DISCUSSION

The present study was undertaken in Sangla Valley; district Kinnaur, Himachal Pradesh, India. The area has high floral diversity with number of plant species due to its unique location. As the area has rough mountainous location with harsh climatic condition, it remains cut off from rest of the part of the state. So, the native people were forced to develop their own indigenous medicine system. Local practitioners of the area have immense knowledge about medicinal plants. However, due to very small income possibilities, the younger generation does not want to pursue this field. As a result, the knowledge of the practitioners remains intact with them. Therefore, the medicinal and aromatic usage of the plants in the valley was felt worth documenting. This was also followed by exploration of antioxidant activities of some selected medicinal plants. The results based on these observations were presented in five sections and discussed here under:

Sangla valley has a rich diversity of medicinal and aromatic plants

An ethnobotanical survey was conducted in Sangla valley, which has varied range of climatic condition and it has rich plant diversity (Singh, 2004; Dutt and Negi, 2007; Negi et al., 2007). The information was gathered about the ethnomedicinal plants used by the tribal community for the treatment of various ailments. The study revealed that the native people of this area still have respect and faith in the amchi system of medicine. During the survey, 80 medicinal and aromatic plants (belonging to 40 families) that are most frequently used by the ethnic people as herbal remedies were identified. Asteraceae was the largest family represented by 10 species. There are many reports supporting Asteraceae as the most dominating family in Kinnaur; Asteraceae holds second, fourth, and seventh position in western Himalaya, eastern Himalaya, and the Flora of British India, respectively (Hooker, 1904; Hara and Hohashi, 1971; Rau, 1975). It is also the most dominant family in Lahaul-Spiti,
Discussion

Bushar Himalaya, and Himachal Pradesh and in the high altitude regions of Western Himalayas and in Sangla valley (Rau, 1975; Nair, 1977; Chowdhery and Wadhwa, 1984; Aswal and Mehrotra, 1994; Chawla et al., 2012; Devi et al., 2014).

Leaves were found to be the most common part used (28 plants) against different ailments. Maximum use of leaves for medicinal purpose indicates their ease of collection in comparison to roots, flowers and fruits (Gurib-Fakim, 2006; Telefo et al., 2011). Another prime reason behind using leaves may be higher medicinal potential due to some active principles with respect to other plant parts (Ghorbani, 2005; Gurib-Fakim, 2006). Local communities of many other places have also been utilising these leaves for different herbal preparations (Srithi et al., 2009; Cakilcioglu and Turkoglu, 2010; Giday et al., 2010; Gonzalez et al., 2010; Kumari et al., 2013). Beside leaves, other parts used were roots (21), seeds and flowers (9 each), rhizome (8), fruits (7), whole plant (6), bark and seed oil (4 each). Out of different life forms present in the area, herb (54) was the most common growth form followed by shrub (12), tree (8) and climber (2). Herb is the most dominant life form present in the area as large portion of landscapes are covered with grasslands. Previous studies show that herb is the most dominant life form present in the high elevation ranges where the diversity of shorter plants such as herbs or shrubs is higher than that of trees as large portion of landscapes are covered with grasslands (Kunwar et al., 2006). Tree diversity is quite less in Western Himalayas probably due to lesser precipitation.

The medicines are prescribed in different forms like powder and decoction, which was followed by paste, oil, raw seeds, juice, root extracts and one each of round pill, wine, flowers, bark, tuber, and tea made of leaves. However, powder and decoction are the most common form of using plants as herbal remedies. But, aforementioned range of preparations were also reported by other workers in their studies (Andrade-Cetto, 2009; Rajkumar and Shivanna, 2009; Srithi et al., 2009; Kumari et al., 2013; Negi et al., 2015). Yet, there are several previous reports available in the literature which indicate that paste is the most important mode of application of medicinal plants used (Giday et al., 2007; Ragupathy et al., 2008; Roosita et al., 2008; Kumari and Singh, 2009).
Discussion

In some cases precautionary measures like the minimum use of chillies, spices or sugar are suggested by local practitioner to avoid any kind of side effects caused by medicinal plants. The present study revealed that different medicinal plants are used against stomach disorders and related ailments. This fact is validated by a study of four common ailments treated by ethnomedicinal plants found in Lahaul-Spiti area (Singh and Lal, 2008). In the present study, valuable information about medicinal plants is reported against number of ailments like cold, cough, stomach ache, cuts, wounds, burns, fever, arthritis, constipation and dysentery.

A number of reports supported the use of Aconitum heterophyllum against stomach disorder and other related issues (Sood et al., 2001; Sharma et al., 2004). Among 80 plant species, Aconitum heterophyllum, Angelica glauca, Arnebia euchroma, Bergenia stracheyi, Bunium persicum, Dioscorea deltoidea, and Sinopodophyllum hexandrum were the most widely used medicinal plants. Fruit juice of Hippophae rhamnoides is recommended to cure disorders related to reproductive system. The study revealed that the maximum numbers of medicinal plants are used to treat gastrointestinal problems. There are plants whose more than one part is used, e.g., Saussurea gossypiphora (Roots and flowers), Saussurea obvallata (Seeds, flowers and roots), Viburnum cotinifolium (Fruits and leaves) and Rumex nepalensis (Roots and leaves).

Results revealed that the status of 12 plant species was threatened. It included 1 Critically endangered: Dactylorhiza hatagirea, 5 Endangered: Aconitum heterophyllum, Picrorhiza kurroa, Betula utilis, Sinopodophyllum hexandrum, Saussurea costus and 6 Vulnerable: Aconitum violaceum, Dioscorea deltoidea, Jurinea dolomiae, Rheum australe, Rhododendron anthropogon, Saussurea obvallata. The habitats of most of the medicinal plants are shrunk due to increase in the human population, expansion of roads, uncontrolled and unscientific harvest, unregulated tourism and construction of new roads. Therefore, there is a decline in the population and availability of these medicinal plants in the Himalayan region (Kala et al., 1998). The overexploitation of Aconitum heterophyllum and Picrorhiza kurroa for commercial purposes has declined their population, and now both are endangered (Singh et al., 2007a). Establishing medicinal plants conservation areas in different parts of Himalayas could be a valuable initiative in the conservation of medicinal
plants (Kala, 2000). Therefore, it is realised that these plants need qualitative and quantitative analysis on regular basis (Clubbe et al., 2010) so that better preservation strategies should be adopted for the conservation and management of these medicinal plants. It can be done by including them under different *ex situ* and *in situ* plant conservation strategies, especially for critically endangered, endangered and rare plant species.

Further, data observed during field surveys were analyzed using three different quantitative analyses: Fidelity level (FL), informant consensus factor (ICF) and use value (UV), to authenticate the data and to have clear picture about different plant species and their usage. The study highlighted that some plants like *Carduus nutans* (0.66), *Artemisia brevifolia* (0.50), *Silene vulgaris* (0.50), *Rhododendron lepidotum* (0.50) and *Asparagus filicinus* (0.40) have high used value. It indicates their unreasonable extraction and excessive use in different ethnomedicinal practices, largely due to their wide availability in the study area. Use value of plant can be associated to their conservation strategies, which were based on the idea that most usable plant species will suffer harvesting pressure and can be related to their scarcity (Chawla et al., 2012). Since their number went down alarmingly, the government of Himachal Pradesh has promoted the cultivation of these ethnomedicinal plants in different nurseries maintained by the forest departments. Whereas, low use value of plant can be related to dynamic change through time and ethnic knowledge about medicinal plants that may not be passing from one generation to other generation with the passage of time so, it is diminishing at very fast pace (Camou-Guerrero et al., 2008). Further, the study was correlated with ICF value and based on different diseases plants were divided in to 18 categories which were computed using use-reports and ranged from 0.5 to 1. Highest FIC value of 1 was calculated for earache and appetizer followed by wounds cuts and snake bite (value of 0.90). Minimum FIC value (0.50) was calculated for Ophthalmology. IFC value is generally based on the traditional knowledge for disease treatment and depended on the availability of plant species in the study area (Rajakumar and Shivanna, 2009). A higher ICF value of plant species recommend that the informants are in accordance to use of certain plant species for particular ailment which increases the effectiveness of plant species (Teklehaymanot and Giday, 2007). Although ICF value of
gastrointestinal system disorders is less compared to other ailment categories, but the maximum numbers of plants are being used under this category citing for treatment of different ailments like stomachache, indigestion, piles, fissures, ulcers, vomiting, colic, dysentery, flatulence, diarrhoea, etc. In contrast, high ICF value for gastrointestinal system disorders have been reported in previous ethnobotanical survey reports (Alzweiri et al., 2011). However, it has also been proposed that the maximum number of plant species were used in the treatment of gastrointestinal system disorders (Heinrich et al., 1992; Sood et al., 2001 Appidi et al., 2008). High ICF value of plant is like a ray of hope, which suggests that plant species may contain some bioactive component that can further be explored for phytochemical analysis (Neves et al., 2009). High ICF value was recorded for different categories in this study, and medicinal tradition is well defined if it has high degree of ICF value (Heinrich, 2000).

Fidelity levels (FL) recorded in plant species differed widely for specific disease. It ranged from 6.25 to 100%. Maximum fidelity level was observed in 19 plant species, which were used in single ailment category with multiple informants. The plants with maximum fidelity level (100%) were Jurinea dolomiaea, Rosa webbiana, Rhododendron lepidotum, Saxifraga diversifolia, Podophyllum hexandrum and Thymus linearis etc. Based on the above quantitative tools, Berberis jaeschkeana was found to be the most important plant to treat dermatological disorder with fidelity level of 83.3%. Cassiope fastigata (with FL 71.4 %) was the most important plant used to treat cuts and burns. Dioscorea deltoidea with FL of 83.3% was most effective against skeletal problem. There are sufficient scientific evidences which showed that these plants are extensively used in many ethnobotanical practices around the world with their therapeutic use (Sood et al., 2001; Singh and Lal, 2008). Study of Ayyanan and Ignacimuthu (2011) shows that plants with high fidelity level gives the indication that they have high healing potential. In relation to plant use it was found that number of medicinal plants traditionally used against various stomach disorders are among the most important ones in the community, and this category has the highest richness of species used accompanied with very high fidelity level. This is similar to studies from other ethnic groups which reveal the use of maximum number of plants for digestive disorders and exhibit their greater importance in rural and poor
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communities (Sood et al., 2001; Alzweiri et al., 2011). Study of Nawash et al. (2013) shows that Mentha longifolia with high fidelity level is used in gastrointestinal system disorders which are in agreement to our study.

**Fatty oils of Prunus armeniaca and P. mira possess antioxidant and radical scavenging potential**

We know that fat is an integral part of our diet (Burr and Burr, 1929). Seed oil has formed the basis of many applications like food preservatives, natural therapies, pharmaceuticals and alternative source of medicine (Reynolds, 1996; Lis-Balchin and Deans, 1997). The modern health care practices are a blend of traditional knowledge that provide effective healthcare services.

As we know that free radicals, generated as a by-product of normal cellular metabolism, are very harmful. Enhanced production of ROS can lead to stress and oxidative damage to body (Abidi and Ali, 1999; Halliwell and Gutteridge, 1999). The free radical scavenging activities of fatty oils were evaluated through their ability to quench or scavenge the synthetic DPPH radical. DPPH is used most frequently in investigating radical scavenging activities because of its ease and convenience of the reaction (Brand-Williams et al., 1995). In the DPPH test, plant extracts and oils are able to reduce stable radical from purple colour to light yellow colour by donating hydrogen and its absorbance can be read at 517 nm. Recently many reports have come up which support that plants are good source of antioxidants and have a tendency to scavenge free radicals without causing any adverse effect (Nuutila et al., 2003; Bakkali et al., 2008).

In the present study, antioxidant activity of fatty oils extracted from *P. armeniaca*, *P. mira* and BHT were studied against DPPH radical as mentioned in section 2. The dose-dependent activity was observed in the study. It was found that positive control BHT exhibits the highest DPPH radical scavenging with 94.5% at 400 µg ml⁻¹ followed by *P. armeniaca* oil with 80.4%, scavenging. However, the scavenging activity was quite less in *P. mira*. Previously, Tian and Zhan (2011) reported that *P. armeniaca* oil has DPPH scavenging effect that increased steadily with increasing concentration and validates our results as similar trend was observed.
Discussion

Gharibzahedi et al. (2013) showed that walnut oil had good scavenging activity against DPPH radical. The antioxidant activities in nut oils are attributed to both phenolic and non-phenolic compounds present in the sample (Savage et al., 1999; Arranz et al., 2008; Miraliakbari and Shahidi, 2008). Furthermore, Tian et al. (2011) studied the DPPH radical scavenging activity of white almond oil and ascorbic acid. The results revealed that DPPH radical scavenging activity of ascorbic acid was more than that of white almond oil. In a similar study, Luffa cylindrica seed oil was found to possess DPPH radical scavenging activity (Prakash et al., 2010).

The oils used in the study also possessed scavenging potential for hydrogen peroxide (H₂O₂). H₂O₂ itself is not a free radical; if some foreign particle triggers, it gives rise to hydroxyl radical that damage cell (Halliwell, 1991). Removal of H₂O₂ is must because it is highly diffusible in nature as it can cross plasma membrane. Therefore, these fatty oil rich in antioxidants can inhibit the reaction by directly reacting with H₂O₂. Out of all positive control, ascorbic acid has maximum scavenging activity of 86.5% at 400 µg ml⁻¹ concentration followed by oil of P. armeniaca, but at lower concentration 25 µg ml⁻¹ oil of P. mira has highest scavenging potential even more than that of positive control ascorbic acid.

The oils used in the study also possessed scavenging potential for hydroxyl radical. Hydroxyl radical, generated by Fenton reaction, is the most unstable free radical found in biological system and has tendency to damage in very large extent (Hochstein and Atallah, 1988). Therefore, exploring sources for the scavenging of this toxic radical has great importance (Zhou et al., 2010). Both P. armeniaca and P. mira has higher hydroxyl radical scavenging activity than that of positive control ascorbic acid at highest concentration (400µg ml⁻¹). These findings are corroborated by similar observations made earlier with Luffa cylindrica seed oil (Prakash et al., 2010) and P. armeniaca (Tian and Zhan, 2011)

The antioxidant activity of plants has been correlated with their reducing potential (Duh, 1998). The reducing ability of the fatty oils was determined in terms of ability to reduce Fe³⁺ to Fe²⁺. The reducing potential of P. armeniaca fatty oil was better than that of P. mira. The present finding is supported by the study of Nagala et al.
(2013) who investigated FRAP of seed oil of five different species of *Artocarpus* and *A. integer* exhibited the highest reducing potential.

Total antioxidant activity (TAA) of fatty oils was expressed in terms of ascorbic acid equivalent. The total antioxidant activity of *P. armeniaca* and *P. mira* at 400 µg ml\(^{-1}\) were 64.9 µg AAE ml\(^{-1}\) and 62.9 µg AAE ml\(^{-1}\) respectively. TAA is an important spectrophotometric method based on the reduction of Mo (V1) to Mo (V) in the presence of antioxidant compounds leading to the formation of green colored phosphate molybdenum (V) complex at acidic pH and at a high temperature. Similar type of study was conducted by Gorinstein *et al.* (2003) on five different types of olives and the highest total antioxidant activity was observed in virgin olive oil.

**Essential oils of some medicinal and aromatic plants of Sangla valley possess antioxidant and radical scavenging potential**

Further, antioxidant and radical scavenging potential of essential oils was explored, essential oils (aromatic oily liquids characterized by strong odor) from aromatic plants are one such source. The studies have shown that essential oils from several plants possess antioxidant and free radical scavenging activities (Burt, 2004; Bakkali *et al.*, 2008; Singh *et al.*, 2009a; Miguel, 2010). The positive control BHT has the maximum scavenging activity at highest concentration, which was followed by *M. longifolia*. But in the case of *C. deodara*, *R. rugosa* and *H. candicans* activity at 400 µg ml\(^{-1}\) are comparable to each other. Similar types of studies have reported the DPPH scavenging activity of essential oils from *Eucalyptus tereticornis* (Kaur *et al.*, 2011b), *Eucalyptus citriodara* (Singh *et al.*, 2012). Gulluce *et al.* (2007) and Mkaddem *et al.* (2009) shows that essential oil of *M. longifolia* possess good DPPH radical scavenging capacity parallel to our findings. Jirovetz *et al.* (2006) found that the DPPH radical scavenging activity of clove oil was greater than that of eugenol, BHT and BHA.

To assess the possible utilization of essential oils, their antioxidant activity was estimated against stable H\(_2\)O\(_2\) radical. It was found that essential oils have good radical scavenging capacity in dose-dependent manner. Out of all test oils, *M. longifolia* has the maximum scavenging activity, both at lower and higher concentration followed by *R. rugosa*. Similar activity was observed in oils of *H.*
candidans and C. deodara at 400 µg ml⁻¹ concentration. H₂O₂ activity is not specific in these essential oils but, there are number of other plants whose essential oils have good H₂O₂ scavenging potential. For example, essential oil obtained from residues of Artemisia scoparia (Singh et al., 2009a), from Thymus vulgaris L. and Ocimum basilicum L. (Bozin et al., 2006). The scavenging activity also varies with stage of maturity of the tissue whose oil has been extracted (Wu et al., 2013). Wu et al. (2013) found that hydrogen peroxide scavenging ability of essential oil obtained from immature fruit was more than that of essential oil extracted from intermediate and mature fruit.

The oils used in the study also possessed good scavenging potential for •OH with more than 50% scavenging at 200 µg ml⁻¹ concentration. The essential oil of M. longifolia has the maximum scavenging potential both at lower and higher concentration, which was followed by C. deodara. In H. candidans and R. rugosa almost comparable activity was observed at 50 µg ml⁻¹ and 100 µg ml⁻¹ concentration. The present study is supported by number of earlier studies that essential oils possess good scavenging potential for •OH radical. The oil extracted from Achillea millefolium exhibited potential to scavenge •OH in the Fe³⁺–EDTA-H₂O₂ deoxyribose system and the capacity was better than the known standards (Candan et al., 2003). The essential oils extracted from the young, mature leaves and plant residues of Artemisia scoparia had a good scavenging capacity for •OH radicals (Singh et al., 2009a). Furthermore Singh et al. (2009b) compared hydroxyl scavenging activities of crude oil extracted from fresh and decaying leaves of Eucalyptus tereticornis and major monoterpenic components like α-pinene, 1,8-cineole, β-citronellal, (−)-isopulegol and (+)-β-citronellol and ascorbic acid. The essential oil of Lycopus lucidus exhibited good scavenging activity towards •OH radical with an IC₅₀ of 1.21 mg/ml (Yu et al., 2011).

Essential oils have good Ferric ion reducing antioxidant power (FRAP) indicating some compounds present in oil were electron donors and could react with free radicals to convert them into more stable products. The C. deodara oil had ~87% activity that was almost comparable to positive control but at 25 µg ml⁻¹ the oils from M. longifolia and R. rugosa have better reducing potential.
Discussion

than that of the positive control (curcumin). All essential oils had attained more than 50% scavenging at 100 µg ml\(^{-1}\). The present results are in agreement with Mohamed et al. (2014) who reported that the reducing power of Commiphora myrrha resin essential oil increased with increasing concentration and reducing potential of essential oil was superior than that of methanolic and ethyl acetate extracts. The results for FRAP activity obtained in this work are in correlation with recent results of other authors like (Sarikurkcu et al., 2009), (Cao et al., 2009) and (Ahmadi et al., 2010). Cavar et al. (2012) demonstrated that essential oil of Artemisia annua has good reducing potential. Shimada et al. (1992) said that the reducing potential may be due to the presence of phenolic compounds such as isothymol and carvacrol. Politeo et al. (2007) reviewed the reducing potential of free volatile aglycones from basil (Ocimum basilicum L.) compared with its essential oil, and the hierarchial order of reducing potential was: eugenol > BHT > basil essential oil > basil volatile aglycones.

The iron chelating activity of all essential oils was studied and it was found that only M. longifolia exhibited iron chelating activity and others did not have any activity towards it. The study results of Sarikurkcu et al. (2010) are in agreement with our findings. It highlighted that the essential oil, hexane and ethyl acetate extracts did not show metal chelating effect. In our study, only the essential oil of M. longifolia has exhibited chelating activity, and an increase in chelation was observed with increasing concentration. Both the essential oil and the positive control have good chelating activity. At lower concentration 25 µg ml\(^{-1}\) the essential oil was more effective than that of positive control, but at higher concentration the activity of the positive control was much more than that of the essential oil.

Though, our observation regarding such an activity for M. longifolia oil contradicts the other oils but there are number of studies to support. As reported in study of Halliwell (1997) bivalent transition metals play a major role in generating free radicals because they act as catalyst; Fe\(^{2+}\) in Fenton reaction acts like a catalyst and form \(\cdot\)OH that can cause many disorder, and lead to the dysfunction of many parts of the body which cannot be repaired. So, in order to remove this chelation, essential oils can play an important role as they are rich in antioxidant activity with
no toxicological concerns linked with their use. Mau et al. (2003) has shown that dried rhizome of Curcuma zedoaria has high iron chelating activity.

The study demonstrated, that essential oils have good total antioxidant activity (TAA) that increased with increasing concentration. Among different essential oils, H. candidans essential oil has the maximum TAA and oil of C. deodara has the least activity. TAA is one of the most widely performed assays to test antioxidant activity due to its ease and convenience. Sarikurkcu et al. (2010), Lazarevic et al. (2011) and Singh et al. (2012) reported TAA of the essential oils of Thymus longicaulis, Allium sphaerocephalon and Eucalyptus citriodora, respectively.

Water extracts of some medicinal and aromatic plants also possess antioxidant and radical scavenging properties

Parallel to fatty oils and essential oils, the aqueous extracts prepared from R. rugosa (PP and RP), H. candidans (PP and RP), M. longifolia (PP and RP), P. armeniaca (F, L and R), P. mira (F, R and L), B. stracheyi (L and R), S. obvallata (L), B. persicum (S), M. spicata (L), A. flavum (L), U. dioica (L), F. tataricum (L and S) and F. esculentum (L and S) also show the radical scavenging activity.

The activity of different aqueous extracts was studied against DPPH radical and it was found that all aqueous extracts possessed significant scavenging activity against DPPH radical. An increase in scavenging was also observed with increasing concentration. Among different aqueous extracts, it was found that the leaf extract of F. tataricum has exhibited maximum scavenging activity of 96.6% at 1% concentration followed by the seed powder extract of F. esculentum with 94.6% activity at same concentration. Although, the root and leaf extract of B. stracheyi possessed good scavenging activity towards DPPH radical. But, the seed powder of F. tataricum exhibited weaker DPPH radical scavenging activity at 1% concentration with respect to all other aqueous extracts. There are numerous reports and studies on the DPPH radical scavenging activity of aqueous extracts on different plants which show similar type of activity.

The DPPH assay is often used to estimate the potential of antioxidants to scavenge free radicals as this assay is known to provide reliable information.
Discussion

about antioxidant activity of tested samples (Huang et al., 2005). Harish and Shivanandappa (2006) and Karagozler et al. (2008) studied the DPPH radical scavenging activity in water extract of Phyllanthus niruri and Dorystoechas hastata. Kubola and Siriamornpun (2008) reported the DPPH radical scavenging activity of various parts (leaf, green fruit, stem and ripe fruit) of Momordica charantia L. against positive control BHT and ascorbic acid, in which the DPPH radical-scavenging activity of ascorbic acid was the highest, followed by BHT, leaf, green fruit, stem and ripe fruit, respectively.

FRAP is often evaluated to check an electron or hydrogen donating ability of natural antioxidant (Shimada et al., 1992). In the present study, the ability of various aqueous extracts to reduce Fe$^{3+}$ to Fe$^{2+}$ was studied. The study highlighted that the aqueous extracts have very high reducing potential. The reducing power of all aqueous extracts increased with increasing concentration. However, reducing power of the P. armeniaca leaf extract was found to be the maximum with 97.4% reducing potential at 1% concentration, followed by the leaf extract of H. candicans and then the fruit extract of P. mira with reducing potential of 94.7% and 94.6%, respectively. But, in the case of F. tataricum seed powder extract, the minimum reducing potential activity was observed.

Many studies have reported on the reducing power of aqueous extracts. A study concomitant to the present study was given by Liu et al. (2012) who demonstrated reducing potential of different extracts of Holotrichia parallela in comparison to positive control $\alpha$-tocopherol and BHT. It was found that the reducing potential of water extract was more than that of ethanolic extract but less than the positive control. Zhenbao et al. (2007) studied the reducing power of different fractions of Cassia tora. Similarly, Kumar et al. (2008) had studied the reducing potential of Kappaphycus alvarezii (Doty) –An edible sea weed, and found that the reducing power of samples decrease in the order: BHT (0.23–0.879) > methanol (0.07–0.74) > ethanol (0.333–0.44) > ethyl acetate (0.013–0.467) > water (0.017–0.193) > hexane (0.017–0.16). The studies of Duh et al. (1997) and Duh (1998) demonstrated that the antioxidant properties of the mung bean hull and burdock extracts were related with development of reducing power.
The ability of aqueous extracts to scavenge $H_2O_2$ was estimated as per the method given by Ruch et al. (1989). Scavenging of $H_2O_2$ by aqueous extracts may be attributed by phenolics present, as they have the ability to donate electron and neutralise $H_2O_2$ in to water (Nabavi et al., 2008). All aqueous extracts were capable of scavenging $H_2O_2$ in dose-dependent manner. Among different aqueous extracts the root extract of $B. stracheyi$ has the maximum $H_2O_2$ scavenging potential (in the range of 18.8 to 92.4), which was followed by the leaf extract of $B. stracheyi$ and then the leaf extracts of $M. spicata$ and $H. candicans$, respectively.

$H_2O_2$ itself is a not a free radical but, sometimes it can be toxic to cell because it may lead to hydroxyl radical generation. This radical is very unstable and has tendency to cause imbalance (Halliwell, 1991). Thus, removing $H_2O_2$ is very important for antioxidant system. Keser et al. (2012) reported $H_2O_2$ scavenging activity of $Crataegus monogyna$ (hawthorn). Sharma and Singh (2012) studied radical scavenging activity and phytochemical screening for the evaluation of antioxidant potential of $Operculina turpethum$ (L.) root extracts using same assay. Gulcin et al. (2004) studied the $H_2O_2$ scavenging activity of water extract of $Urtica dioica$ L. (nettle) against positive control. The hydrogen peroxide scavenging activity decreased in the order of BHT > α –tocopherol > BHA > Water extract.

Among various plant extracts investigated for Fe-chelating activity, only extracts of $R. rugosa$ (PP and RP), $S. obvallata$ (L), $P. armeniaca$ (Fand L), $B. persicum$ (S), $M. spicata$ (L), $A. flavum$ (L), $U. dioica$ (L), $M. longifolia$ (PP and RP) and $H. candicans$ (PP and RP) exhibited iron chelation effect. The study found that the powder extract of $M. longifolia$ plant has 75% chelating effect on ferrous ions, which was significantly higher than other plant parts. The leaf extracts of $S. obvallata$ and $M. spicata$ have also exhibited good chelating activity, but the extracts of other parts of plants exhibited the minimum chelating activity. As per Gordon (1990) the chelating agents serve as secondary antioxidants as they have ability to reduce the redox potential, thereby stabilizing the oxidized form of the metal ions. Singh et al. (2007b) studied the iron chelating activity of $Acacia auriculiformis$ bark and found that the water fraction showed better chelating effect than the ethyl acetate and crude
Discussion

*OH is an extremely reactive free radical formed in biological system. It has short biological half-life and tends to react with every molecule found in living cells due to its unstable nature (Yasuda et al., 2000). Thus, effective scavenger must be needed to scavenge these radicals. The study revealed that all aqueous extracts have *OH scavenging ability in dose-dependent manner with significant change at each concentration. The highest *OH scavenging potential was found in the root extract of B. stracheyi followed by the leaf extracts of M. spicata and B. stracheyi. The percent scavenging value ranged from 91.6 % to 93.2%. Previously, similar type of studies carried out on other plants such as Piper betle L. (Dasgupta and De, 2004), Smilax excels L. (Ozsoy et al., 2008) and Rumex dentatus L. (Nisa et al., 2013) have demonstrated *OH radical scavenging activity.

Further, all the aqueous extracts exhibited TAA, the assay is based on the reduction of Mo (VI) to Mo (V) by the extract and subsequent formation of a green phosphate/Mo (V) complex at acid pH (Prieto et al., 1999). It is a quantitative method since the antioxidant activity is expressed in terms of the number of equivalents of ascorbic acid.

The aqueous extracts were found to have different levels of total antioxidant activity in the tested plants. The antioxidant activity increased with increasing concentration of extracts of all the plants. The leaf extracts of H. candicans and A. flavum exhibited higher TAA compared to the other test plants followed by fruit extract of P. armeniaca. Dasgupta and De (2004) studied TAA of the three different varieties of Piper betle and found different levels of antioxidant activity in the order Kauri > Ghanagete > Bagerhati. Earlier studies have shown that the extracts of Centaurea urvillei and Crataegus monogyna and exhibit TAA (Zengin et al., 2011; Keser et al., 2012).
Methanolic extracts of some medicinal and aromatic plants also possess antioxidant and radical scavenging properties

The radical scavenging activity of methanolic extracts was also explored to study the antioxidant activity of methanol-soluble constituents. Keeping this in mind, the antioxidant activity of the methanolic extracts of *B. stracheyi* (L and R), *F. esculentum* (S and L), *F. tataricum* (S and L), *A. flavum* (L), *M. spicata* (L), *S. obvallata* (L) and *U. dioica* (L) was studied against different radicals, as mentioned in section 5.

The DPPH radical scavenging activity of all methanolic extracts increased with increasing concentration. The leaf extracts of *B. stracheyi* revealed very high potency of 70.3% at 400 μg/ml towards the DPPH radical followed by root extracts of *B. stracheyi*. Other extracts have lower activity towards the DPPH radical. The scavenging was lower than 50% in most of the extracts. The DPPH assay measures the ability of extracts to donate hydrogen to the DPPH radical, to stabilise it resulting in discoloration of DPPH solution (Miguel, 2010). The observations made during the present work are supported by previous finding of Mohamed *et al.* (2014) who demonstrated that the methanolic extract exhibited highest DPPH radical scavenging activity as compared to the ethyl acetate extract and the essential oil. There are number of studies in relation to DPPH radical scavenging activity of extracts of plant like *Phyllanthus niruri* (Harish and Shivanandappa, 2006), *Mammea longifolia* (Rathee *et al*., 2006), and *Carum copticum* (Zahin *et al*., 2010). Furthermore, the observations made in the present study are in agreement with those by Khan *et al.* (2013a) who revealed that the methanolic extract of TSB (Tut stem barks) had similar free radical scavenging activity when compared with standard BHT. Raturi *et al.* (2011) demonstrated that the methanolic extracts of bark of *P. persica* had a highly effective free radical scavenging based on DPPH assay.

Further, the antioxidant potential of methanolic extracts of the test plants was also evaluated in terms of H₂O₂ scavenging and FRAP assay. Although H₂O₂ is not a radical species, but, it is an important ROS generating species contributing to the oxidative stress. The present study revealed good H₂O₂ scavenging activity of all methanolic extracts in dose-dependent manner. Maximum activity was
observed in *F. tataricum* leaf extract followed by seed powder extracts of *F. tataricum*. However, H$_2$O$_2$ scavenging is not specific to above mentioned extracts but there are several other extracts, from different plants such as *Mammea longifolia* (Rathee *et al*., 2006), *Garcinia indica* (Singh *et al*., 2011) and *Aconitum heterophyllum* (Prasad *et al*., 2012) also exhibiting this capacity. Further, this is supported by previous finding of Kumaran and Karunakaran (2007) who demonstrated the H$_2$O$_2$ scavenging activity of methanol extracts of five *Phyllanthus* species against positive control BHT and ascorbic acid. The study revealed that H$_2$O$_2$ scavenging decreased in the order: *P. debilis* > BHT > Ascobic acid > *P. urinaria* > *P. virgatus* > *P. maderapatensis* > *P. amarus*. Further, the presence of antioxidant in the extract has a potential to cause the reduction of the Fe$^{3+}$-ferricyanide complex to the ferrous form. Therefore, formation of Fe$^{2+}$ can be measured by formation of Perls Prussian blue. The reducing power of the extracts increased with increasing concentration.

Earlier, Tanaka *et al.* (1988) have observed that a direct correlation between the reducing capacities of compounds can be associated with the presence of reductones and indicator of its possible antioxidant activity. All the extracts at all concentrations exhibited higher activities than control. Among different extracts, the root extract of *B. stracheyi* exhibited the highest reducing potential of 88.6% at 400 μg/ml followed by the leaf extract of *B. stracheyi*. Ozturk *et al.* (2007) studied the reducing power of the root and stem extracts of *Rheum ribes* and found that the chloroform extracts of the roots and stems showed stronger reducing power than that of the methanol extracts. Karagozler *et al.* (2008) showed that the *Dorystoechas hastata* extract displayed higher reducing power than ascorbic acid at higher concentration. Jamuna *et al.* (2012) studied the reducing ability of the leaf and roots extracts of *Hypochaeris radicata* against positive control and found that the reducing ability of the leaf extract was far higher than the stem extract and ascorbic acid.

*•*OH radical has ability to attack all the proteins, membrane lipids and wide range of biomolecules that come in its contact (Aruoma, 1999). The methanolic extracts exhibited significant *•*OH scavenging with increasing concentration, indicating that some compounds in the methanolic extract were electron donors and could also react with the free radicals to convert them into more stable. The study revealed that the
leaf extract of *U. dioica* exhibited the maximum scavenging of 53.7% at 400 μg/ml. It was comparable to the seed powder extract of *F. esculentum* which quenched the 53% of the •OH radical at same concentration. However, the •OH scavenging activities of other extracts were significantly lower. Previously, similar types of studies were carried out on other plants such as *Mammea longifolia*, *Garcinia kola* and *Amaranthus lividus* L. whose methanolic extracts exhibited a good •OH radical scavenging activity (Rathee *et al.*, 2006; Okoko, 2009; Ozsoy *et al.*, 2009). Sowndhararajan and Kang (2013) studied the •OH scavenging activity of chloroform, acetone, methanol and hot water extracts of *Bauhinia vahlii* leaves and its was found to be maximum in methanolic extracts than that of other extracts.

The methanolic extracts exhibited some degree of TAA in a dose-dependent manner. TAA of *B. stracheyi* root extract was the maximum (108.2 μg AAE/ml) followed by the leaf extract of *B. stracheyi* with 103.0 μg AAE/ml TAA. Arabshahi-Delouees and Urooj (2007) showed that the methanol and acetone extracts of *Morus indica* have similar activity; however, the lowest TAA was observed in water extracts. Abdille *et al.* (2005) conducted a study on different extracts of *Dillenia indica* fruit to assess TAA and it was found that the amount of TAA decreased in the order: methanol extract > ethyl acetate extract > water extract, respectively.

**Chemical constituents of essential oil**

At present, approximately 3000 essential oils are known, of which 300 are commercially important especially for the pharmaceutical, food and agronomic usage. There are some essential oils that exhibit medicinal properties and have been claimed to cure one or other organ dysfunction or systemic disorder (Perry *et al.*, 2003; Silva *et al.*, 2003). Previously number of studies had reported in relation to the essential oils of different members of aromatic families and their antioxidant properties (Burt, 2004; Miguel, 2010). An essential oil is able to scavenge free radicals and hence, plays an important role in the prevention of some diseases such as cancer, heart disease, brain dysfunction and immune system disorder. There are number of
evidences which have suggested that disease may result from cellular damage caused by free radicals (Aruoma, 1998; Kamatou and Viljoen, 2010).

In the present study, the essential oils were extracted from leaves of Mentha longifolia, Rabdosia rugosa and Heracleum candicans and wood chips of Cedrus deodara. The yield of the oils varied from ~ 0.3 to 0.5% on the fresh and dry weight basis. In general, the oil from H. candicans was pale yellow in colour, whereas R. rugosa and M. longifolia oil was light yellow to brownish yellow in colour. The oil extracted from C. deodara wood chip was brown to dark brown in colour. Upon GC-MS analyses, the oil was found to be the mixture of monoterpenes, sesquiterpenes and diterpenes.

The oil of C. deodara was rich in sesquiterpenes, constituting 87.75% of the total constituents on the other hand monoterpenes were representing only 2.49%. A total 23 constituents were identified from oil, in which (E)-α-atlantone (23.66%) was found to be major constituent present in the oil followed by β-himachalene (16.74%) and α-himachalene (7.73%).

High percentage of the himachalenes accounting to 31.94% was observed in the essential oil of C. deodara. Boudarene et al. (2002) also reported similar type of observation with only difference in the percentage of the himachalenes accounting to 67% as the major constituent. Chaudhary et al. (2009) also reported higher content of the himachalene in the pentane fraction of C. deodara. The constituents like himachalenes (31.94%), atlantones (38.09%), and himachalol (0.43%) were also reported in the C. deodara essential oil are similar to those previously reported, and the only difference is the percentage composition (Nigam et al., 1990). The composition of essential oil varies greatly in same genus even in different plant parts. The chemical composition of oil varies from one geographical location to the other, distillation technique, plant part used and collecting time (Salido et al., 2002; Duquesnoy et al., 2006).

In the essential oil of M. longifolia, the major components of oil were tr-piperitone oxide (46.90%) and cis-piperitone oxide (26.97%) constituting major portion of oil. The identification of the tr-piperitone oxide as a major constituent in the oil is not in accordance with the previous results from India in which oil had
piperitenone oxide as a major constituent of oil (Singh et al., 2008b). Sharopov et al. (2012) studied essential oil composition of *M. longifolia* and reported the presence of *cis*-piperitone epoxide (7.8–77.6%), piperitenone oxide (1.5–49.1%), carvone (0.0–21.5%), and pulegone (0.3–5.4%). *cis*-Piperitone oxide is the main component in the oil of Croatia and South Africa specimens which is in agreement with our results (Mastelic and Jerkovic, 2002; Viljoen et al., 2006). The major portion of the oil is dominated with oxygenated monoterpenes (91.25%), which is in agreement with the previous results. Younis et al. (2004) showed that the oxygenated monoterpenes comprised of (81.5%) in *M. longifolia* oil. Singh et al. (2008b) reported piperitenone oxide (54.23%), *trans*-piperitone oxide (24.06%) and *cis*-piperitone oxide (7.04%) in the essential oil of *M. longifolia* which is concomitant to our results with only difference in percentage composition.

Some of the major components of the *H. candicans* oil were viridiflorol (24.30%), caryophyllene (4.78%), caryophyllene oxide (4.13%), germacrene D (3.82%), α-pinene (3.69%) and intermedol (3.66%). Though, a study on chemical characterisation of *H. candicans* oil is not reported to the best of our knowledge, but, there are number of studies on the other species of *Heracleum*. Chu et al. (2012) reported β-pinene as the major monoterpene in the essential oil of *Heracleum moellendorffii* but, in contrast to the previous results, our study reported α-pinene as the major monoterpene present in the oil, as reported by Chatzopoulou et al. (2009) in *H. perforatum*. The chemical composition of both the species (*H. perforatum* and *H. candicans*) contradict with each other as *H. perforatum* is rich in monoterpenoid and *H. candicans* is sesquiterpenoid in nature. The oil consists of some major components like viridiflorol (24.30%), caryophyllene (4.78%), caryophyllene oxide (4.13%), germacrene D (3.82%), α-pinene (3.69%) and intermedol (3.66%) although, most of these components are already reported in essential oil of other plant species (Ozek et al., 2002). Padalia and Verma (2011) reported that *Plectranthus rugosus* Wall. (Syn. *Rabdosia rugosa* Wall.) oil was of sesquiterpenoid type, which is in agreement with our results. Mallavarapu et al. (1999) and Singh et al. (2002) reported phenolic compounds in essential oils of *P. melissoides*, *P. ambionicus* (*Coleus ambionicus*) and *P. aromaticus* from India. However, in the present study these compounds were not reported even in trace amounts.
Monoterpenes and sesquiterpenes were the major constituents present in the essential oils used in present study. Cyclic monoterpenes with two double bonds impart antioxidant and radical scavenging properties (Edris, 2007). A widely distributed sesquiterpene β-caryophyllene is known for its antioxidant activity. Miguel (2010) reported that the essential oil from the leaves and flowers of aromatic plants had good antioxidant activities, nonetheless inferior to those of BHA and BHT. In fact, essential oils have been proposed as potential substitutes for synthetic antioxidants (Mimica-Dukic et al., 2003-2011).

**Chemical constituents of Fatty oils**

Fatty oils are very essential nutrient and source of energy for everyone, whether human or an animal and their content have important nutritional value that plays an important role in regulation of cholesterol synthesis and its transport (Simopoulos, 1991). Edible oils are rich in various micronutrients like tocotrienols, β-carotene, oryzanol, squalene and tocopherol. Depending upon their type and tocopherols present, the oil has ability to scavenge free radical or to deactivate free radicals and recognized for the antioxidant activity (Khan et al., 2013b).

In *P. mira*, oleic acid was found to be major fatty acid (56.14) and linoleic acid was detected as the second most abundant constituent with 30.36 %. Other fatty acid constituents present in the oil were palmitic acid, stearic acid, palmitoleic acid and linolenic acid. Polyunsaturated fatty acids (PUFAs) were the main components and Saturated fatty acids (SFAs) contributed to a minor part of the fatty acid profile of the oil. Our findings are in accordance with those of Orhan et al. (2008) who reported that oleic acid was the most abundant fatty acid (68.65%) in the oil of *P. armeniaca*. Likewise, the study of AbdEl-Aal et al. (1986) had shown that the apricot kernel oil of Egyptian origin contains oleic, linoleic, and palmitic acids as the principal fatty acids, which is similar to our result.

In *P. americana* fatty oil, oleic acid and linoleic acid with 63.59% and 26.0% were the major constituents whereas, other fatty acids including palmitic acid, palmitoleic acid, stearic acid, lenolenic acid and palmitic acid were identified in minor quantities. Gandhi et al. (1997) has shown that in the seed oil of wild apricot ~94.4% of unsaturated fatty acids are present.
This data is comparable to our study, as oil of *P. armeniaca* constitute 89.5\% unsaturated fatty acids. Likewise, unsaturated fatty acids are present more than that of saturated fatty acids in the seed oil (Sabudak, 2007).

The high intake of monounsaturated fatty acid, particularly oleic acid, lowers the chances of coronary heart diseases because it lowers total cholesterol and low-density lipoprotein cholesterol (Dennys *et al.*, 2006). On the other hand, high intake of saturated fatty acids can lead to obesity simultaneously with a risk factor to cardiovascular diseases (Gillian *et al.*, 2008). In the present work, PUFA is the major constituents present in fatty oil and the antioxidant activity of fatty oil can be related to the polyunsaturated fatty acid. As per the study of Siger *et al.* (2008), phenolic components present in edible oil provide oxidative stability to the polyunsaturated fatty acids. There is a strong positive correlation between intake of diet supplement with *α*-linolenic acid and *n*-3 polyunsaturated fatty acid and associated health benefits (Crawford *et al.*, 2000).

**Phenolics and flavonoids in water extracts impart antioxidant and radical scavenging properties**

It is a known fact that the antioxidant activities of extracts are attributed to phenolic and flavonoid compounds, as these compounds have been used for decades as industrial antioxidants. The content of the phenolics and flavonoids was measured in all the test plants. Both the phenolics and flavonoids were found to be present in the aqueous extracts of all the test plants. However, the amount of flavonoid content was found to be higher in all the test plants except in the root of *B. stracheyi* in which the phenolic content was more than that of the flavonoid content. The highest phenolic content was present in the leaf of *A. flavum* and *F. esculentum* followed by the leaf extracts of *H. candicans* and the root extracts of *B. stracheyi* among all the test plants. On the other hand, the leaf extracts of *P. mira* and *A. flavum* have highest amount of flavonoid content followed by the leaf extracts of *M. spicata* and *P. armeniaca*.

The action of the phenolics and flavonoids as antioxidants is viewed as beneficial to both as food and medicine to human system. So, they are getting
a considerable attention, which led to a number of studies in relation to the phenolic and flavonoid content of different plant extracts. Antioxidant activity of plant extracts are positively correlated with the phenolic compounds present in them (Cook and Samman, 1996). Plant phenols constitute different compounds that act as primary antioxidant (Hatano et al., 1989). Phenolic compounds have tendency to react with radicals like hydroxyl •OH and superoxide (Hussain et al., 1987; Afanselv et al., 1989). A similar type of study on flavonoids demonstrated that the highest level of flavonoid content positively correlated with the maximum scavenging of •OH and superoxide anions in leafy vegetables (Dasgupta and De, 2007). The accumulation of soluble phenolic content is greater in the outer tissues than the inner ones (Hawker et al., 1972). The ability of phenolic compounds to quench free radical is due to their acidity and delocalized pi electron (Brown, 1995). Recently, many studies have shown that the phenolics have better antioxidant activity than that of Vitamin C and E (Rice-Evans et al., 1995). The studies indicate that in Citrus the flavonoids are present in predominant amount and possess good antioxidant activity (Nogata et al., 1994). Plant phenolics, in particular the phenolic acids, tannins and flavonoids are known to be the potent antioxidants that occur in vegetables, fruits, nuts, seeds, roots and barks (Pratt and Hudson, 1990). Flavonoids are derived from 2-phenylchromen-4-one and are commonly known for their antioxidant activities. Furthermore, they show anti-allergic, anti-inflammatory, antimicrobial and anticancer activity (Rauha et al., 2000; Cushnie and Lamb, 2005). The flavonoids in the body are known to reduce the risk of heart diseases (Urquiaga and Leighton, 2000). Both flavonoids and phenolics possess good free radical scavenging activity (Rice-Evans et al., 1995, 1996). It is also possible to establish a relationship between structure of phenolics and flavonoids and their antioxidant properties (Rice-Evans et al., 1996).

Thus, the study concludes that the medicinal and aromatic plants have promising future as a source of medicine, with blend of various active components. They can be used as an alternative natural source of antioxidant in place of synthetic medicine without any side effects.
CONCLUSIONS

Based on the present study involving ethnobotanical survey of Sangla valley and investigation of antioxidant activity of selected medicinal plants, the following conclusions can be drawn:

- The present investigation identified 80 ethnomedicinal plant species used for different ailments by ethnic people in their day to day life.
- Asteraceae was the most dominating family with 10 species followed by Lamiaceae with 7 species.
- The most frequently used method for the consumption of medicinal plant part was in the form of powder and decoction (23 plants), followed by paste (19 plants).
- Leaves were the most common plant part used, while herb was the most common growth form.
- The most commonly used medicinal plants of study site were Aconitum heterophyllum, Angelica glauca, Arnebia euchroma, Bergenia stracheyi, Bunium persicum, Dioscorea deltoidea and Podophyllum hexandrum.
- Twelve plant species were identified as threatened, including 1 Critically Endangered, 5 Endangered, and 6 Vulnerable, which needs attention to prevent their extinction.
- Informant consensus factor (ICF), a quantitative tool used as an indicator showing the maximum use of medicinal plant against a particular health disorder, was calculated to be the maximum for appetizer and earache followed by wounds, cuts and snake bite.
- The study highlighted number of medicinal plants with high fidelity level and use value.
- Fatty oils of Prunus armeniaca and P. mira exhibited antioxidant and radical scavenging activity and the fatty oils P. armeniaca oil exhibited
Conclusions

the maximum scavenging activity towards H₂O₂, *OH and DPPH radicals, total antioxidant activity and FRAP activity.

- Essential oil possessed antioxidant and radical scavenging activity which varied from plant to plant.
- *M. longifolia* oil showed the maximum activity towards different radicals like DPPH, H₂O₂, *OH and iron chelating as compared to other oils.
- Highest ferric reducing antioxidant power was exhibited by *C. deodara* oil, whereas the maximum TAA was observed with *H. candicans* oil.
- DPPH scavenging activity was found to be more in leaf extract of *F. tataricum*, seed powder extract of *F. esculentum* and leaf and root extracts of *B. stracheyi*.
- Hydroxyl (*OH) radical scavenging activity was more in the root extract of *B. stracheyi*, which was followed by the leaf extracts of *M. spicata* and *B. stracheyi*.
- Highest iron chelating activity was observed in plant powder extract of *M. longifolia* but H₂O₂ was found to be more in root extract of *B. stracheyi*.
- FRAP was found to be more in leaf extract of *P. armeniaca*, which was followed by *H. candicans* leaf extracts.
- TAA was more in *H. candicans* leaf extract.
- Leaf and root extracts of *B. stracheyi* has the highest FRAP, TAA and DPPH scavenging activity.
- *OH scavenging was the maximum with *U. dioica*, whereas H₂O₂ scavenging was the maximum with *F. tataricum* leaf extracts.

- Upon GC-MS analysis, the oil of *Cedrus deodara*, *Rabdosia rugosa* and *Heracleum candicans* was found to be sesquiterpenoid type, whereas the oil of *Mentha longifolia* was of monoterpenoid type.
- Majority of components found in *Cedrus deodara*, *Rabdosia rugosa* and *Heracleum candicans* were oxygenated sesquiterpenes, but in case of *Mentha longifolia* oil it was oxygenated monoterpenes.
- The major components in *M. longifolia* oil were cis-piperitone oxide, trans-piperitone oxide, and in *C. deodara* oil were (E)-α-atlantone and β-himachalene.
Conclusions

However, in case of *Rabdosia rugosa* and *Heracleum candicans* oils the major components were intermedol and viridiflorol, respectively.

- Fatty oil of *P. armeniaca* and *P. mira* were found to be rich in polyunsaturated fatty acids (PUFAs).
- Oleic acid and Linoleic acid were the major components identified in both the oils.
- Residue powder, oil residue, leaf, seed and root extracts of selected medicinal and aromatic plants were rich in total phenolics and flavonoids.
- Amount of total flavonoids in extracts was more than that of total phenolics in all the test plants.
- Maximum total phenolic content was detected in leaf extracts of *A. flavum* and *F. esculentum*, while the content of total flavonoid was maximum in leaf extracts of *P. mira* and *A. flavum*. 