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GC-MS Analysis, Antioxidant Capacity and Antimicrobic Action of *Vetiveria zizanioides.* Essential Oil Cultivated in North Egypt

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ABSTRACT

Essential oils constituents are receiving growing interest due to their bioactivities. This study focused on some aspects of the essential oil obtained from vetiver plant roots, cultivated in the north of Egypt. It is considered as a promising aromatic crop in Egypt, with numerous advantages which compromise with Egypt's environment and soil problems. The vetiver oil was extracted through hydrodistillation, then, the chemical structure of the essential oil was studied using GC-MS. A total of sixty-three compounds were identified as a result of oil GC- MS analysis. The major compounds were khusimol, Isovalencenol, 2- isopropyl -5- methyl -9- methylene-bicyclo -1-decene (4.4.0), α-vetivol, beta-maalene, vetiselinenol, γ-selinenes, zizanol, khusiol and β-vatirenes. Furthermore, the antioxidant capacity and total phenolic content were also investigated using phosphomolybdenum assay and Folin-Ciocalteu colorimetric assay respectively. The essential oil showed 75.5% of total antioxidant capacity at 0.1 mg/ml (100 ppm) while the total phenolic content was 6.7 mg GAE /g. Lastly, antimicrobial activity was studied using an agar medium assay and agar disc diffusion method. All *in vitro* tested concentrations of the vetiver essential oil had proved its efficiency against *Fusarium oxysporum*, *Alternaria citri*, *Rhizoctonia solani*, and *Erwinia carotovora* compared to respective controls.

***Keywords*:** Vetiver, *Vetiveria zizanioides*, essential oil, antioxidant, antimicrobial activity

INTRODUCTION

Plants produce substances known as secondary metabolites (SMs) as a result of their interactions with biotic and abiotic elements in the environment for defense and adaptation. The complex and highly evolved production and accumulation of SMs is influenced by a wide range of elements, including internal genetic circuits that are still forming (regulated genes and enzymes) and external ecological factors (light, temperature, water, salinity, etc). (Li *et al*., 2020). Recent years have seen a significant increase in the investigation of essential oils derived from various herbs and spices, in part due to the increasing discovery of their multifunctional qualities beyond their traditional role as culinary flavouring and/or perfumes. Numerous essential oils have been studied and found to possess antioxidant, antibacterial, antifungal, and anti-inflammatory effects. (Lee and Shibamoto, 2002; Güllüce *et al*., 2003; Kim *et al*., 2004; Devprakash *et al*., 2011; Soni and Dahiya, 2015; Efe, 2019 and Soidrou *et al*., 2020).

Vetiver grass, (*Chrysopogon zizanioides* (L.) Roberty syn. *Vetiveria zizanioides* (L.) after recognized as khus, kha-khas, khas grass, is a member of *Poaceae* family (Maffei, 2002), is a fast growing, tall, perennial, tufted and fragrant grass, its stem is straight and stiff with a long-narrow leaf and an intense, complex, abundant and fibrous adventitious root system that is highly valued (Chōmchalao, 2001). The root system can reach a length of 3-4 meters in the first year of planting (Hengchaovanich, 1998), extend a total length of 7 meters in 36 months (Lavania, 2003). Vetiver tolerates extremely harsh climatic conditions with temperatures ranging from -20 to 60 degrees celsius (District, 2000 and Lavania *et al.*, 2004) and is highly resistant to acidic, alkaline, and saline growing media (District, 2000 and Truong, 1999). Additionally, vetiver has a remarkable ability to flourish in a wide range of soils as well as in flooded or waterlogged environments. This grass can prevent soil and sediment erosion owing to its unique structural and functional characteristics (Greenfield, 1995) The vetiver structure has been shown to provide a sustainable solution to various other ecological problems, including soil and water management, wastewater treatment, dam steadying, flood regulator, contamination reduction, and agroforestry management (Xu *et al.*, 2003 and Lavania *et al.*, 2004). Its role in sustainable mitigation of environmental pollution makes it the best material for restoring the environmental quality that the earth offers. Consequently, it could be a good solution for reclaiming the Egyptian deserts.

Vetiver is grown to produce a valuable essential oil utilized in perfumery and aromatherapy (Chowdhury *et al.*, 2002 and Weyerstahl *et al.*, 1996). Vetiver root oil has several aesthetic benefits, including restoring moisture to dry and parched skin, rejuvenating aged skin, and treating cuts, injuries, and inflamed skin (Curtis, 1996). as well as, preventing stretch marks after pregnancy. The oil helps treat depression, insomnia, anxiety, stress, tension, and nervousness by strengthening the central nervous system (Fischer-Rizzi, 1990 and Wilson, 2002). It is good as a warming and analgesic rubbing oil for stiffness, muscle aches, sprains, stiffness, rheumatism, and arthritis (Chōmchalao, 2001). The roots are used to treat fevers, inflammations, stomach irritations, and liniments in addition are stimulating, tonic, cooling, stomachic, diuretic, antispasmodic, and emmenagogue (Ghani, 2003). Vetiver oil is used to cure a variety of ailments, including mouth infections. it has been used to treat mouth sores, fever, headaches, inflammation, and gastritis (Luqman *et al.*, 2009 and Liu *et al.*, 2010). Vetiver is a multipurpose plant with nearly all components being used in some form, and it serves a variety of

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cultural and industrial uses. The aim of this work was to evaluate the chemical profile, antioxidant capacity, total phenols content and antimicrobial action of *V. zizianoides* roots essential oil produced under the environmental conditions of north Egypt.

MATERIALS AND METHODS

Sample extraction

Roots of vetiver were separated and washed well with water several times to remove any soil, then dried in a shady place. The essential oil of roots was extracted by hydrodistillation. The Clevenger hydrodistillation apparatus was used to extract 350 g of well-dried vetiver roots for 15 hours. The extraction process was carried out at a temperature of 40 degrees Celsius. The extracted oil was collected in a dark glass tube and stored at +4 Celsius for further analysis. The yield of oil extraction was calculated in mg/100 g of dried vetiver root. The yield was 1.20% (v/w).

$$\text{Essential oil content (\%)} = \frac{Quantity\ of\ extracted\ essential\ oil}{weight\ of\ roots\ (100\ g)} \times 100$$

Plant materials & Microorganisms sources

Adult vetiver plants (24 months old) were obtained in December 2021 from the Herbal Family Group company farm located on the 70th Km Cairo – Alexanderia desert road. (Plate 1)

Standard cultures of *Fusarium oxysporum*, *Alternaria citri*, *Rhizoctonia solani and Erwinia carotovora* were used for the study. All stock cultures were obtained from the Department of Plant Pathology, Fac. Of Agriculture, Ain Shams University, Cairo, Egypt.

Gas chromatography mass spectroscopy (GC/MS)

GC/MS- MS analysis of vetiver essential oil was performed using an Agilent 7000 Series Triple Quad gas chromatograph connected to a mass spectrometer (GC/MS-MS). The gas chromatograph is equipped with an Elite 5MS (5% diphenyl/ 95% dimethylpolysiloxane) fused to a capillary column (30 x 0.25um ID x 0.25um df). An electron ionization system with ionization energy of 70ev was used for GC-MS detection. Helium gas (99.999%) with a constant flow rate of 1ml/min and injection volume of 2ul was used as carrier gas (split ratio of 30:1); injector temperature 250° C; ion source temperature 200° C. Oven temperature was programmed from 110° C (isothermal for 2 min) with an increase of 109° C/min to 2009° C, then 5° C/min to 2809° C, ending with a 9-min isothermal at 280° C. Mass spectra were acquired at 70ev: a scan interval of 0.5 seconds and fragments from 45 to 450Da; total GC run time was 36 minutes. The relative percentage of each component was calculated by comparing the average peak area to the total areas. The software used to process the mass spectra and chromatograms was Turbo Mass. GC/MS- MS mass spectra were evaluated using the National Institute of Standard and Technology database (NIST), which contains more than 62,000 samples. The spectrum of the unknown components was stored in the NIST library. The name, molecular weight and structure of the components of the test materials were determined (Neelamegam and Ezhilan, 2012).

Total antioxidant activity by phosphomolybdenum assay

The total antioxidant activity (TAC) of vetiver essential oil was measured using the phosphomolybdenum assay described by (Prieto *et al.*, 1999). The assay is n the antioxidant chemicals reducing Mo (VI) / Mo (V) and forming a green phosphate/Mo (V) complex at acidic pH.

Total phenols content

The content of total phenols was determined spectrophotometrically using the Folin-Ciocalteu colorimetric assay (Singleton *et al.*, 1999). The reaction mixture consisted of 0.5 ml of sample (0.1 mg/ml), 2.5 ml of 10% Folin-Ciocalteu reagent diluted in water, and 2.5 ml of 7.5% $NaHCO_3$. Samples were incubated at 45°C for 15 minutes. Absorbance was measured at max = 765 nm. After calibration against gallic acid standards, results were expressed as mg gallic acid equivalents (GAE)/g essential oil. The information shown is the average of three measurements.

Antifungal activity assay

The effect of antifungal activity of vetiver oil on radial growth of *Fusarium oxysporiuum.*, *Alternaria citri.* and *Rhizoctonia solani* was performed using agar medium assay according to (Thabet and Khalifa, 2018). Different concentrations of vetiver oil (0, 500, and 1000 µg/ml) were added to Potato Dextrose Agar (PDA) medium. Due to vetiver oil viscosity; 10% dimethyl sulfoxide (DMSO) was added to dilute the oil to known concentration to make it well mixable with the medium. The calculated quantities of diluted vetiver oil were added to the melted media using 0.45µ microfilter to prepare the mentioned treatments. The medium was poured into glass Petri-dishes (9 cm) 20 ml in each one. Then, inoculated at the center with a mycelial disc (0.5 cm in diameter) taken from the margins of 4-6 days-old *Fusarium* spp., *Alternaria citri*, and *Rhizoctonia solani cultures.* Three replicates were conserved for each treatment. Additionally, positive control (vetiver oil free) was inoculated as mentioned before. The incubation temperature was 25°C. The colony diameter was monitored daily until the mycelia totally covered the control medium surfaces.

The percentage of Mycelial Growth Inhibition (MGI) was calculated according to the following equation:

Mycelial Growth Inhibition (MGI) % = (Do – De) / Do x 100

Where: Do = the mycelia growth diameter in the positive control – 0.5 cm

De = the mycelia growth diameter in oil supplemented plates – 0.5 cm

Antibacterial activity assay

Agar disc diffusion method was done using sterilized nutrient agar plates, according to (Efe, 2019). The suspension of *Erwinia carotovora*. (10^8 CFU/ml) was prepared from overnight grown cultures (24 h). 100 µl of inoculums were spread upper the surface of agar plates with a sterile glass spreader to uniform the microbial growth on the plates. As soon as inoculum absorbed by agar, sterile filter discs (Whatman no 1, 6 mm diameter) were dipped in specified concentration of diluted vetiver oil and placed on thesurface of the agar plates using sterilized forceps (dipped in ethanol and flamed). Filter disc moistened with 10 % DMSO solution was used as control. The plates were incubated at 28±2 °C for 48-72 h and observed for antibacterial activity. After the incubation period, the antibacterial activity was measured by zone of inhibition in millimeters, for each disc. The zone of inhibition was interpreted as described previously by (Ponce *et al.*, 2003) not sensitive = total diameter <8.00 mm; sensitive = total diameter of 8–14 mm; very sensitive = total diameter of 15–19 mm; extremely sensitive = total diameter >20 mm.

Data analysis:

All data were analyzed by ANOVA using SAS software. The means were separated using the Least Significant Difference (LSD) test at $P \leq 0.05$

RESULTS AND DISCUSSION

Chemical profile of the essential oil

The essential oil extracted from the roots of vetiver plant (*Vetiveria zizanioides*) has aromatic properties due to its chemical (Soni and Dahiya, 2015 and Chōmchalao, 2001). The cultivation of vetiver plant is expanded worldwide, but

the chemical profiles of essential oils are known to vary depending on geographical regions and climatic conditions. Therefore, it was necessary to study the essential oil extracted from the roots of vetiver plant grown under the climatic conditions of north Egypt.

Generally, the most components of vetiver oil comprise of sesquiterpene hydrocarbons like amorphine, cadenene, cloven, aromadendrine, junipene and their alcohol derivatives– vetiverols like epiglobulol, spathulenol, khusinol, khusimol and khusol. Carbonyl derivatives– vetivones like α-vetivone and β-vetivone, khusimone and nootkatone. Acid derivatives like khusenic acid and ester derivative like khusinol acetate, (Sellier *et al.*, 1991 and Demole *et al.*, 1995) have also been described in majority of the collections.

Vetiver essential oil composition is various deepening several factors, however growing climatic conditions of geographical region play the prominent factor. North India feature with high percent of Khusimol, khusinol, germacrene-D, junipene and γ-muurolene, while the vetiver oil from south India feature with higher percent Khusimol, bicyclovetivenol and viridiflorene (Dubey *et al.*, 2010) In Taiwan, Cedr-8-en-13-ol, α-amorphene, β-vatirenene and α-gurjuene are the major percent of the vetiver oil (Chou *et al.*, 2012). Khusinol, β-vetivenene and dehydro-aromadendrene are the major components of the oil obtained from Southeast Medierranean (Turkey) (Kirici *et al.*, 2011). The vetiver oil from Brazil, China, India, Java, Madagascar, Mexico, Reunion and Salvador feature with high percent of β-vetisprene, khusimol, Vetiselineol and α-vetivone (Filippi *et al.*, 2013). In Bangladesh, the major components of vetiver oil are 2,6- Dimethyl–10-methylene-12-oxatricyclo [7.3.1.0 (1,6)] tridec-2-ene and 2- (4a,8-dimethyl-1,2,3,4,4a, 5,6,7-octahydro-napthalen-2yl) prop-2-en-1-ol 4 (Bhuiyan *et al.*, 2008). Lastly in Sri Lanka the oil feature with higher percent of ecotype, Khusimol, longipinene, valerenol, epizizanal, α-vetivone and β-vetivone (Thubthimthed *et al.*, 2003).

GC- MS analysis provided qualitative and quantitative results, which are presented in Table 1 and Figure 1. As a result of the analysis, a total of sixty-three compounds were identified. The major compounds were khusimol (12.77%), (E)-Eremophila-1(10),7(11)-dien-12-ol (isovalencenol) (7.34%), 2-isopropyl-5-methyl-9-methylene-bicyclo-1-decene (4.4.0) (4.1%), α-vetivol (4.07%), beta-maalene (3.95%), vetiselinenol (3.11%), γ-selinenes (2.98%), zizanol (2.54%), khusiol (2.53%), β-vatirenes (2.06%).

Plate 1. *Vetiveria zizanioides.* plants grown in north Egypt.

Antioxidant capacity and Total phenolic content

The essential oil of Vetiver roots had 75.5% of total antioxidant capacity at 0.1 mg.ml^{-1} (100ppm). The total content of phenols gave a value of 6.7 mg GAE /g of essential oil.

Table 1. The percentages of peak areas of vetiver essential oil GC- MS analysis.

Peak	Name of the compound	Molecular weight (g/mol)	Formula	Peak area (%)
1	Linalool	154.25	$C_{10}H_{18}O$	0.15
2	Trans-Rose oxide	154.2493	$C_{10}H_{18}O$	0.05
3	Menthone	154.25	$C_{10}H_{18}O$	0.04
4	Trans Methone	154.2493	$C_{10}H_{18}O$	0.25
5	Citronellol	156.26	$C_{10}H_{20}O$	1.55
6	D-Carvone	150.22	$C_{10}H_{14}O$	0.14
7	Geraniol	154.25	$C_{10}H_{18}O$	0.47
8	Citronellyl formate	184.27	$C_{11}H_{20}O_2$	0.35
9	Geranyl formate	182.26	$C_{11}H_{18}O_2$	0.10
10	Zizanal	218.33	$C_{15}H_{22}O$	0.12
11	Beta-Bourbonene	204.35	$C_{15}H_{24}$	0.07
12	Acora-3(7),14-diene	204.3511	$C_{15}H_{24}$	0.29
13	Caryophyllene	204.35	$C_{15}H_{24}$	0.21
14	Daucene	204.35	$C_{15}H_{24}$	0.16
15	(+)-Epi-bicyclosesquiphellandrene	204.35	$C_{15}H_{24}$	0.24
16	Prezizaene	204.35	$C_{15}H_{24}$	0.68
17	Khusimene	204.3511	$C_{15}H_{24}$	0.89
18	Alpha. Gurjunene	204.35	$C_{15}H_{24}$	0.21
19	((1R,5R)-1-Iso propyl-8-methyl-4-methy lenespiro [4.5] dec-7-ene	204.3511	$C_{15}H_{24}$	0.19
20	Selina-3,7(11)-diene	204.35	$C_{15}H_{24}$	0.06
21	α-Amorphene	204.3511	$C_{15}H_{24}$	1.36
22	Cis-Eudesma-6,11-diene	204.35	$C_{15}H_{24}$	0.17
23	Beta-Vetispirene	202.33	$C_{15}H_{22}$	0.74
24	Beta-Cadinene	204.35	$C_{15}H_{24}$	0.60
25	Gamma-Muurolene	204.35	$C_{15}H_{24}$	0.34
26	D-Cadinene	204.35	$C_{15}H_{24}$	0.89
27	Iso ledene	204.35	$C_{15}H_{24}$	0.95
28	Cadina-1(10),4-diene D-Amorphene	204.35	$C_{15}H_{24}$	0.20
29	11,12,13-tris-nor -trans-Eud esm-5-en-7-one	178.2707	$C_{12}H_{18}O$	0.33
30	Alpha-Calacorene	200.32	$C_{15}H_{20}$	0.23
31	β-Vatirenene	202.33	$C_{15}H_{22}$	2.06
32	Isolongifolene, 4,5,9,10-dehydro-	200.32	$C_{15}H_{20}$	0.14
33	4-(1,3,3-Trimethyl-bicyclo [4.1.0] he pt-2-yl)-but-3-en-2- one	206.324	$C_{14}H_{22}O$	0.09
34	γ-Vetivenene	202.3352	$C_{15}H_{22}$	0.80
35	Ylangene	204.35	$C_{15}H_{24}$	0.53
36	Beta-Maaliene	204.35	$C_{15}H_{24}$	3.95
37	13-nor-Erem ophil-1(10)-en-11-one	206.32	$C_{14}H_{22}O$	0.18
38	Junenol	222.37	$C_{15}H_{26}O$	1.78
39	γ-selinene	204.35	$C_{15}H_{24}$	2.98
40	Beta-Cadinene	204.35	$C_{15}H_{24}$	0.70
41	Valencene	204.35	$C_{15}H_{24}$	1.61
42	Beta-Guaiene	204.35	$C_{15}H_{24}$	0.62
43	2-Isopropyl-5-methyl-9-methylene-bicyclo-1-decene (4.4.0)	204.35	$C_{15}H_{24}$	4.11
44	Cyclocopacamphenol	220.35	$C_{15}H_{24}O$	1.41
45	Spiro [4.5] dec -8-en-7-ol, 4, 8-dimethyl-1-(1-methy lethyl)-	222.3663	$C_{15}H_{26}O$	0.96
46	Zizanol	220.35	$C_{15}H_{24}O$	2.54
48	Khusiol	222.37	$C_{15}H_{26}O$	2.53
49	Juniper camphor	222.37	$C_{15}H_{26}O$	0.75
50	Cycloheptane, 4-methylene-1-methyl-2-(2-methyl-1-propen-1-yl)-1-vinyl-	204.35	$C_{15}H_{24}$	0.60
51	Delta-selinene	204.35	$C_{15}H_{24}$	0.60
52	Vetiselinenol	220.35	$C_{15}H_{24}O$	3.11
53	α-Isonootkatol	220.35	$C_{15}H_{24}O$	1.10
54	Khusimol	220.35	$C_{15}H_{24}O$	12.77
55	α-Vetivol	220.35	$C_{15}H_{24}O$	4.07
56	α-Costol	218.33	$C_{15}H_{22}O$	0.29
57	Valerenol	220.35	$C_{15}H_{24}O$	0.17
58	β-Vetivenene	202.33	$C_{15}H_{22}$	0.11
59	(E)-Eremophila-1(10),7(11)-dien-12-ol (Isoval encenol)	220.35	$C_{15}H_{24}O$	7.34
60	(Z)-Isovalencenal	218.33	$C_{15}H_{22}O$	0.33
61	β-Vetivone	218.33	$C_{15}H_{22}O$	1.87
62	(E)-Isovalencenal [eremophila-1(10),7 (11)-di en-12-al	218.3346	$C_{15}H_{22}O$	1.67
63	α-vetivone	218.33	$C_{15}H_{22}O$	1.77

Antimicrobial activity

The essential oil of *Vetiveria zizanioides* is reported to contain alkaloids, terpenoids, flavonoids, saponins, phenols and tannins which either separately or in combination utilize antimicrobial properties (Kumar and Gayathri, 2016). Flavonoids are observed to be effective element against broad spectra of microbes, owing to their ability to combine with outer cellular membrane and soluble proteins. The biological action of tannins may correlate to their capacity to deactivate adhesion

enzymes and cell envelope transport proteins of microbes, as well as their ability to combine with polysaccharides (Kannan *et al.*, 2009). Vetiver derived combinations have also been studied for pest and pathogen management. Allelopathic or repellant activity was established versus several organisms, including bacteria and fungi (Zahoor *et al.*, 2018).

Data in Table (2) and Fig (2) showed that, there was a significant inhibition in radial growth of all tested fungi species including *Fusarium oxysporum*, *Alternaria citri* and *Rhizoctonia solani.* due to vetiver oil application. The inhibition was high at the lowest application rate (500 µg/ml) and enhanced by increasing the tested concentration to (1000 µg/ml). The inhibition in linear growth of *F. oxysporum* and *Alternaria citri* was lower than that observed for *Rhizoctonia solani* in all tested concentrations (Fig. 1). This concentration led, however, to 60.3, 69.2 and 79.2 % reductions in the growth of *F. oxysporum*, *Alternaria citri and Rhizoctonia solani* respectively. The biological impact of vetiver oil opposed to *E. carotovora* was measured by zone of inhibition (mm) using an agar well diffusion method shown in Table (2) and Fig (3). The diameter of inhibition zone wider than 8 mm was considered as sensitive. Data indicated that *E. carotovora* was sensitive to vetiver oil at 500 and 1000 µg/ml. The average of inhibition zones of vetiver oil were 9.33 mm and 13.5 mm at 500 µg /ml and 1000 µg/ml respectively.

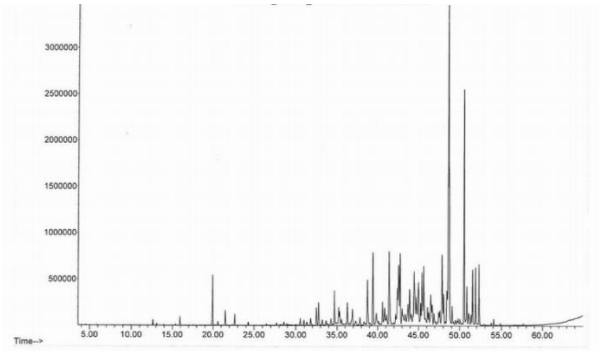

Figure 1. Chromatogram GC of vetiver essential oil.

Table 2. Effect of vetiver oil on fungal growth and bacterial inhibition zone.

Treatments		*Fusarium oxysporum*		*Alternaria citri*		*Rhizoctonia solani*		*Erwinia carotovora*
		MG (cm)	MGI %	MG (cm)	MGI %	MG (cm)	MGI %	Inhibition zones (mm)
Control		9^{a}±0.0	0^{f}±0.0	9^{a}±0.0	0^{f}±0.0	9^{a}±0.0	0^{f}±0.0	0^{c} ±0.0
Vetiver oil	500 µg/ml	6^{b}±0.23	33.3^{e}±2.56	5.2^{c}±0.29	42.2^{d}±3.29	4^{d}±0.05	55.5^{c}±0.63	9.33^{b}(s) ±0.57
	1000 µg/ml	3.6^{d}±0.14	60.3^{c}±1.62	2.8^{e}±0.14	69.2^{b}±1.62	1.9^{f}±0.08	79.2^{a}±1.0	13.5^{a} (s) ±0.57
LSD		0.43	4.86	0.43	4.86	0.43	4.86	1.63

Note: MG (cm) = Mycelia Growth (cm), MGI% = Mycelia Growth Inhibition %. (S): sensitive according to Ponce *et al.* [2003]. Means in each column followed by the same letter(s) are not significantly different according to (LSD) test at ($P \leq 0.05$)

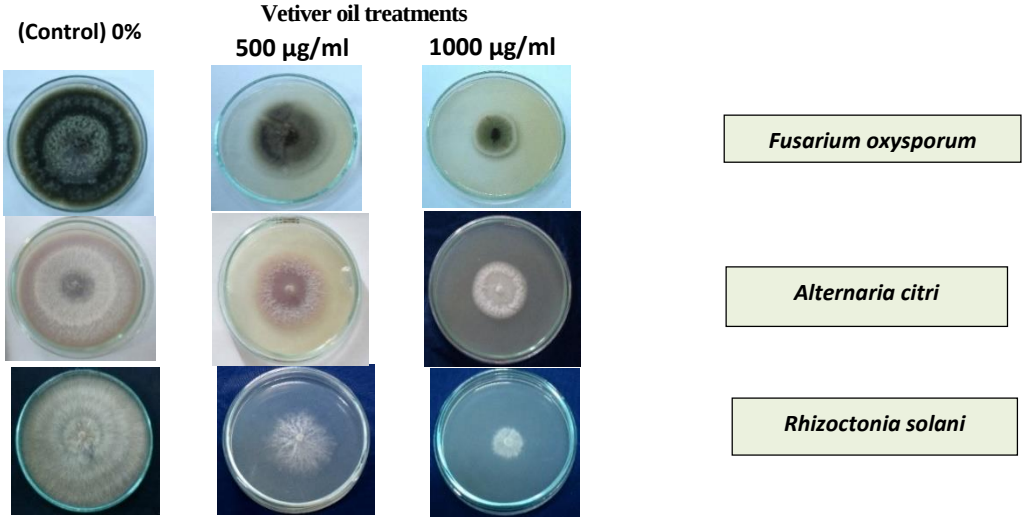

Fig. 2. Mycelial growth of different fungi after 10 days incubation with different concentrations of vetiver oil (0, 500, 1000 µg/ml).

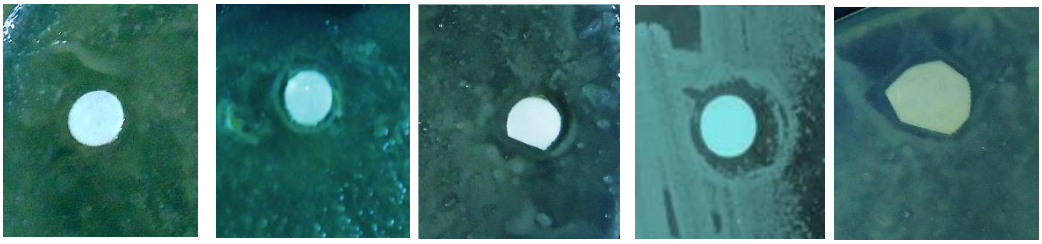

Fig 3. Inhibition zone of *Erwinia carotovora* after 24 h incubation with different concentrations of vetiver oil (0, 500, 1000 µg/ml).

Our findings are consistent with those obtained by Soni and Dahiya, 2015 and Soidrou *et al.*, 2020 which revealed that, vetiver oil possesses antifungal and antibacterial properties. The fungi versus activity of vetiver oil also investigated, particularly opposed to phytopathogenic fungi (Devprakash *et al.*, 2011 and Powers *et al.*, 2018). Similar trend of results was conducted by Dubey *et al.*, 2010 who reported the sensitivity of *Rhizoctonia solani to* vetiver oil. Additionally, Ramandeep *et al.*, (2016) investigated the efficacy of vetiver root essential oil counter to three species of wheat and rice fungi *i.e. Fusarium moniliforme*, *Dreschlera oryzae* and *Alternaria triticina.* According to the findings, vetiver oil extract could be effective in the development

of botanical fungicides to combat these phytopathogenic fungi. The antibacterial activity of *Vetiveria zizanioides* essential oil have also been quoted by Efe, (2019); Zahoor *et al.*, (2018) and Devi *et al.*, (2010) which confirmed that flavonoids hold biological activity against the gram-negative bacteria. In addition, tannins in the vetiver oil extract are an active component with antibacterial activity *in vitro*. In general, the presence of phenols, aldehydes, and alcohols in essential oils is mainly responsible for their action (Sacchetti *et al.*, 2005) Terpenols are actually potent antibacterial agents (Kelen and Tepe, 2008). Our oil analysis revealed a high profile in terpenic alcohols as 72 - 97% of its constituents were phenolic and alcoholic compounds.

CONCLUSION

Depending on the presented findings; Vetiver plants grown successfully under the Egyptian environmental conditions. Moreover, the essential oil of its roots showed unique chemical profile as sixty-three compounds were identified according to GC-MS analysis. Furthermore, the essential oil had a good antioxidant activity and phenolic content. Concerning the antimicrobial activity of the essential oil, all *in vitro* tested concentrations of the vetiver essential oil had proved its inhibition effect on pathogenic fungi (*Fusarium oxysporum, Alternaria citri, Rhizoctonia solani*) and bacteria (*Erwinia carotovora*) compared to respective controls. It's advisable to expand the planting of Vetiver in Egypt not for its valuable essential oil only; but for the advantages of the Vetiver plant itself and its environmental benefits.

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التحليل الكروماتوجرافي والسعة المضادة للأكسدة والنشاط المضاد للميكروبات للزيت العطري لنبات *Vetiveria zizanioides.* المزروع في شمال مصر

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الملخص

تلقى الزيوت العطرية اهتماماً متنامياً بسبب الانشطة الحيوية لمكوناتها؛ تركز هذه الدراسة على بعض الخصائص للزيت العطري المستخلص من جذور نبات *Vetiveria zizanioides*المزروع في شمال مصر. يعتبر هذا النبات محصولاً واعداً في مصر حيث ان له العديد من المميزات التي تتوائم مع البيئة المصرية ومشاكل التربة بها. تم استخلاص الزيت العطري بالتقطير المائي ثم درس التركيب الكيماوي للزيت باستخدام التحليل الكروماتوجرافي GC-MS حيث تم تعريف اجمالي ثلاثة وستون مركب وكانت المركبات الرئيسية هي خوسيمول و ايسوفالينسول و 2-ايزوبروبيل-5- ميثيل -9-ميثيلين بايسيكلو-ل- ديسين(4.4.0) و الفا فيتيفول و بيتا ماليين و فيتاسيلينينول و جاما سيلنينس و زيزانول و خوسيول و بيتا فاتيرينس. بالاضافة الى ذلك تم تقدير السعة المضادة للأكسدة باختبار الفوسفوموليبدنم ومحتوى الفينولات الكلية باختبار Folin-Ciocalteu اللوني. حيث اظهر الزيت العطري 75.5% من إجمالي السعة المضادة للأكسدة عند 0.1 مجم/ ملليلتر (100 جزء في المليون) بينما كان المحتوى من الفينولات الكلية 6.7 مجم مكافىء لحمض الجاليك/ جم. اخيراً تم دراسة النشاط المضاد للميكروبات باستخدام اختبار بيئة الأجار وطريقة الانتشار القرصى فى الأجار. اشارت النتائج المعملية ان جميع تركيزات الزيت العطري المختبرة برهنت كفاءته ضد الفطريات الممرضة فيوزاريوم اوكسيسبورم و الترناريا ستراي وريزوكتونيا سولاني و كذلك بكتريا ايروينيا كاروتوفورا مقارنة بالكنترول.