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Phytochemical analysis of selected medicinal plants of Margalla Hills and surroundings

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The present study investigate the qualitative and quantitative analysis of the major bioactive constituents of 13 medicinally important plants, namely *Woodfordia fruticosa*, *Adhatoda vasica*, *Chenopodium ambrosoides*, *Viburnum cotinifolium*, *Euphorbia hirta*, *Vitex negundo*, *Peganum harmala*, *Broussonetia papyrifera*, *Taraxacum officinale*, *Urtica dioica*, *Verbascum thapsus*, *Caryopteris grata* and *Mimosa rubicaulis* collected from different localities of Margalla Hills, Islamabad Pakistan, for their authentication. Alkaloids, saponins, tannins, anthraquinones, flavonoids, flavons, flavonols and chalcones, terpenoids, phlobatanins, coumarins, steroids and cardiac glycosoides were analyzed qualitatively where as alkaloids, flavonoids, tannins, phenols and saponins were analysed quantitatively too. In *W. fruticosa* and *V. cotinifolium*, all the constituents were detected except coumarins and steroids. All the constituents were detected in *A. vasica*, *C. ambrosoides* and *P. harmala* except anthraquinones, coumarins, steroids and terpenoids. *V. negundo* exhibited all the studied phytochemicals except coumarins, steroids and phlobatanins. Maximum alkaloid content (1.13%) was recorded in *A. vasica* followed by *P. harmala* (1.11%), *W. fruticosa* (1.036%) and *V. cotinifolium* (0.90%). Maximum (0.87%) phenolic content was observed in methanolic extract of *W. fruticosa*. Tannin content was recorded maximum (15.75%) in *M. rubicaulis* followed by *W. fruticosa* (14.16%), *C. grata* (13.4%), *V. cotinifolium* (12.33%), *E. hirta* (11.2%), *B. papyrifera* (10.56%) and *P. harmala* (10.2%). Maximum flavonoid content (10.95%) was observed in *V. negundo*. Maximum saponin content (5.06%) was recorded in methanolic extract of *T. officinale*.

Key words: Medicinal plants, Margalla Hills, qualitative, quantitative analysis.

INTRODUCTION

Medicinal plants are the plants or their parts used for the health care. They probably constitute a single larger functional group of the plants globally. According to an estimate, 120 or so plant based drugs prescribed for use through the world come from just 95 plant species (Lewington, 1990). This group approximately consists of 30,000 species belonging to 5000 genera and more than 1000 families and sub-families. They occupy a wide altitude ranging from the Great Tibetan Plateau down to

the sea coastal areas including aquatic plants and lower plants like fungi and lichens (Shankar, 1998). The use of medicinal plants as traditional medicine is well known in rural areas of the many developing countries (Sandhu and Heinrich, 2005). Mitscher et al. (1987) reported that the higher plants show a potential source for the new antimicrobial agents. Natural antimicrobials can be derived from plants, animal tissues and microorganisms (Zaika, 1975). The shortcomings of the drugs available today propel the discovery of new pharmacotherapeutic agents from medicinal plant research (Cordell, 1993). In order to promote the use of herbal medicines and the determination of their potentials, the studies of

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medicinal plants should be more intensified especially those used as folk medicines (Ali, 2001; Nair et al., 2005). Chemicals present universally in all the plants can be classified as primary and secondary metabolites. Primary metabolites include proteins, amino acids, sugars, purines and pyrimidines of nucleic acids, chlorophylls etc., while secondary phytochemicals are alkaloids to terpenoids and acetogenins to different phenols.

The qualitative and quantitative distribution of these metabolites differs from plant to plant and part to part. Alkaloids found in low concentrations relative to the phenolic compounds are offset by their high biological potency in vegetative tissues. Besides this, alkaloids are found in higher concentration in storage tissues (roots, fruits and seeds) as compared to the green leaves (Walton and Brown, 1998). Alkaloids and glycosides are complex chemical substances and are distributed in large varieties of the plants throughout the plant kingdom. Many of these alkaloids and glycosides are poisonous but still many are harmless and possess medicinal properties if used in little amount. The amount of poisonous substances varies considerably from species to species and even from plant to plant, depending on the age and various ecological and climatic factors (Baquar, 1989).

Plants have limitless ability to synthesize aromatic substances, mostly phenols or their oxygen-substituted derivatives (Geissman, 1963). Most of the natural products are secondary metabolites and about 12,000 of such products have been isolated so far. These products serve as plant defense mechanisms against predation by microorganisms, insects and herbivores (Fransworth and Morris, 1976).

MATERIALS AND METHODS

Phytochemical analysis

Chemical tests for the screening and identification of bioactive chemical constituents in the medicinal plants under study were carried out in extracts as well as powder specimens using the standard procedures as described by Sofowara (1993), Trease and Evans (1989) and Harborne (1973).

Qualitative analysis

Preparation of reagents

Preparation of Maeyer's reagent: 0.355 g of mercuric chloride was dissolved in 60 ml of distilled water. 5.0 g of potassium iodide was dissolved in 20 ml of distilled water. Both solutions were mixed and volume was raised to 100 ml with distilled water.

Preparation of Dragendorff's reagent: Solution A: 1.7 g of basic bismuth nitrate and 20 g of tartaric acid were dissolved in 80 ml of distilled water. Solution B: 16 g of potassium iodide was dissolved in 40 ml of distilled water. Both solutions (A and B) were mixed in 1:1 ratio.

Test for alkaloids

0.5 to 0.6 g of the methanolic plant extract was mixed in 8 ml of 1% HCl, warmed and filtered. 2 ml of the filtrate were treated separately with both reagents (Maeyer's and Dragendorff's), after which it was observed whether the alkaloids were present or absent in the turbidity or precipitate formation.

Test for saponins

0.5 g of the methanolic plant extract was dissolved in boiling water in a test tube. Test cooling aqueous extracts were mixed vigorously to froth and the height of the froth was measured to determine the saponin contents in the sample.

2.0 g of the powdered plant material was boiled in distilled water in a test tube in boiling water bath and filtered. 10 ml of the filtrate was mixed with 5 ml of distilled water and was shaken vigorously to the formation of stable persistent froth. The frothing was mixed with 3 drops of olive oil and shaken vigorously for the formation of emulsion thus a characteristic of saponins.

Test for anthraquinones

1.0 g of methanolic plant extract was boiled in 6 ml of 1% HCl and filtered. The filtrate was shaken with 5 ml benzene and the benzene layer was removed. 10% NH_4OH was added and the colour in the alkaline phase was observed. Formation of pink/violet or red colour indicated the presence of anthraquinones.

Test for coumarins

0.5 g of the moistened methanolic plant extract was taken in a test tube. The mouth of the tube was covered with filter paper treated with 1 N NaOH solution. Test tube was placed for few minutes in boiling water and then the filter paper was removed and examined under the UV light for yellow fluorescence indicated the presence of coumarins.

Test for sterols and terpenes

0.5 g of methanolic plant extract was shaken with petroleum ether in order to remove the colouring material. Residue was extracted with 10 ml chloroform and the chloroform layer was dried over anhydrous sodium sulphate. 5 ml of chloroform layer was mixed with 0.25 ml of acetic anhydride and then two drops of concentrated sulphuric acid was added. Different colours were observed to indicate the presence of sterol or terpenes. Green colour indicated the presence of sterols while pink to purple terpenes and triterpenes.

Test for steroids

0.5 g of the methanolic extract fraction of each plant was mixed with 2 ml of acetic anhydride followed by 2 ml of sulphuric acid. The colour changed from violet to blue or green in some samples indicated the presence of steroids.

Test for terpenoids (Salkowski test)

5 ml of each plant extract was mixed in 2 ml of chloroform followed by the careful addition of 3 ml concentrated (H_2SO_4). A layer of the

reddish brown colouration was formed at the interface thus indicating a positive result for the presence of terpenoids.

Test for flavonoids

0.5 g of the methanolic plant extract was shaken with petroleum ether to remove the fatty materials (lipid layer). The defatted residue was dissolved in 20 ml of 80% ethanol and filtered. The filtrate was used for the following tests:

(a) 3 ml of the filtrate was mixed with 4 ml of 1% aluminium chloride in methanol in a test tube and the colour was observed. Formation of yellow colour indicated the presence of flavonols, flavones and chalcones.

(b) 3 ml of the filtrate was mixed with 4 ml of 1% potassium hydroxide in a test tube and the colour was observed. A dark yellow colour indicated the presence of flavonoids (Sofowara, 1993; Harborne, 1973).

(c) 5 ml of the dilute ammonia solution was added to the portion of the aqueous filtrate of each plant extract followed by the addition of concentrated H_2SO_4 . The appearance of the yellow colouration indicated the presence of flavonoids.

(d) Few drops of 1% aluminium solution were added to the portion of each filtrate, a yellow colouration was observed thus indicating the presence of flavonoids.

(e) A portion of powdered plant in each case was heated with 10 ml of ethyl acetate in a test tube over a steam bath for 3 min. The mixture was filtered and 4 ml of the filtrate was shaken with 1 ml of dilute ammonia solution. Yellow coloration was observed thus indicating the presence of flavonoids.

Test for tannins

0.25 g of the methanolic plant extract was dissolved in 10 ml distilled water and filtered. 1% aqueous Iron chloride ($FeCl_3$) solution was added to the filtrate. The appearance of intense green, purple, blue or black colour indicated the presence of tannins in the test samples.

Test for phlobatannins

Aqueous fraction of the methanolic extract of each plant was boiled with 1% aqueous hydrochloric acid, resulted in the formation of red precipitate thus indicated the evidence for the presence of phlobatannins.

Test for cardiac glycosides (Keller-Killani test)

5 ml of each methanolic plant extract was mixed with 2 ml of glacial acetic acid containing one drop of ferric chloride ($FeCl_3$) solution, followed by the addition of 1 ml concentrated sulphuric acid. Brown ring was formed at the interface which indicated the presence of deoxysugar of cardenoloides. A violet ring may appear beneath the brown ring, while in the acetic acid layer, a greenish ring may also form just gradually throughout the layer.

Quantitative analysis

Alkaloid determination using Harborne (1973) method

The sample was weighed into a 250 ml beaker and 200 ml of 10% acetic acid in ethanol was added. Beaker was covered and allowed to stand for 4 h. Then it was filtered and the extract was concentrated on a water bath to one quarter of its original volume.

Concentrated ammonium hydroxide was added drop wise to the extract until the precipitation was complete. The whole solution was allowed to stand till its settlement. The precipitate was easily collected from the solution and was washed with dilute ammonium hydroxide and filtered. The residue was the alkaloid which was weighed after complete dryness and the percentage was calculated.

Tannin determination by Van-Burden and Robinson (1981) method

500 mg of the sample in each case was taken in a plastic bottle, and 50 ml of distilled water was added. Then it was shaken in a mechanical shaker for 1 h, and filtered in a 50 ml volumetric flask made up to the mark. 5 ml of the filtrate was pipetted out into the test tube and mixed with 2 ml of 0.1 M $FeCl_3$ in 0.1 N HCl and 0.008 M $K_4Fe(CN)_6$ (potassium ferrocyanide). The absorbance was measured at 120 nm with in 10 min.

Saponin determination by (Obadoni and Ochuko, 2001)

20 g of each grounded sample was put into a conical flask and 100 cm^3 of 20% aqueous ethanol was added. Then the flask was heated on a hot water bath for 4 h. with constant stirring at about 55°C. The mixture was then filtered and the residue was again extracted with another 200 ml 20% ethanol. The combined extract was reduced to 40 ml on a hot water bath at about 90°C. The concentrate was transferred into a 250 ml separatory funnel, added 20 ml diethyl ether in it followed by vigorous shaking. The aqueous layer was recovered while the ether layer was discarded. The purification process was repeated. 60 ml of n-butanol was added. The combined n-butanol extracts were washed twice with 10 ml of 5% aqueous sodium chloride. The remaining solution was heated in a water bath. After evaporation the samples were dried in oven, weighed and saponin content was calculated as percentage.

Determination of total phenols by spectrophotometric method

2 g of each plant sample was defatted with the help of 100 ml of diethyl ether using a soxhlet apparatus for 2 h. The fat free sample was boiled with 50 ml of ether for 15 min for the extraction of phenolic component. 5 ml of the extract was pipetted into a 50 ml flask and 10 ml distilled water was added. 2 ml of ammonium hydroxide solution and 5 ml of concentrated amylalcohol were also added in it. The samples were made up to mark and left to react for 30 min. Colour was developed and its absorbance was measured at 505 nm.

Flavonoid determination by the method of Bohm and Kocipai-Abyazan (1994)

10 g of each plant sample was extracted with 100 ml of 80% aqueous methanol repeatedly at room temperature. The whole solution was filtered through Whatman filter paper # 42 (125 mm). The filtrate was later transferred into a crucible and evaporated into dryness over a water bath, the weight of the material and percentage quantity was calculated.

RESULTS AND DISCUSSION

Qualitative analysis of selected medicinal plants

Tables 1 and 2 show the phytochemical analysis of

Table 1. Qualitative analysis of selected medicinal plants.

Class of compounds	<i>W. fruticosa</i>	<i>A. vasica</i>	<i>C. ambrosoides</i>	<i>V. cotinifolium</i>	<i>E. hirta</i>	<i>V. negundo</i>
Alkaloids	+++	+++	+++	+++	+	++
Saponins	+	+	+	+	+	+
Tanins	+	+	+	+	+	+
Anthraquinones	+	-	-	+	-	+
Coumarins	-	-	-	-	-	-
Flavonoids	Dark yellow	Dark yellow	Dark yellow	Dark yellow	Dark yellow	Dark yellow
Flavones, flavonols, chalcones	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Steroids	-	-	-	-	Green	-
Terpenoids	Pink to purple	-	-	+	-	Pink to purple
Phlobatanins	+	+	+	+	-	-
Cardiac glycosides	+	+	+	+	+	+

+++; Strongly positive, ++; moderately positive, +; weakly positive, -; negative, green; steroids positive, pink to purple; terpenoids positive, dark yellow; flavonoids positive, yellow; flavones, flavonols and chalcones positive.

Table 2. Qualitative analysis of selected medicinal plants.

Class of compounds	<i>P. harmala</i>	<i>B. papyrifera</i>	<i>T. officinale</i>	<i>U. dioica</i>	<i>V. thapsus</i>	<i>C. grata</i>	<i>M. rubicaulis</i>
Alkaloids	+++	++	-	+	+	+	+
Saponins	+	+	+	-	-	+	+
Tanins	+	+	-	+	+	+	+
Anthraquinones	-	-	-	+	+	+	-
Coumarins	-	-	-	-	-	-	+
Flavonoids	Dark yellow	Yellow	Dark yellow	Dark yellow	Dark yellow	Dark yellow	Dark yellow
Flavones, flavonols, chalcones	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Steroids	-	Green	-	-	-	Green	-
Terpenoids	-	Pink to purple	-	Pink to purple	Pink to purple	Pink to purple	Pink to purple
Phlobatanins	+	+	+	+	-	+	+
Cardiac glycosides	+	+	+	+	+	+	-

+++; Strongly positive, ++; moderately positive, +; weakly positive, -; negative, green; steroids positive, pink to purple; terpenoids positive, dark yellow; flavonoids positive, yellow; flavones, flavonols and chalcones positive.

different chemical constituents of selected plant species under study on qualitative basis.

Alkaloids, saponin, tannin, anthraquinones, flavonoids, flavones, flavonols and chalcones, terpenoids, phlobatanins and cardiac glycosides were present in *Woodfordia fruticosa* but coumarins and steroids were found absent. In *Adhatoda vasica*, *Chenopodium ambrosoides* and *Peganum harmala*, all the chemical constituents were present except anthraquinones, coumarins, steroids and terpenoids. *Viburnum cotinifolium* showed the presence of all the constituents except coumarins and steroids. In *Euphorbia hirta* all the constituents were present except anthraquinones, coumarins, terpenoids and phlobatanins. *Vitex negundo* showed the presence of all the constituents studied except coumarins, steroids and phlobatanins. In *Broussonetia papyrifera*, all the constituents except anthraquinones and coumarins were present. In *Taraxacum officinale* saponins, flavonoids, flavones, flavonols, chalcones, phlobatanins and cardiac glycosides were present while alkaloids, tannins, anthraquinones, coumarins, steroids and terpenoids were found absent. In *Urtica dioica*, saponins, coumarins and steroids were absent and all others were present. In *Verbascum thapsus*, saponins, coumarins, steroids and phlobatanins were absent while all the other constituents were present. In *Caryopteris grata* only coumarins was absent and all the other chemical constituents studied were present. In *Mimosa rubicaulis*, anthraquinones, steroids and cardiac glycosides were absent and all others present.

The analysis revealed that coumarins was absent in all the plant species except *M. rubicaulis*. Alkaloids were present in all the species except *T. officinale*. Flavonoids, flavones, flavonols and chalcones were present in all the species studied. Tannin was found present in all the species except *T. officinale*. In analysis ranking, *W. fruticosa* = *V. cotinifolium* and *A. vasica* = *C. ambrosoides*. Steroids were absent in all the species except *E. hirta*, *B. papyrifera* and *C. grata*. Cardiac glycosides were present in all the species except *M. rubicaulis*. Alkaloids showed strong positive reaction in *W. fruticosa*, *A. vasica*, *C. ambrosoides*, *V. cotinifolium* and *P. harmala*, moderate positive reaction in *V. negundo* and *B. papyrifera* and weakly positive reaction in *E. hirta*, *U. dioica*, *V. thapsus*, *C. grata* and *M. rubicaulis*. Tannins, anthraquinones, phlobatanins and cardiac glycosides showed weak positive reaction in all the species studied qualitatively (Tables 1 and 2).

Mojab et al. (2003) studied alkaloids, flavonoids and tannins in many plants and found that these chemical constituents were found in sufficient amount among the studied plants. Hadi and Bremner (2001) studied alkaloids in 100 plant species and the result percentage was 37. Djordje et al. (2007) quantitatively analysed the total polyphenols, tannins, proanthocyanidins and flavonoids in 20 Serbian and Chinese cultivars of

Soybean (*Glycine max* L.). Njoku and Akumefula (2007) studied the phytochemical and nutrient evaluation of *Spondias mombin* leaves and reported the qualitative and quantitative analysis of various groups of chemical constituents, minerals and vitamins. The present study regarding the qualitative analysis of the selected medicinal plants is in agreement with the previous findings of the various researchers.

Quantitative analysis of selected medicinal plants

Medicinal plants are of prime importance to the health of individuals and communities and the medicinal values of these economically important plant species is due to presence of some chemical substances which produce a definite physiological action on human body like alkaloids, tannins, flavonoids and saponin etc. (Edeoga et al., 2005). These plants are used as sources of spices and food. During present investigation, the phytochemicals were estimated in 13 selected medicinal plant species collected from Margalla Hills.

The results presented in Table 3 revealed that maximum alkaloid content (1.13%) was recorded in *A. vasica* followed by *P. harmala* (1.11%), *W. fruticosa* (1.036%) and *V. cotinifolium* (0.90%) respectively as compared to other plant species. The ranking of selected medicinal plants on the basis of their alkaloid content was as follows: *A. vasica* > *P. harmala* > *W. fruticosa* > *V. cotinifolium* > *V. negundo* > *C. ambrosoides* > *E. hirta* > *B. papyrifera* = *M. rubicaulis* > *U. dioica* > *V. thapsus* = *C. grata* > *T. officinale*. The *T. officinale* was the only plant species with no alkaloid content.

The results revealed that maximum (0.87%) phenolic percentage was observed in methanolic extract of *W. fruticosa*. Next to *W. fruticosa*, the maximum phenolic percentage (0.81%) was recorded in *V. negundo* followed by *V. cotinifolium* (0.7%), *U. dioica* (0.65%), *T. officinale* (0.6%), *E. hirta* (0.34%), *M. rubicaulis* (0.26%), *C. ambrosoides* (0.22%), *C. grata* and *B. papyrifera* (0.20%), *P. harmala* (0.16%) and *V. thapsus* (0.09%) (Table 3).

The tannin content was recorded in all selected medicinal plant species except *T. officinale*. Maximum quantity of tannin was observed in *M. rubicaulis* (15.75%) followed by *W. fruticosa* (14.16%), *C. grata* (13.4%), *V. cotinifolium* (12.33%), *E. hirta* (11.2%), *B. papyrifera* (10.56%) and *P. harmala* (10.2%), respectively. While in the remaining plant species, the tannin content was recorded less than 10% (Table 3).

The flavonoid content was found in all selected medicinal plant species. However, the flavonoid content was different among the selected plant species. The maximum flavonoid content (0.95%) was observed in *V. negundo* while minimum flavonoid content (0.15%) was recorded in *E. hirta*. According to flavonoid content, the selected medicinal plant species were ranked as:

Table 3. Quantitative analysis of selected medicinal plants collected from Margalla Hills. The data represents mean of three replicates.

Plant species	Alkaloids (%)	Phenols (%)	Tannin (%)	Flavonoids (%)	Saponin (%)
<i>Woodfordia fruticosa</i>	1.036±0.02	0.87±0.00	14.16±0.12	0.94±0.00	3.83±0.02
<i>Adhatoda vasica</i>	1.13±0.01	0.13±0.01	6.13±0.08	0.21±0.01	2.09±0.10
<i>Chenopodium ambrosoides</i>	0.82±0.02	0.22±0.00	5.43±0.21	0.53±0.00	1.8±0.01
<i>Viburnum cotinifolium</i>	0.90±0.04	0.7±0.015	12.33±0.18	0.86±0.00	4.53±70.10
<i>Euphorbia hirta</i>	0.75±0.01	0.34±0.01	11.2±0.11	0.15±0.00	0.55±0.00
<i>Vitex negundo</i>	0.86±0.00	0.81±0.01	9.39±0.08	0.95±0.01	3.03±0.08
<i>Peganum harmala</i>	1.11±0.04	0.16±0.00	10.2±0.11	0.33±0.01	4.8±0.05
<i>Broussonetia papyrifera</i>	0.74±0.01	0.2±0.005	10.56±0.23	0.58±0.00	1.53±0.01
<i>Taraxacum officinale</i>	ND*	0.6±0.251	ND*	0.29±0.00	5.06±0.12
<i>Urtica dioica</i>	0.49±0.01	0.65±0.02	8.08±0.05	0.59±0.00	ND*
<i>Verbascum thapsus</i>	0.44±0.01	0.09±0.00	7.6±0.15	0.3±0.00	ND*
<i>Caryopteris grata</i>	0.44±0.01	0.20±0.01	13.4±0.05	0.77±0.02	3.38±0.02
<i>Mimosa rubicaulis</i>	0.74±0.02	0.26±0.00	15.75±0.04	0.87±0.01	3.06±0.03

(ND* Not detected).

V. negundo > *W. fruticosa* > *M. rubicaulis* > *V. cotinifolium* > *C. grata* > *U. dioica* > *B. papyrifera* > *C. ambrosoides* > *P. harmala* > *V. thapsus* > *T. officinale* > *A. vasica* > *E. hirta* (Table 3).

The saponin was absent in *V. thapsus* and *U. dioica*. The maximum (5.06%) saponin content was recorded in methanolic extract of *T. officinale* while the *E. hirta* possessed the minimum (0.55%) saponin content. The methanolic extract of *P. harmala* possessed 4.8%, *V. cotinifolium* had 4.53% while *W. fruticosa* exhibited 3.83% saponin content (Table 3).

The results further revealed that alkaloids and tannins were absent in methanolic extract of *T. officinale* but it exhibited higher quantities of saponin. Nonetheless, saponin was absent in *U. dioica* but it possessed higher quantities of tannins.

Thappa et al. (1996) studied the alkaloid content of *A. vasica* and reported two new alkaloid pyrroloquinazoline alkaloids, namely 1,2,3,9-tetrahydropyrrolo(2,1-b)-quinazolin-9-one-3*R*-hydroxy-3(2'-dimethylamino phenyl) (desmethoxyaniflorine) and 7-methoxy - 3*R* - hydroxyl - 1, 2, 3, 9 - tetrahydropyrrolo - [2, 1 - b] - quinazolin - 9 - one (7 methoxyvasicinone) from leaves. Similarly, Edeoga et al. (2005) isolated alkaloids from leaves of some Nigerian medicinal plants and evaluated their biological activities. Chakraborty and Brantner (1999) characterized several alkaloids extracted from stem bark of *Holarrhena pubescens* for their antibacterial activity. They further stated that they tested the methanolic extract for its antibacterial efficacy against *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Streptococcus faecalis*, *Bacillus subtilis*, *Escherichia coli* and *Pseudomonas aeruginosa*. The crude methanolic extract was active against all tested bacteria. Further chemical fractionation indicated that the antibacterial activity was mainly associated with the alkaloids. In this study all the selected medicinal plant species collected

from Margalla Hills possessed alkaloid content and therefore, could be a good source of alkaloids particularly *A. vasica*, *P. harmala*, *W. fruticosa* and *V. cotinifolium* and these plant species were also found with higher antibacterial activity.

Tawaha et al. (2007) studied the total phenolic content of selected Jordanian plant species and established that antioxidant activity was closely correlated with phenolic content. Therefore, they concluded that phenolic compounds were the major antioxidant machinery in the investigated plant species. During the present work, it was found that *W. fruticosa* exhibited higher antioxidant activity with higher phenolic content. These findings are in agreement with previous reports that there is linear relation between antioxidant activity and total phenolic contents. Therefore, it can be suggested that the phenolic compounds significantly contributed to the antioxidant potential of the selected plant species. These results are in agreement with the previous findings of some research workers who have reported positive correlation between phenolic content and antioxidant activity (Cai et al. 2004).

Vaya and Mahmood (2006) studied flavonoid content in leaf extracts of the three medicinal plants, namely fig (*Ficus carica* L.), carob (*Ceratonia siliqua* L.) and pistachio (*Pistacia lentiscus* L.). They reported that the major flavonoids in Ficus were quercetin and luteolin, while in ceratonia leaves, nine different flavonoids were detected. Flavonoids are important antioxidants and help in removal of oxidative stress. The main drawback with the utilization of synthetic antioxidants is the side effects associated with them when taken *in vivo* (Chen et al. 1992). During the present study, it was found that *V. negundo*, *M. rubicaulis*, *W. fruticosa*, *V. cotinifolium*, *M. rubicaulis* and *C. grata* possessed higher flavonoid content and therefore, could be potential sources of flavonoids.

Kannabiran et al. (2008) studied the antibacterial

activity of saponin extracted from leaves of *Solanum trilobatum*. They reported that there was linear relation with the saponin content and antimicrobial activity. Present study indicated that *T. officinale*, *V. cotinifolium*, *W. fruticosa*, *V. negundo*, *M. rubicaulis* and *C. grata* had higher saponin content with higher antimicrobial potential. Further, the studied plants could be developed as bactericidal drugs to be used as therapeutic agent against microbial infections.

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