analysis was carried out using the software package SPSS v20.0 (SPSS Inc., Chicago, USA), and the comparison of the averages of three replicates for each sample was based on two tailed unpaired T test at a significance level of 5% ($P \leq 0.05$).

3. Results and Discussion

The potential bioactivity of wild plants is typically evaluated by the quantitative analysis of phytoconstituents particularly polyphenol and flavonoids contents. In this regard both the subject plants were screened for their polyphenolic and flavonoid contents. The results revealed that methanolic extract of *O. baccatus* have high polyphenolic contents (123.71 ± 5.89 mg GAE g^{-1}) as compared with those of *A. javanica* (87.27± 3.49 mg GAE g^{-1}) Table 1. Phenolic compounds possess some biological properties as anti-inflammation and antimicrobial activities [24]. It is noteworthy that phenolic compounds effectively act as hydrogen donors and thereby as an effective antioxidant [25]. Our results show that phenols are the main antioxidant of *O. baccatus* as manifested by the increase in its TAC and EC_{50} values Table 1. On the other hand, the flavonoids content of *A. javanica* (38.90 ± 1.91 mg QE g^{-1}) were found to be higher than that of *O. baccatus* (26.33 ± 0.52 mg QE g^{-1}) Table 1. Flavonoids are a large group of ubiquitous molecules synthesized by plants. These compounds are also known for their health benefits derived from their antioxidant potential; the functional hydroxyl groups in flavonoids mediate their antiradical activity [26], as was further demonstrated in *A. javanica* (40.9 ± 0.14 mM ASAE/g dw). Our results are in agreement with Shahzad **Murtaza et al.** [27], **Nawaz et al.** [28], **Suleiman** [29], and **Saleem et al.** [30] who reported that methanolic extract of *A. javanica* show high antioxidant activity. Furthermore, the biological activity of the methanolic extract *A. javanica* in our study might be attributed to the presence of some flavonoid derivatives and other hydroxylated and glycosylated compounds identified during GC-MS analysis Table 2. Such synergistic activity of these chemical constituents may drive up its antimicrobial potential by disrupting bacterial or fungal membrane integrities Table 3. Similarly, **Khalid et al.** [31] reported that biological activities of *A. javanica* are mainly ascribed to be rich in flavonoids constituents.

Table 1 Averages of total phenolic (mg GAE/g dw), flavonoid (mg QE/g dw), total antioxidant capacity assay (mg GAE/g dw)), DPPH assay (mM ASAE/g dw) and EC_{50} Reducing power (mg/mL) of *A. javanica* and *O. baccatus*

	Phenolic content	Flavonoids content	Antioxidant activity		
			TAC assay	DPPH assay	Reducing power EC_{50}
A. javanica	87.27 ± 3.49	38.90 ± 1.91	1.34 ± 0.04	40.9 ± 0.14	0.2 ± 0.01
O. baccatus	123.71 ± 5.89	26.33 ± 0.52	2.8 ± 0.11	32.0 ± 0.82	3.8 ± 0.29

Data expressed as means ± standard deviation (n= 3)

Table 2 GC-MS analysis of methanolic extract of *Aerva javanica*

PK	RT	Area %	Name of compound	formula	M wt
1	7.8	0.73	(Methoxymethyl)trimethylsilane	$C_5H_{14}OSi$	118.3
2	7.8	0.59	Hydrazine, 1-ethyl-1-(2-methylpropyl)-	$C_6H_{16}N_2$	116.2
3	7.9	0.14	1-Propanol, TMS derivative	$C_6H_{16}OSi$	132.3
4	8.1	0.29	.alpha.-D-Xylofuranoside, methyl	$C_6H_{12}O_5$	164.2
5	8.2	0.28	(2-Ethoxyethoxy)acetic acid, TMS derivative	$C_9H_{20}O_4Si$	220.3
6	8.4	2.38	Trimethylsilylmethanol	$C_5H_{14}OSi$	118.3
7	8.6	0.22	(Methoxymethyl)trimethylsilane	$C_6H_{16}N_2$	116.2
8	8.9	1.46	[2-(4-Chlorophenylthiomethoxy)ethyl]trimethylsilane	$C_{12}H_{19}ClOSSi$	274.9
9	11.1	0.19	Silane, butyltrimethyl-	$C_7H_{18}Si$	130.3
10	11.4	0.09	Silane, tetramethyl-	$C_4H_{12}Si$	88.2
11	12.3	75.95	D-(-)-Fructofuranose, pentakis(trimethylsilyl) ether (isomer 1)	$C_{21}H_{52}O_6Si_5$	541.1
12	12.4	1.10	1,4-Dioxane-2,3-diol, (Z)-, 2TMS derivative	$C_4H_8O_4$	120.1
13	12.7	2.28	L-Rhamnose, 4TMS derivative	$C_{18}H_{44}O_5Si_4$	452.9
14	12.8	0.57	D-(-)-Erythrose, tris(trimethylsilyl) ether, trimethylsilyloxime (isomer 1)	$C_{12}H_{32}O_3Si_3$	308.6
15	13.1	8.39	D-(+)-Galacturonic acid, 5TMS derivative	$C_{21}H_{50}O_7Si_5$	555.0
16	13.5	0.86	Glycolic acid, TMS derivative	$C_5H_{12}O_3Si$	148.2
17	14.3	1.26	3-Methylcyclohexanol, (E)-, TMS derivative	$C_{18}H_{34}OSi$	294.5
18	14.6	0.11	2-[(Trimethylsilyl)oxy]tetradecanoic acid, bis(trimethylsilyl) ester	$C_{23}H_{50}O_5Si_3$	490.9
19	15.1	0.22	Ethyl (trimethylsilyl) ethylmethylmalonate	$C_8H_{16}O_4Si$	204.3
20	15.5	0.09	2-[(Trimethylsilyl)oxy]tetradecanoic acid, bis(trimethylsilyl) ester	$C_{23}H_{50}O_5Si_3$	490.9
21	15.7	0.20	(2-Butoxyethoxy)acetic Acid, TMS derivative	$C_8H_{16}O_4$	176.2
22	15.8	0.32	13,13-Dimethyl-3,6,9-trioxa-13-silatetradecan-1-ol	$C_{12}H_{28}O_4Si$	264.4
23	15.9	0.72	2-[(Trimethylsilyl)oxy]tetradecanoic acid, bis(trimethylsilyl) ester	$C_{23}H_{50}O_5Si_3$	490.9
24	16.5	0.74	(Methoxymethyl)trimethylsilane	$C_6H_{16}N_2$	116.2
25	17.4	0.39	Suberic acid, 2TBDMS derivative	$C_{20}H_{42}O_4Si_2$	402.7
26	18.1	0.37	3-Decen-1-ol, (E)-	$C_{10}H_{20}O$	156.3
27	18.9	0.07	2-Hydroxyisocaproic acid, TMS derivative	$C_{12}H_{28}O_3Si_2$	276.5

RT = retention time (min), PK = peak area and M wt = molecular weight

Table 3 GC-MS analysis of methanolic extract of *Ochradenus baccatus*

PK	RT	Area %	Name of compound	formula	M wt
1	7.8	2.90	1-Butoxy-2-propanol, TBDMS derivative	$C_7H_{16}O_2$ or $CH_3CH(OH)CH_2O(CH_2)_3CH_3$	132.2
2	7.9	0.18	(Methoxymethyl) trimethylsilane	$C_6H_{16}N_2$	116.2
3	8.0	0.05	Glycine, TMS derivative	$C_8H_{21}NO_2Si_2$	219.4
4	8.2	0.06	2-Pentanone, 4-methyl-, oxime	$C_6H_{13}NO$	115.2
5	8.2	0.44	2,3-Dibromo-2-methylpropionic acid, 2-trimethylsilylethoxycarbonylmethyl ester	$C_4H_6Br_2O_2$	245.9
6	8.4	1.34	Trimethylsilylmethanol	$C_5H_{14}OSi$	118.3
7	8.6	0.10	(Methoxymethyl)trimethylsilane	$C_6H_{16}N_2$	116.2
8	8.9	17.50	Acetin, bis-1,2-trimethylsilyl ether	$C_{11}H_{26}O_4Si_2$	278.5
9	9.1	0.04	3,10-Dioxa-6,7-dithia-2,11-disiladodecane, 2,2,11,11-tetramethyl-, 6,6-dioxide	$C_{12}H_{26}O_2Si_2$	258.5
10	9.1	0.09	Phosphorodifluoridous hydrazide, trimethyl-	$C_3H_9F_2N_2P$	142.1
11	9.5	0.03	2-Butenedioic acid, (Z)-, 2TBDMS derivative	$C_{16}H_{32}O_4Si_2$	344.6
12	10.5	1.31	(Methoxymethyl)trimethylsilane	$C_6H_{16}N_2$	116.2
13	11.1	0.07	Methane, isothiocyanato-	C_2H_3NS	73.1
14	11.2	0.05	.alpha.-Ketoisovaleric acid, TMS derivative	$C_8H_{16}O_3Si$	188.3
15	11.6	0.04	1,4-Dioxane-2,3-diol, (E)-, 2TMS derivative	$C_4H_8O_4$	120.1
16	11.7	0.64	Ribitol, 5TMS derivative	$C_{20}H_{52}O_5Si_5$	513.0
17	12.0	0.04	Malic acid, 3TBDMS derivative	$C_{22}H_{48}O_5Si_3$	476.9
18	12.3	4.23	.beta.-D-Galactofuranoside, ethyl 2,3,5,6-tetrakis-O-(trimethylsilyl)-	$C_{20}H_{48}O_6Si_4$	496.9
19	12.4	0.10	Ribitol, 5TMS derivative	$C_{20}H_{52}O_5Si_5$	513.0
20	12.5	0.05	4-Cyclohexene-1,2-dicarboxylic acid, 4-chloro-, bis(trimethylsilyl) ester	$C_8H_{10}O_4$	170.2
21	12.7	0.21	Gluconic acid, 2-methoxime, tetra(trimethylsilyl)-, trimethylsilyl ester	$C_{22}H_{53}NO_7Si_5$	584.1
22	12.9	0.17	L-(+)-Threose, tris(trimethylsilyl) ether, ethyloxime (isomer 1)	$C_{14}H_{35}NO_4Si_3$	365.7
23	13.1	0.23	.beta.-D-(-)-Ribopyranose, 4TMS derivative	$C_{17}H_{42}O_5Si_4$	438.9
24	13.5	62.27	Palmitic Acid, TMS derivative	$C_{19}H_{40}O_2Si$	328.6
25	14.1	0.16	Pantolactone, (3R)-, TMS derivative	$C_9H_{18}O_3Si$	202.3
26	14.2	0.04	2-Ketohexanoic acid, trimethylsilyl ester	$C_{12}H_{26}O_3Si_2$	274.5
27	14.3	3.45	3-Methylcyclohexanol, (Z)-, TMS derivative	$C_{18}H_{34}OSi$	294.5
28	14.8	0.05	6-Ethyl-3-di(tert-butyl)silyloxyoctane	$C_{17}H_{36}$	240.5
29	15.1	0.22	Dihydroxyacetone, 2TMS derivative	$C_{16}H_{24}F_5NO_3Si_2$	429.5
31	15.2	0.13	2-Hydroxyisocaproic acid, TMS derivative	C12H28O3Si2	276.5
32	15.5	0.05	2-[(Trimethylsilyl)oxy]tetradecanoic acid, bis(trimethylsilyl) ester	$C_{23}H_{50}O_5Si_3$	490.9
33	15.7	0.63	Monoethyl methylmalonate, TMS derivative	$C_8H_{16}O_4Si$	204.3
34	15.8	0.27	2-Oxopentanoic acid, TMS derivative	$C_8H_{16}O_3Si$	188.3
35	15.9	0.10	2-Oxopentanoic acid, TMS derivative	$C_8H_{16}O_3Si$	188.3
36	15.9	0.10	2-Hydroxyisocaproic acid, TMS derivative	$C_{12}H_{28}O_3Si_2$	276.5
37	16.0	0.28	D-(-)-Erythrose, tris(trimethylsilyl) ether, ethyloxime (isomer 2)	$C_{12}H_{32}O_3Si_3$	308.6
38	16.2	0.17	2-Oxopentanoic acid, TMS derivative	$C_8H_{16}O_3Si$	188.3

Table 3 Cont.

39	16.3	0.14	2-Oxopentanoic acid, TMS derivative	$C_8H_{16}O_3Si$	188.3
40	16.5	0.53	2-Oxopentanoic acid, TMS derivative	$C_8H_{16}O_3Si$	188.3
41	16.9	0.13	Butoxyacetic acid, TMS derivative	$C_7H_{16}O_2Si$	160.3
42	17.1	0.10	.alpha.-Ketoisovaleric acid, TMS derivative	$C_8H_{16}O_3Si$	188.3
43	17.2	0.07	2-[(Trimethylsilyl)oxy]tetradecanoic acid, bis(trimethylsilyl) ester	$C_{23}H_{50}O_5Si_3$	490.9
44	17.4	0.20	1,3-dioxane-5-carboxylic acid, 5-methyl-, trimethylsilyl ester	$C_{15}H_{32}O_5Si_2$	348.6
45	17.5	0.20	2-[(Trimethylsilyl)oxy]tetradecanoic acid, bis(trimethylsilyl) ester	$C_{23}H_{50}O_5Si_3$	490.9
46	17.9	0.24	Carbitol, TMS derivative	$C_9H_{22}O_3Si$	206.4
47	18.0	0.04	3-Methyl-2-oxovaleric acid, TMS derivative	$C_9H_{18}O_3Si$	202.3
48	18.2	0.25	(Methoxymethyl)trimethylsilane	$C_6H_{16}N_2$	116.2
49	18.6	0.07	Monoethyl methylmalonate, TMS derivative	$C_8H_{16}O_4Si$	204.3
50	18.7	0.02	Ethyl 3-hydroxy-2,2-dimethylbutanoate, TMS derivative	$C_7H_{14}O_3$	146.2
51	18.8	0.2	Acetin, bis-1,3-trimethylsilyl ether	$C_{11}H_{26}O_4Si_2$	278.5

RT = retention time (min), PK = peak area and M wt = molecular weight

In the present study both *A. javanica* and *O. baccatus* extracts exhibited DPPH radical scavenging activities along with increments in the concentration of phenolic compounds. The key role of phenolic compounds as free radical scavengers has been described in numerous works [32 - 34]. The phenolic content was found to be strongly correlated to the DPPH assay in both tested plants (R^2= 1, data not shown). Similarly, Sethi and Sharma [9] reported a direct correlation between total phenolic compound and antioxidant activities of *A. tomentosa*. Such antioxidants activities provide direct or indirect disease avoiding effects against oxidative stress responsible for several pathological conditions [35].

The GC-mass analysis for *Aerva javanica* showed 27 bands of 24 different compounds, between these compounds some have economic values used as antimicrobial agents such as L-Rhamnose, 4TMS derivative antibacterial activity against Gram-positive bacteria *Bacillus Sp*. [36], Glycolic acid, TMS derivative exhibits potent antibacterial activity against *Cutibacterium. Acnes* [37], 3-Decen-1-ol, (E)- common antimicrobial activity was demonstrated [38] and 2-Hydroxyisocaproic acid used as antimicrobial agent [39]. On the other hand, for *Ochradenus baccatus* the GC-mass analysis showed 51 bands representing 40 different compounds among these are phosphorodifluoridous hydrazide, trimethyl; with varied biological activities, such as anticonvulsant, antitubercular, anticancer, anti-inflammatory, antiviral, antibacterial, antifungal and antiprotozoal action [40], palmitic acid; inhibition of HIV-1 infection [41] and 2-Hydroxyisocaproic acid, TMS derivative has fungicidal properties [39].

The antimicrobial results indicated that plant extracts displayed different degrees of antimicrobial activities against all tested bacterial and fungal microorganisms, and thus, different zones of inhibition (mm) Table 4. *A. javanica* was effective against *S. aureus*, *B. subtilis*, *K. pneumonia*, and *P. aeruginosa* Table 4. Such bacteria are of particular concern, as those belonging to the ESKAPE group (multi-drug resistant pathogens), particularly *K. pneumoniae*, often show resistance to almost all antibiotics available in clinical practice, thus severely limiting the therapeutic options available [42,43]. While methanolic extract of *O. baccatus* was effective against different microbes (*S. aureus, B. subtilis, and K. pneumoniae*), the same extract showed negligible activity against *P. aeruginosa* Table 4. These results showed that the selected plant extracts have antimicrobial properties, however, *A. javanica* was more effective against selected bacterial strains. Similar results are also reported by **Kaithwas et al.** [44], **Panda** [45], **Shad et al.** [46] and **Ibrahim et al.** [47]. In case of fungal strains, both plant's methanolic extracts had no activity against *Aspergillus flavus* and *Penicillium expansum*, however, they exhibited an antifungal activity against *Candida tropicalis*, particularly, *O. baccatus* (the highest value of inhibition zone) Table 4. This activity can be explained from the result of GC-mass which showed many compounds in both plants with antibacterial or antifungal activity.

Table 4 The diameter of the inhibition zone in mm produced on a range of pathogenic microorganisms

Tested Microorganisms	*A. javanica*	*O. baccatus*	Control
Fungi			Ketoconazole
Aspergillus flavus (RCMB 002002)	NA	NA	16
Candida tropicalis (RCMB 005004) (1)	8	10	21
Penicillium expansum (RCMB 001001) (1) IMI28169	NA	NA	17
Gram Positive Bacteria			Gentamycin
Staphylococcus aureus (RCMB 010010)	9	9	24
Bacillus subtilis RCMB 015 (1) NRRL B-543	8	9	26
Bacillus cereus RCMB 027 (1)	NA	NA	25
Gram Negative Bacteria			Gentamycin
Escherichia coli (RCMB 010052) ATCC 25955	NA	NA	30
Klebsiella pneumonia RCMB 003 (1) ATCC 13883	10	12	21
Pseudomonas aeruginosa	12	NA	17

Note: NA = not active

4. Conclusion

In conclusion, the current report provides data on the GC-MS analysis, the antimicrobial and antioxidant activities of the methanolic extracts of *A. javanica and O. baccatus.* Both methanolic extracts displayed comparatively potent antimicrobial and antioxidant activities due to the presence of phenolic and flavonoid derivatives as well as other phytoconstituents which suggest their usage as good source for therapeutic purposes or intermediate materials for synthesis of useful drugs.

5. References

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