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PHYTOCHEMICAL CONSTITUENTS OF COMMON GROWING *FAGONIA* SPECIES (ZYGOPHYLLACEAE) IN EGYPTIAN DESERTS AND ITS BIOLOGICALACTIVITIES

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Abstract

This study aimed to determine the phytochemical constituents, antioxidant, antimicrobial properties and allelopathic activities of aerial parts of *Fagonia* species collected from the coastal and inland desert of Egypt. Total phenols, tannins, saponins, flavonoids, and alkaloids were determined in the studied *Fagonia* species. The antioxidant activity was measured based on the reduction of DPPH. Antimicrobial activity was evaluated against pathogenic bacteria and fungi, as well as the allelopathic potential against *Portulaca oleracea* was assayed. *F. creticus* attained the highest values of alkaloids and flavonoids among the other studied *Fagonia* species. However, *F. Arabica* exhibited the highest values of phenols and tannins. *F. mollis* extract was higher (IC_{50} = 0.74 mg ml^{-1}) in its free radical scavenging activity followed by *F. arabica* and *F. criticus* (IC_{50} = 0.76 and 0.82 mg ml^{-1}, respectively). The methanol extract of *F. arabica* and *F. criticus* exhibited broad spectrum (87.5% each) against both Gram-positive bacteria and Gram-negative bacteria, followed by *F. mollis* extract (50%). In addition the pathogen *Escherichia coli* and *Streptococcus pyogenes* were the most sensitive bacteria in case of *Fagonia arabica.* The methanolic extracts of *F. arabica* was highest inhibited the germination and seedling growth of *P. oleracea* at 40 mg ml^{-1}. Moreover, the extracts of *Fagonia mollis* and *Fagonia mollis* inhibited the germination of *P. oleracea* by about 86.2% and 76.4%, respectively. Similar inhibitory effects on radicle and plumule growth were observed. In conclusion, bioactive compounds from wild plants can be used as green bio-herbicides against the noxious weeds.

Key words: *Fagonia*, bioactive compounds, phytotoxicity, antioxidants, antimicrobial, *Portulaca oleracea*

Introduction

Plants are valuable source of a wide range of secondary metabolites (SMs), which are used as pharmaceuticals, agrochemicals, flavors, and additives. The SMs are responsible for the medicinal value of the plants but they have very limited distribution than primary metabolites (Alonso-Amelot, 2018). Medicinal plants are the nature gift to human brought to help them pursue a disease-free health life. Today, the whole world culture has a vast knowledge of herbal medicine, two-thirds of the new chemicals identified yearly were extracted from higher plants; moreover 75% of the world population used plants for therapy and prevention (Shakya, 2016; Zaki *et al.,* 2018)**.** Research on plant SMs has been reported to possess various biological activities including antioxidant, allelopathic (Abd El-Gawad *et al.,* 2018a & b; Elshamy *et al.,* 2019), antifungal, antibacterial, antiviral (El-Amier *et al.,* 2014 & 2016a; Alghanem and El-Amier, 2017), anti-inflammatory (Tohidi *et al.,* 2017) and insecticidal (Castillo *et al.,* 2017) activities. In addition, the SMs are intergrated in food preservation industries, fragrance industries, cosmetic, and agro-industrial (Zuin and Ramin, 2018).

The genus *Fagonia* belongs to the botanical plant family Zygophyllaceae. It consists of about 18 species (Tackholm, 1974), but it was represented by 15 species in Boulos (2000). It was reported that Bedouins and indigenous people in Africa used this genus as medicinal plants. It is a flowering plant found mainly as low shrubs or perennial herbs, rarely annuals (Boulos, 2000). The plants of genus *Fagonia* is distributed in sandy plains, calcareous coastal ridges and desert wadis. In Egypt it

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occurs in the Mediterranean coastal strip, the oases of the western desert, all the deserts of Egypt and the entire Sinai Peninsula. This genus are used commonly as home remedy, and their aqueous, and alcoholic extracts as medicines for treatment of conditions like diabetes, fever, asthma, toothache, stomach pain and kidney problems (El-Zayat, 2002; Kamran *et al.,* 2017). Photochemistry and the evaluation of *Fagonia* species were studied by Al-Wakeel and Shannaz (1992), Shoeb *et al.,* (1994) and Farheen *et al.,* (2017).

The Egyptian desert and Nile Delta region is flourished by many medicinal species in the native flora of Egypt. Current environmental conditions may induce the accumulation of high concentration of SMs as in products in the plant tissues, which seem to be promising economically. Some wild plants and weeds can be used as forages (Zahran and El-Amier, 2013) and/or agro-industrial raw materials (Zaharan and El-Amier, 2014) and in drug industry (Zaki *et al.,* 2016a &b). This research aimed to determine the phytochemical constituents, antimicrobial properties, antioxidant and allelopathic activities of aerial parts of *Fagonia* species collected from the coastal and inland desert of Egypt, in order to assess their biological activity and their future industrial uses.

Material and Methods

Plant Material

Fagonia arabica L. and *F. mollis* Delile samples were collected from wadi Hagul, North Eastern desert, while *F. cretica* L. was collected from Western Mediterranean coastal belt of Egypt. The identification of species was done according to Boulos (2000). At the flowering stage (April 2019), plant sample was collected, air-dried and grinded into a powder using a blender. The dried plant powder (100g) was extracted using methyl alcohol by socking overnight with periodical shacking. The solution was filtered and evaporated to dryness. The dried residue was dissolved in dimethyl sulfoxide (DMSO) and kept at -20°C for future use.

Phytochemical Analysis

Total phenolics, flavonoid and alkaloids were estimated according to the methods described by Chlopicka *et al.,* (2012), Stankovic (2011) and Joshi *et al.,* (2013), respectively. Saponins content was determined by the method adopted by Obadoni and Ochuko (2001), while tannins according to Van Burden and Robinson (1969).

Determination of biological activity

Antioxidant activity

The antioxidant activity was determined by using the free radical scavenging method (DPPH) described by Miguel (2010). Two ml of 0.15 mM DPPH was added to 2 ml of plant extracts in different concentrations (100-1000 ppm). A control was prepared by adding 2 ml solvent instead of sample. The mixture was incubated for 30 min. in dark at the room temperature. The absorbance was measured at 517 nm and the IC50 was calculated graphically. The antioxidant activity was calculated using the following equation:

$$\% \text{ Radical scavenging activity} = [1 - (A \text{ sample}/A \text{ control})] \times 100$$

Antimicrobial activity

The methanolic extract from aerial parts of *Fagonia* species were tested against four gram negative bacteria: *Proteus vulgaris, Klebsiella pneumoniae, Escherichia coli, Pseudomonas aeruginosa*, and three gram positive bacteria; *Streptococcus pyogenes, Staphylococcus aureus, Bacillus subtilis* as well as *Candida albicans* is fungal strain employed in the screening. Filter paper discs (5 mm in diameter) were prepared before use and sterilized in an autoclave for 20-30 min. A sterile paper disc was socked in crude extract of the studied plant and then placed over the surface of the inoculated nutrient agar in antibacterial assay and on potato dextrose agar in antifungal assay (Cappuccino and Sherman, 2008). All Petri dishes were incubated at 37°C for 24 hrs. After incubation, the diameter of inhibition zone (cm) was measured for recording the clear zone and compared with the DMSO as control.

Allelopathic activity

The seeds of *Portulaca oleracea* (purslane) were collected from cultivated fields in Mansoura city, Al-Dakahlia Governorate, Egypt. Uniform and ripened seeds were sterilized by soaking for 3 min in NaOCl (0.3%), then washed by sterile-distilled water three times and dried on sterilized Whatman cellulose filter paper and kept in sterilized bottles until further use.

In order to test the phytotoxic activity, two layers of Whatman No. 1 filter paper were placed in 7 cm diameter glass petri dishes. In each petri-dish 20 seeds were placed and 4 ml of each plant extract added in a concentration of 5, 10, 20 and 40 mg ml^{-1} and incubated in the growth chamber at 27°C (Abd El-Gawad and El-Amier, 2015). After 4 days, rate of germination and the percentage of inhibition were calculated. Meanwhile, the length of radicle and plumule was measured for each replicate after 14 days of treatment. The experiment was designed with three replications for each treatment and was repeated two times.

Statistical Analysis

The data were analyzed for the test using one way analysis of variance (ANOVA) followed by Duncan's test at a probability level of 0.05 using the COSTAT 6.3 program.

Results and Discussion

Phytochemical Analysis

Phytochemical analysis provided significant ideas for the development of new herbicides and drugs against deadly diseases. Natural products of wild plants still play a central role in the biological activities and healthcare system of large proportions of the world's population (Cseke, 2016; Roy *et al.,* 2018). The importance of plants lies in certain chemicals in the cells, such as alkaloids, anthraquinones, coumarins, flavonoids, saponins, sterols and/or terepenes, tannins and phenolic compounds (Edeoga *et al.,* 2005). The concentrations of the phytochemicals present in the studied *Fagonia* species are presented in Fig. 1. The total phenolic compounds were 9.62, 7.33 and 4.38 mg/g DW for *F. arabica*, *F. mollis* and *F. creticus* methanolic extracts, respectively. The total flavonoids compounds were 7.16, 6.87 and 5.11 mg/g DW for *F. creticus, F. arabica* and *F. mollis* methanolic extracts, respectively. The total alkaloids contents were 4.43, 3.44 and 3.32 mg/g DW for *F. creticus, F. mollis* and *F. arabica* methanolic extracts, respectively.

The total saponins content were 8.14, 7.45 and 5.87 mg/g DW for *F. mollis*, *F. arabica* and *F. creticus* methanolic extracts, respectively. While, it was found that total tannins content were 12.44, 9.22 and 6.66 mg/g DW for *F. arabica, F. creticus* and *F. mollis* methanolic extracts, respectively Fig. 1. It is obvious that, the present

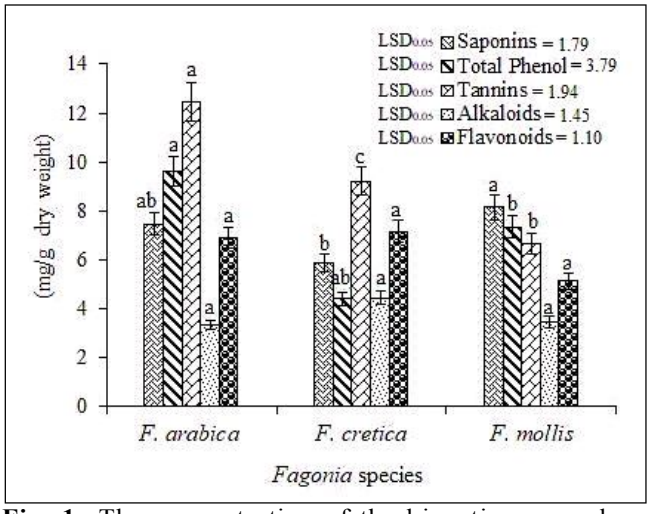

Fig. 1: The concentration of the bioactive secondary compounds in the selected *Fagonia* species.

results showed that methanolic extract of *F. creticus* was the richest in total alkaloids and flavonoids. In addition, *F. arabica* was found to be the richest among the other studied *Fagonia* species in total phenol and tannins Fig. 1. This result is consistency by the study of El-Amier *et al.,* (2014 & 2016) on *Senecio glaucus* and *Urospermum picroides*, Egypt. They are comparing these results to that for other plant species, the secondary metabolites of *Fagonia* species lower than those reported by Alghanem and El-Amier (2017) on *Pergularia tomentosa* and Djeridane *et al.,* (2006) on *Anthemis arvensis* and *Artemisia campestris*.

Antioxidant Activity

The evaluation of the antioxidant activity of the three plant extracts is showed in Table 1. By increasing the plant extract concentration there was a corresponding continuous increase in scavenging activity. In case of *F. arabica*, *F. criticus* and *F. mollis* extracts the increase was up to 1000 µg ml^{-1} where the scavenging activity was 55.36%, 52.61%, and 55.46%, While at 100 ìg ml^{-1} the scavenging activity was 9.22%, 12.64%, and 15.84%, respectively.

The IC_{50} is inversely proportional to the antioxidant power where the lower the IC_{50}, the higher the antioxidant activity (Jin *et al.,* 2018). The data represented in Table 1 indicated that the methanolic extract of *F. mollis* (IC_{50} = 0.74 mg ml^{-1}) was higher in its free radical scavenging activity followed by *F. arabica* (IC_{50} = 0.76 mg ml^{-1}) and *F. criticus* (IC_{50} = 0.82 mg ml^{-1}), respectively. All the tested extracts have considerable antioxidant scavenging activities but with values lower than that of catechol. Catechol was employed as standard compound in this assay.

Antimicrobial activity assessment

In this experiment, methanol extracts from three *Fagonia* spp. exhibited significantly inhibited activities (*P d" 0.05*) against the tested bacterial and fungal strains with different degrees of inhibition zones developed by the extracts Table 2. In case of *F. arabica* the inhibition zone of extract varied according to the type of examined bacteria. The *Escherichia coli* was the most potent inhibitor (28 mm) followed by *Streptococcus pyogenes, Staphylococcus aureus*, *Bacillis subtillis*, *Pseudomonas aeruginosa* and *Klebsiella pneumoniae*. On the other hand, *Proteus vulgaris* expressed negative results (has no effect). In case of *F. criticus* the methanolic extract inhibited all tested bacteria with different inhibition zones Table 2 except *K. pneumoniae*. The shoot extract of *F. criticus* showed the highest activity against *P. aeruginosa* (18 mm), while it exhibited the lowest

Table 1: Percentage of DPPH radical scavenging activity and IC_{50} values of methanolic extracts of *Fagonia* species.

Treatment	Concentration (µg ml^{-1})	Scavenging activity (%)	IC_{50} (mg ml^{-1})	$LSD_{0.05}$
Fagonia arabica	1000	55.36^{a}±1.68	0.76	5.73
	800	50.25^{ab}±2.33		
	600	49.20^{b}±1.49		
	400	45.05^{c}±1.37		
	200	16.18^{d}±0.80		
	100	9.22$_{e}$±0.28		
F. creticus	1000	52.61^{a}±1.59	0.82	
	800	49.62^{ab}±177		
	600	46.58^{b}±1.41		
	400	38.90^{c}±1.18		
	200	25.83^{d}±0.78		
	100	12.64^{e}±0.38		
F. mollis	1000	55.46^{a}±2.44	0.74	
	800	52.69^{ab}±1.52		
	600	49.18^{b}±1.49		
	400	43.80^{c}±1.33		
	200	26.47^{d}±0.49		
	100	15.84^{e}±0.48		
Catechol			0.15	

Values are means ± standard error of triplicates. Different letters in each treatment mean values significant.
$LSD_{0.05}$: least significant difference at 0.05 probability level.

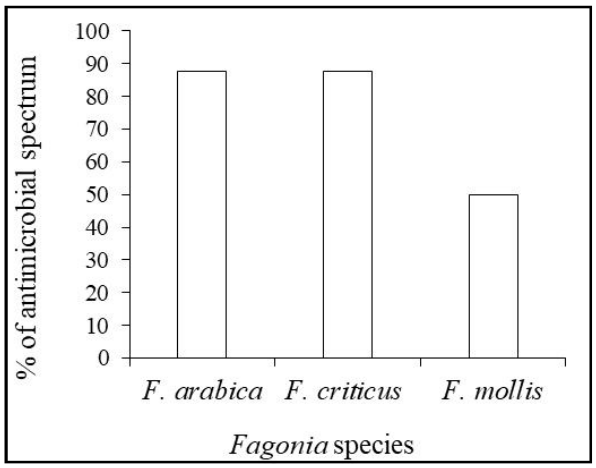

Fig. 2: % of antimicrobial spectrum of *Fagonia* species

inhibitory activity against *P. vulgaris* (8 mm).

The results in Table 2 showed that, in case of *F. mollis* the methanol extract inhibit the growth of pathogenic bacteria with different rates except *S. aureus*, *P. aeruginosa* and *P. vulgaris*. The tested bacteria *B. subtillis* and *Pseudomonas aeruginosa* were the most potent inhibitor (11 and 10 mm, respectively) while *Escherichia coli* and *K. pneumoniae* showed the lowest sensitivity to plant extracts (9 mm, each). On the other hand, *Candida albicans* is the only fungi used in this experiment, the data showed that the methanolic extracts of *Fagonia arabica* and *F. criticus* exhibited marked effect (9 mm, each), while *F. mollis* extract has no effect on *C. albicans*.

In the present study methanol extract of *F. arabica* and *F. criticus* exhibited broad spectrum (87.5% each) against both Gram-positive bacteria and Gram-negative bacteria Fig. 2, followed by *F. mollis* extract (50%). The pathogen *E. coli* and *S. pyogenes* were the most sensitive bacteria in case of *F. arabica,* while *P. aeruginosa* in case of *F. criticus* and *B. subtillis* in case of *F. mollis.*

Table 2: Inhibition zone diameters (mm) of the crude extract from *Fagonia* species at the concentration of 50 mg ml^{-1}.

Test microorganisms	*Fagonia* spp			p-value
	F. arabica	***F. criticus***	***F. mollis***	
Gram positive bacteria				
Staphylococcus aureus	19±0.24	14±0.13	n.a	0.0000***
Bacillis subtillis	15±0.19	13±0.17	11±0.14	0.15ns
Streptococcus pyogenes	22±0.28	15±0.19	10±0.09	0.0008***
Gram negative bacteria				
Pseudomonas aeruginosa	11±0.14	18±0.23	n.a	0.0000***
Escherichia coli	28±0.36	15±0.19	9±0.11	0.0004***
Proteus vulgaris	n.a	8±0.10	n.a	0.0002***
Klebsiella pneumoniae	8±0.10	n.a	9±0.08	0.0000***
Fungi				
Candida albicans	12±0.15	10±0.13	n.a	0.0000***

n.a: Not active. Values are means ± standard error of triplicates. The significant difference after Duncan's test (P d ≤ 0.05)

Allelopathic activity on the germination and seedling growth of *P. oleracea*:

Fig. 3 shows the allelopathic effects of methanol extracts of three common *Fagonia* species, namely *F. arabica*, *F. criticus* and *F. mollis* after four days treatment (DAT) on *Portulaca oleracea*. The crude extract of the aerial parts from the *Fagonia* species showed significant phytotoxic effect against on the germination and seedling growth of *P. oleracea* Fig. 3 at different concentrations (5–40 mg ml^{-1}) over control. The data obtained indicated that the root system of *P. oleracea* was more affected than the shoot system to the inhibitory allelopathic activity induced by *Fagonia* spp. This could be ascribed to the radicle is the first to emerge and consequently direct contact with the phytotoxic compounds in the extracts (Abd El-Gawad *et al.,* 2018a; Ximenez *et al.,* 2019). At higher concentration (40 mg ml^{-1}) the germination of the tested seed was highly inhibited by 93.20, 86.21 and 76.41 mg ml^{-1}, while the shoot and root were reduced by 82.45, 77.18, 65.97% and 98.71, 89.29, 92.07%, for *F. arabica, F. creticus*

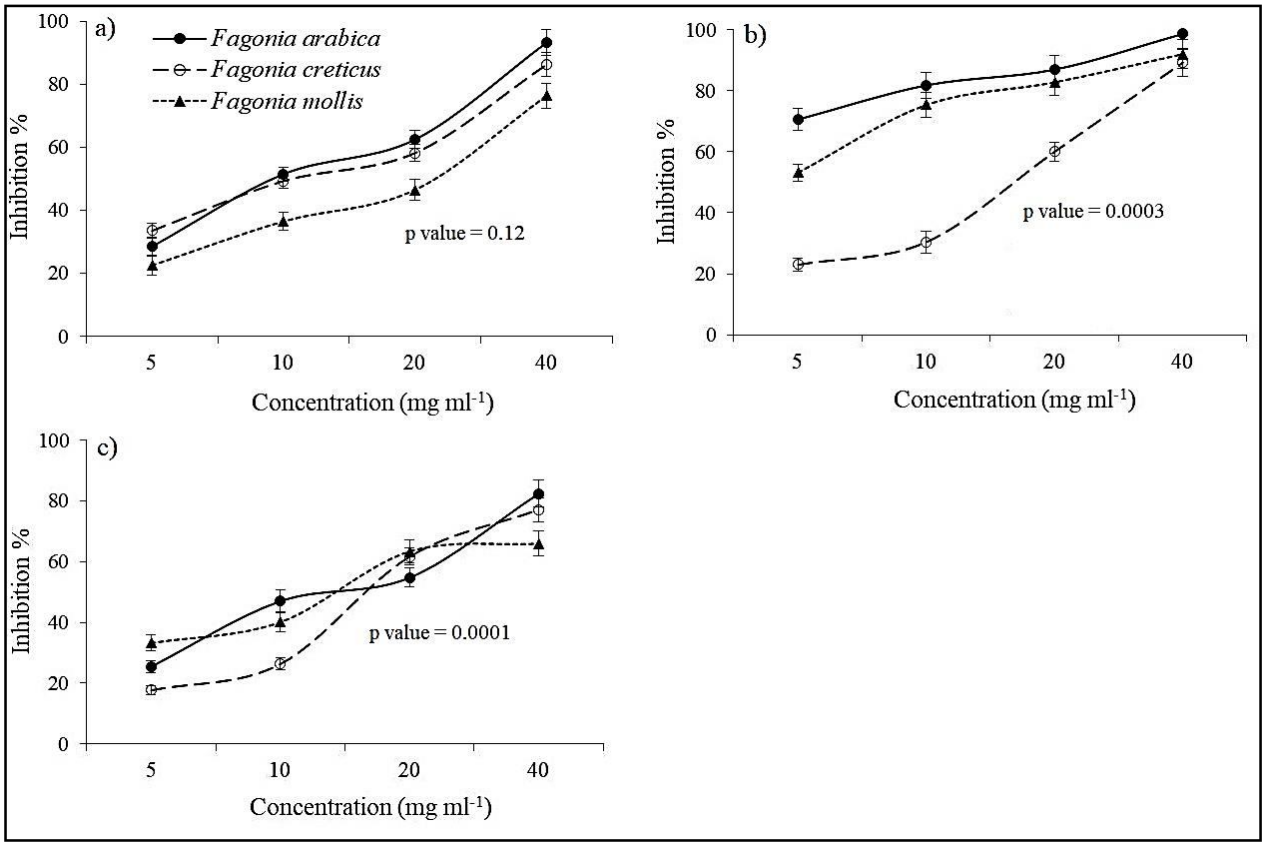

Fig. 3. Allelopathic effect of the crude extract from *Fagonia* species aerial parts on a) germination, b) root length and c) shoot length of *Portulaca oleracea*. The bars indicate a standard error, n = 3. *P-value*: at 0.05 probability level.

and *F. mollis,* respectively Fig. 3. However, the opposite response was observed at the lower concentration (2.5 gl^{-1}).

The previous biological investigation of *Fagonia* spp. reported that different parts of this herb have been used to cure various diseases such as hematological, neurological, endocrinological and inflammatory disorders (Saeed and Wahid, 2003), antioxidant activities (Eman, 2011; Satpute *et al.,* 2012), antibacterial, antifungal and insecticidal effect (Gehlot and Bohra, 2000; Pareek *et al.,* 2012), as well as cytotoxic (Ibrahim *et al.,* 2008), ascribed to the high phenolic contents which exhibited efficient free radical scavenging potential (Shehab *et al.,* 2015). The present results showed the potent allelopathic effect of *Fagonia* species on the nuisance weed *P. oleracea*, which could be ascribed to the high content of phenolics, tannins, and alkaloids. Moreover, the species of *Fagonia* contains saponins (Abdel-Khalik *et al.,* 2001), alkaloids (Sharawy and Alshammari, 2009), terpenoids (Perrone *et al.,* 2007), sterols (Shoeb *et al.,* 1994), flavonoids (Ibrahim *et al.,* 2008), proteins and amino acids (Sharma *et al.,* 2010), coumarins (Zhan *et al.,* 2008), Glycosides and trace elements (Fatima *et al.,* 1999).

The results of the current research against weed *P. oleracea* agree with most of the previous results obtained by other researchers, which confirmed that extracts of many plant species inhibited germination of *P. oleracea* seeds (Azizi *et al.,* 2005; Al-Harbi, 2018; Abd El-Gawad *et al.,* 2018a & 2019).

Conclusion

This study results revealed that *Fagonia* species are rich in secondary metabolites such as flavonoids, alkaloids, and phenolics. Moreover, *F. arabica* was found to be the richest among the other studied *Fagonia* species in total phenol and tannins. *Fagonia* species also serve as a good source for antioxidant and green materials, which have $IC_{50} < 1$. Also, methanolic extract of *F. arabica* and *F. criticus* are recommended to be used against Gram-positive, Gram-negative bacteria, and *Candida albicans*. The crude extract of the aerial parts from the *Fagonia* species showed significant phytotoxic effect against on the germination and seedling growth of *P. oleracea* at different concentrations (5–40 mg ml^{-1}) while the root system was more affected by the inhibitory allelopathic activity of *Fagonia* spp.

References

Abd El-Gawad, A.M. and Y.A. El-Amier (2015). Allelopathy and potential impact of invasive *Acacia saligna* on plant diversity in Deltaic Mediterranean coast of Egypt. *Int. J Environ Res.,* **9(3):** 923-932.

Abd El Gawad, A. M., Y.A. El Amier and G. Bonanomi (2018 a). Allelopathic activity and chemical composition of *Rhynchosia minima* L. D C. essential oil from Egypt. *Chem. Biodiversity,* **15(1):** p.e1700438.

Abd El Gawad, A.M., Y.A. El Amier and G. Bonanomi (2018b). Essential oil composition, antioxidant and allelopathic activities of *Cleome droserifolia* (Forssk.) Delile. *Chem. biodiversity,* **15(12):** p.e1800392.

Abd-El Gawad, A.M., A. I. Elshamy, Y.A. El-Amier, A.G. El Gendy, S.A. Al-Barati, B.A. Dar, S. L. Al-Rowaily and A.M. Assaeed (2019). Chemical composition variations, allelopathic and antioxidant activities of *Symphyotrichum squamatum* (Spreng.) Nesom essential oils growing in heterogeneous habitats. *Arabian J. Chem.,* **12(6):** in press.

Abdel-Khalik, S.M., T. Miyase, F.R. Melek and H.A. El-Ashaal (2001). Further saponins from *Fagonia cretica*. *Pharmazie,* **56:** 247-250.

Alghanem, S.M. and Y.A. El-Amier (2017). Phytochemical and biological evaluation of *Pergularia tomentosa* L. (Solanaceae) naturally growing in arid ecosystem. *Int. J. Plant Sci. Eco.,* **3:** 7-15.

Alonso-Amelot, M.E. (2018). Milk as a Natural Product: Foreign Natural and Anthropogenic Organic Compounds in It. *In Stu. Nat. Prod. Chem.,* **56:** 335-435.

Al-Wakeel, S.A. and A.M. Shahnaz (1992). Significance of flavonoid chemistry in the Egyptian *Fagonia glutinosa* and *F. isothricha* complex. *Biochem. Sys. Eco.,* **20:** 259-264.

Azizi, M. and Y. Fuji (2005). Allelopathic effect of some medicinal plant substances on seed germination of *Amaranthus retroflexus* and *Portulaca oleraceae*. In I International Symposium on Improving the Performance of Supply Chains in the Transitional Economies. 699 (pp.61-68).

Al-Harbi, N.A. (2018). Allelopathic effect of leaf extract of two wild plants on seed germination, shoot and root length of two weed species; *Portulaca oleracea* and *Chenopodium murale*. *Biosciences Biotechnology Research Asia,* **15(4):** 929-935.

Boulos, L. (2000). Flora of Egypt, Vol. 2. Al Hadara Publishing, Cairo, Egypt.

Cappuccino, J.G. and N. Sherman (2008). Microbiology a laboratory manual, Pearson / Benjamin Cummings.

Castillo, R.M., E. Stashenko and J.E. Duque (2017). Insecticidal and repellent activity of several plant-derived essential oils against *Aedes aegypti*. *J. Am. Mosq. Cont. Assoc.,* **33(1):** 25-36.

Chlopicka, J., P. Pasko, S. Gorinstein, A. Jedryas and P. Zagrodzki (2012). Total phenolic and total flavonoid content, antioxidant activity and sensory evaluation of pseudocereal breads. *LWT – Food Sci. Technol.,* **46:** 548-555.

Cseke, L.J., A. Kirakosyan, P.B. Kaufman, S. Warber, J.A. Duke and H.L. Brielmann (2016). Natural products from plants. CRC press.

Djeridane, A., M. Yousfi, B. Nadjemi, D. Boutassouna, P. Stocker and N. Vidal (2006). Antioxidant activity of some Algerian medicinal plants extracts containing phenolic compounds. *Food Chem.,* **9:** 654–660.

Edeoga, H.O., D.E. Okwu and B.O. Mbaebie (2005). Phytochemical constituents of some Nigerian medicinal Plants. *Afri. J. Biotech.,* **4(7):** 685-688.

El-Amier, Y.A., A.M. Abdelghany and A. Abed Zaid (2014). Green synthesis and antimicrobial activity of *Senecio glaucus*-mediated silver nanoparticles. *Res. J. Pharm. Biol. Chem. Sci.,* **5(5):** 631-642.

El-Amier, Y.A., O.N. Al-hadithy and T.J. Abdullah (2016). Antioxidant and antimicrobial activity of different extracts obtained from aerial parts of *Urospermum picroides* L. FW from Egypt. *J. Adv. Chem. Sci.,* **2(3):** 299-301.

El-Amier, Y.A., O.N. Al-Hadithy, H.L. Abdulhadi and E.M. Fayed (2016a). Evaluation of antioxidant and antimicrobial activities of *Euphorbia terracina* L. from Deltaic Mediterranean coast, Egypt. *J. Nat. Prod. Res.,* **2(2):** 83–85.

Elshamy, A.I., A.M. Abd ElGawad, Y.A. El Amier, A.E.N.G. El Gendy and S.L. Al Rowaily (2019). Interspecific variation, antioxidant and allelopathic activity of the essential oil from three *Launaea* species growing naturally in heterogeneous habitats in Egypt. *Flav. Frag. J.,* **34(4):** 1–13.

El-Zayat, M.M. (2002). Infusions of *Varthemia montana* (*Jasonia mortana*): Phenolic profile and antioxidant activity. M.Sc. Thesis, Mediterranean Agronomic Institute of Chania, Crete, Greece. pp: 112.

Eman, A.A. (2011). Morphological, phytochemical and biological screening on three Egyptian species of *Fagonia*. *Academia Arena,* **3(1):** 18-27.

Farheen, R., I. Mahmood and R. Parveen (2017). Review of medicinal and bioactive role of genus *Fagonia fuuast*. *FUUAST J. Biol.,* **7(1):** 33-36.þ

Fatima, K., S. Khaula, M.A. Kalhoro and B. Yasmeen (1999). Trace element in indigenous plant of *Rhazya sticta*, *Vinca Roseea*, and *Fagonia cretica*. *Phytochem.,* **42:** 182-183.

Gehlot, D. and A. Bohra (2000). Toxic effects of various plant part extracts on the causal organisam of typhoid fever. *Cur. Sci*., **78:** 7-10.

Ibrahim, L.F., S.A. Kawashty, El-Hagrassy, A.M., M.L. Nassar and T.J. Mabry (2008). A New kaempferol triglycosides from *Fagonia indica,* cytotoxic activity of its extract. *Carb Res.,* **343(1):** 155-158.

Jin, T.Y., K. Saravanakumar and M.H. Wang (2018). In vitro and

in vivo antioxidant properties of water and methanol extracts of linden bee pollen. *Biocat. Agr. Biotechnol.,* **13:** 186-189.

Joshi, A., M. Bhobe and A. Saatarkar (2013). Phytochemical investigation of the roots of *Grewia microcos* Linn. *J. Chem. Pharm. Res.,* **5:** 80-87.

Kamran, S.H., R.M. Shoaib, M. Ahmad, S. Ishtiaq and R. Anwar (2017). Antidiabetic and renoprotective effect of *Fagonia cretica* L. methanolic extract and *Citrus paradise* Macfad. juice in alloxan induced diabetic rabbits. *J. Pharm. Pharmacog. Res.,* **5(6):** 365-380.þ

Miguel, M.G. (2010). Antioxidant activity of medicinal and aromatic plants. *Flav. Frag. J.,* **25:** 291-312.

Obadoni, B.O. and P.O. Ochuko (2001). Phytochemical studies and comparative efficacy of the crude extracts of some homeostatic plants in Edo and Delta States of Nigeria. *Glo. J. Pure Appl. Sci.,* **8:** 203-208.

Pareek, A., N. Batra and M. Goyal (2012). Phytochemical and biological activity of *Fagonia indica*. *Int. Res. J. Pharm.,* **3(6):** 56-59.

Perrone, A., M.A. Masullo, C. Basarello, A.I. Hamed, M.A. Belisario and C. Pizza (2007). Sulfated triterpene derivative from *Fagonia arabica*. *J. Nat. Prod.,* **70:** 584-88.

Rice, E.L. (1972). Allelopathic effect of *Andropogon virginicus* and its persistence in old field. *Am. J. Bot.,* **59:** 752-755.

Roy, A., N. Jauhari and N. Bharadvaja (2018). Medicinal plants as a potential source of chemopreventive agents. in anticancer plants: Natural products and biotechnological implements (pp. 109-139). Springer, Singapore.

Saeed, M.A. and S.A. Wahid (2003). Effects of *Fagonia cretica* L. constituent on various hematological parameters in rabbits. *J. Ethopharmacolo.,* **85:** 195-200.

Satpute, R.M., R.S. Kashyap and H.F. Daginawala (2012). Antioxidant potential of *Fagonia arebica* against the chemical ischemia induced in PC12 cell. *Int. J. Pharm. Res.,* **11(1):** 303-313.

Shakya, A.K. (2016). Medicinal plants: future source of new drugs. *Int. J. Herbal. Medic.,* **4(4):** 59-64.

Sharawy, S.M. and A.M. Alshammari (2009). Checklist of poisonous plant and animal in Aja Mountains, Hilli Region, Saudi Arabia. *Aust. J. Basic Appl. Sci.,* **3:** 2217-25.

Sharma, S., V. Gupta and G. Sharma (2010). Phytopharmacology of *Fagonia indica* L. a review. *J. Nat. Cons.,* **1:** 143-7.

Shehab, N.G., E. Abu-Gharbieh and F.A. Bayoumi (2015). Impact of phenolic composition on hepatoprotective and antioxidant effects of four desert medicinal plants. *BMC Compl. Alter. Medic.,* **15(1):** 401-413.

Shoeb, H.A., M.M. Sharada, L.A.X. El-Sayed and E. El-Wakeel (1994). Triterpenoid and sterolglycosides from *Fagonia arabica* L. *Al-Azhar J. Pharm. Sci.,* **13:** 41-48.

Stankovic, M.S. (2011). Total phenolic content, flavonoid concentration and antioxidant activity of *Marrubium peregrinum* L. extracts. *Kragujevac. J. Sci.,* **33:** 63-72.

Tackholm, V. (1974). Students' Flora of Egypt. 2nd Edition, Cairo Univ. Press.

Tohidi, B., M. Rahimmalek and A. Arzani (2017). Essential oil composition, total phenolic, flavonoid contents, and antioxidant activity of *Thymus* species collected from different regions of Iran. *Food Chem.,* **220:** 153-161.

Van-Buren, J.P. and W.B. Robinson (1969). Formation of complexes between protein and tannic acid. *J. Agri. Food Chem*., **17:** 772-777.

Ximenez, G.R., S.M.O. Santin, M.C. Ignoato, L.A. Souza and L.H. Pastorini (2019). Phytotoxic potential of the crude extract and leaf fractions of *Machaerium hirtum* on the initial growth of *Euphorbia heterophylla* and *Ipomoea grandifolia*. *Planta Daninha,* **37:** e019180433.

Zahran, M.A. and Y.A. El-Amier (2014). Ecology and establishment of fiber producing taxa naturally growing in the Egyptian deserts. *Egyp. J. Basic Appl. Sci.,* **1(3-4):** 144-150.

Zahran, M.A. and Y.A. El-Amier (2013). Non-traditional fodders from the halophytic vegetation of the deltaic Mediterranean coastal desert, Egypt. *J. Biol. Sci.,* **13(4):** 226-233.

Zaki, A.A., Z. Ali, Y.A. El Amier and I.A. Khan (2016a). A new lignan from *Zygophyllum aegyptium*. *Mag. Reso. Chem.,* **54(9):** 771-773.

Zaki, A.A., Z. Ali, Y.A. El-Amier and I.A. Khan (2016b). A New Neolignan from *Panicum turgidum*. *Natl. prod. Comm.,* **11(7):** p.1934578X1601100729.

Zaki, A.A., S.A. Ross, Y.A. El-Amier and I.A. Khan (2018). New flavans and stilbenes from *Cyperus conglomeratus*. *Phytochem. Let.,* **26:** 159-163.

Zhan, W., K. Krohn, S. Draeger and B. Schulz (2008). Bioactive isocoumarins isolated from the endophytic fungus Microdochium bolleyl. *J. Nat. Prod.,* **71:** 1078-81.

Zuin, V.G. and L.Z. Ramin (2018). Green and sustainable separation of natural products from agro-industrial waste: Challenges, potentialities, and perspectives on emerging approaches. In Chemistry and Chemical Technologies in Waste Valorization (pp. 229-282). Springer, Cham.