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Musk Rose (*Rosa moschata*) Grown at Middle Hill Climatic Conditions of the Western Himalayas: A Rich Source of Anti-Oxidants and Nutrients

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Musk rose (*Rosa moschata*) is an important wild aromatic climbing shrub of Rosaceae family. Scant scientific information is available on phyto-chemical composition and antioxidant activity of the Himalayan plant. Here we report, nutrient compositions, antioxidant constituents and activities of the different plant parts like leaves, petals, and rest of the flower parts of musk rose. Chlorophyll pigments and carotenoids contents were significantly higher in the mature leaves (2113.1 and 125.2 mg/g fresh weight respectively). The mature leaves also contained significantly higher amount of ascorbic acid (227.0 mg/100g) followed by the dried petals (141.6 mg/100g). The total antioxidant activity, determined based on ABTS and DPPH free radical scavenging ability, was higher in the hydro-alcoholic extracts from dried petals, dried flowers and mature leaves than that in the other parts. Analysis of the extracts from the dried petals revealed significantly higher contents of phenolics (62.9 mg/g), flavonoids (23.7 mg/g), tannins (133.8 mg/g), total carbohydrates (191.6 mg/g) and soluble protein (49.3 mg/g). The mature leaves were found to be the next richer sources for these nutrients. Correlation analysis revealed positive correlation of total antioxidant activities and the antioxidant constituents of the plant extract suggesting contribution of these compounds to the higher antioxidant activities. Thus, the phyto-chemical composition analyses suggest dried petals and mature leaves as potential natural sources of the nutrients and antioxidants. The study may further enhance utility of the Himalayan plant as source for preparing alternative natural medicines and functional foods.

Keywords: Antioxidants, Composition, Nutrients, Musk rose, Phyto-chemicals, Wild rose

Introduction

Wild rose (*Rosa moschata*) is popularly known as musk rose because of the characteristic musky fragrance of its flowers. It is an economically important woody, aromatic, climbing, perennial shrub of Rosaceae family. The hardy plants tolerate frost and snow and, successfully survive up to an altitude of 3000 m above the mean sea level in the temperate Himalayas. The woody stems attain height of up to 5 m and are covered with straight or slightly curved prickles with broad base. Therefore, the plants can also be utilized for establishing bio-fences for protection of farm lands from wild animals at mid and the upper Himalayas, and other regions with the similar climatic conditions. Leaves are alternate and light green in color with 3–5 leaflets. It produces hermaphrodite, creamy white flowers during the period of May to June in the mid and upper Himalayas. Rose petals are used as food additives while making herbal tea, cake etc. *R. moschata*, depending on the flower appearance, has three main phenotypes viz. single (*R. moschata moschata*), double (*R. moshcata plena*) and very double.[1] The single musk flowers have five petals whereas double and very double musk flowers have many petals. Rest of the plant morphology like flower color, leaf structure and size of rosebush are similar in these phenotypes. Traditionally, rose flower has been used for preparing medicine and cuisine. Essential oils are extracted from the flowers and used for preparing rose water or jams. The rose petals are used in preparing herbal tea with pleasant smell and antioxidant properties.[2] The pseudo-fruits (called hips) are small, ovate and turn orange-red on maturity in the months of November to February. Rose hips are well known for their various health benefits. The hips are edible and rich in antioxidants and other bioactive compounds.[3] The higher anti-oxidant activity may be attributed to the individual and synergistic effects of higher polyphenols, ascorbic acid and carotenoids contents.[4] Rose hips are also reported to possess anti-inflammatory, anti-diabetic and anti-cancer properties.[5,6] The hips or extracts are therefore used in formulating food supplements, herbal medicines, vitamin C tablets and herbal tea. Seeds are small in size, hard and yellowish in color. The seeds are rich

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source of minerals and oil and, the powder made after removing the seed hairs can be used as a food supplement.

The musk roses are grown in different parts of the world as a landscape plant for essence and related products. In the Himalayas, it grows wild and being utilized by the local inhabitants mainly for its perfumery values and in traditional medicine. The essential oil extracted from the flowers is used in the perfumery and cosmetics industries due to its medicinal properties and pleasant aroma. Plant genotype and the environmental conditions during the growth are the major factors which contribute significantly to the composition and concentration of metabolites and nutritional quality.[4] Numerous studies have been carried out on biochemical compositions of different parts from variety of rose species grown under different geographical locations.[7,8] However, systematic study on contents of the nutrients and antioxidant metabolites in different plant parts are not reported in this economically important plant species growing in its natural habitats of western Himalayas. Therefore, the present study was designed to analyze the composition and antioxidant properties of the local rose species for its possible use in food and pharmaceuticals. Present study reports nutrient compositions and antioxidant constituents of different plant parts like leaves, petals and rest of the flower parts of the musk rose.

Materials and Methods

Plant Material

Taxonomic authentication of the plant species was carried out with the kind help of Dr. Gajendra Singh, Scientist, Uttarakhand Space Application Centre, Dehradun, Uttarakhand, India. Different plant parts viz. petals from fresh flowers, fresh flowers without petals, fertilized ovary with sepals and mature leaves were handpicked (from 0900 to 1000 IST) from the campus landscape of the Defence Institute of Bio-Energy Research Field Station Pithoragarh, Uttarakhand, India (N29°35.524' E080°13.709', Altitude 1497 m). The plant parts were collected from well grown healthy musk rose plants during May 2020 (Fig. 1). The flowers were air dried for ten days and, dried petals and dried flowers without petals were analyzed for bio-chemical constituents.

Chemicals

Acetone, ethanol, ascorbic acid, methanol, potassium persulphate, 2, 2- azino-bis (3-ethyl benzothiazoline-6- sulfonic acids) diammonium salt (ABTS), 1,1-diphenyl-2-picryl-hydrazyl (DPPH), hydrochloric acid, tannic acid, potassium ferric cyanide, trichloroacetic acid, ferric chloride, potassium acetate, aluminium chloride, sodium dihydrogen phosphate, sodium carbonate, nitric acid, sodium hydroxide were purchased from E Merck India Ltd. and Sigma chemicals, USA and, were of analytical grade.

Estimation of Chlorophyll and Carotenoid Contents

Chlorophyll (a, b and total) and total carotenoid (xanthophylls + β-carotene) contents in the plant parts were determined from around 250 mg samples following the method reported earlier.[9] The plant materials were ground in a pre-chilled mortar in 80 % (v/v) acetone. The mixture was filtered and the volume was adjusted to 30 ml with cold acetone. The absorbance of the extract was measured at 664, 647 and 470 nm using a spectrophotometer (Make: Eppendorf; Model: Basic) and the pigment contents (µg/g of plant sample) were calculated using formulae:-

$$\text{Chlorophyll a (µg/ml)} = 12.25\ (A_{664}) - 2.55\ (A_{647})$$
$$\text{Chlorophyll b (µg/ml)} = 20.31\ (A_{647}) - 4.91\ (A_{664})$$
$$\text{Total chlorophyll (µg/ml)} = 17.76\ (A_{647}) + 7.34\ (A_{664})$$
$$\text{Total carotenoids (µg/ml)} = (1000A_{470} - 3.27[\text{chl a}] - 104[\text{chl b}])/227$$

Determination of Ascorbic Acid Contents

Ascorbic acid contents were determined using around 500 mg plant samples following the method reported earlier.[10] In brief, working standard solution (ascorbic acid; 100 µg/ml; 5.0 ml) was mixed with

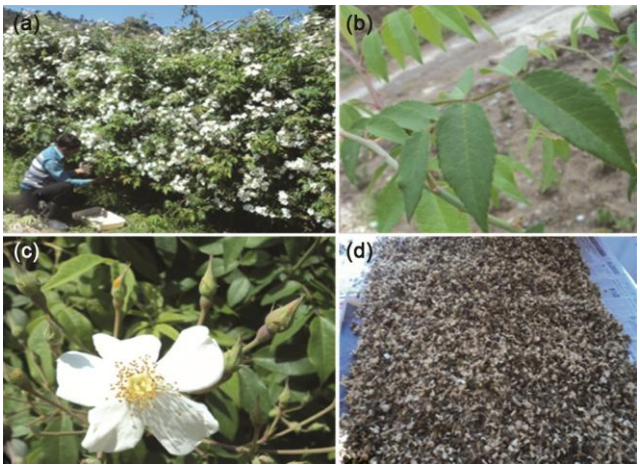

Fig. 1 — Musk Rose (*Rosa moschata*) plant during flowering stage along with different plant parts: (a) Plant during flowering stage, (b) Leaves, (c) Flower and flower buds, (d) Dried flowers

oxalic acid (4.0 %, w/v; 10.0 ml) and titrated against the dye (2,6-dichloro phenol indophenols). End point is the appearance of the pink color which persists for a few minutes. The amount of dye consumed (V_1 ml) is equivalent to the amount of ascorbic acid. Similarly, the extracts prepared in 4.0 % oxalic acid were titrated against the dye (V_2 ml).

Amount of the ascorbic acid (mg/100 g samples) = (0.5 mg/V_1 ml) × (V_2/5 ml) × (100 ml/Weight of sample) × 100

Preparation of Hydro-Alcoholic Extracts

Plant samples (around 500 mg) were extracted in ethanol (50 %, v/v) using mortar and pestle. The extracted volume was adjusted to 20 ml with ethanol. To ensure complete extraction, the extracts were subjected to ultra-sonication for one hour at room temperature (25 ± 2.0°C). The extracts were centrifuged at 5000 g for 10 min and the supernatants were collected in fresh tubes before storing at 4 ± 2°C inside refrigerator till further analyses.

Analysis of Anti-Oxidant Activity

ABTS (2, 2'-Azino-bis (3-Ethylbenzothiazoline-6-Sulfonic Acid) Assay

The total antioxidant activity was estimated based on ABTS free radical scavenging ability of the extract using earlier reported method.[11] ABTS (7.0 mM) and potassium persulphate (2.45 mM) solutions were mixed in equal volume and allowed to react for 12 hours in the dark. The blue-green chromogen, ABTS radical cation ($ABTS^{\bullet+}$), so produced was used in analysis of the antioxidant activity. In brief, different volumes (10−80 µl) of the extracts were reacted with ABTS radical cation ($ABTS^{\bullet+}$), a blue-green chromogen (λ max 734 nm). Control reaction was performed similarly without the plant extract. Hydrogen donating ability of the antioxidants in the extract was estimated by a change in color of the radical cation ($ABTS^{\bullet+}$) to colorless ABTS. The ability of the extract to scavenge the radical was measured by the discoloration of the solution. The extent of discoloration, an indicator of antioxidant activity of the extract, was measured by change in absorbance at 734 nm. The free radical scavenging activities (FRSA) of the different concentrations of the extracts were determined as,

$$FRSA\ (\%) = [(OD_{control} - OD_{test})/ OD_{control}] \times 100$$

Further extract concentration resulting in 50% inhibition (IC_{50}) was calculated as,

IC_{50} = (Conc. of test extract/FRSA nearest to the 50%) × 50

DPPH (1, 1-diphenyl-2-picrylhydrazyl) method

The total antioxidant activity was also estimated based on DPPH free radical scavenging ability of the plant extracts using method reported by Kumar *et al.*[12] with minor modifications. In brief, different volumes (10−80 µl) of the plant extracts were mixed with methanolic solution of DPPH (0.1 mmol; 2000 µl) in test tube. The reaction was incubated in a dark for 40 min. The absorbance was measured at 517 nm against methanol as a blank. Ascorbic acid was used as a standard. FRSA (%) of test samples was evaluated by comparing with control (2.0 ml DPPH + 1.0 ml methanol). The FRSA (%) and IC_{50} values were calculated as described in ABTS method.

Determination of Total Phenolic Contents

The total phenolic contents in the plant extracts were determined by using Folin-Ciocalteu method.[13] In brief, plant extracts were reacted with Folin-Ciocalteau reagent (0.5 ml) and Na_2CO_3 (20 %, w/v; 2.0 ml) in glass tubes. A blue color was developed due to the complex redox reaction with phosphomolibdic acid in the Folin-Ciocalteau reagent. The test solutions were warmed for 1 min, and absorbance was measured at 650 nm. The concentration of total phenol (mg catechol equivalent of phenol/g of sample) was measured by using standard calibration curve prepared with catechol.

Determination of Total Flavonoid Contents

The total flavonoid contents were determined by aluminum chloride colorimetric method.[14] The assay was performed by mixing the plant extracts (0.5 ml) to methanol (1.5 ml), aluminum chloride solution (10 %, w/v; 0.1 ml), potassium acetate solution (1.0 M; 0.1 ml) and distilled water (2.8 ml). Absorbance of the mix was measured at 415 nm against the suitable blank (all reagents except aluminum chloride) after 30 min incubation. The total flavonoid contents of the extracts (mg/g) were estimated equivalent to quercetin by using standard calibration curve.

Determination of Total Tannin Contents

Total tannin contents in the extracts were determined by Folin-Denis method with slight modifications.[15] In brief, the sample extracts (0.05 ml) were mixed with Folin-Denis reagent (2.5 ml) and sodium carbonate solution (35% w/v; 5 ml) and, the reaction volume was adjusted to 50 ml with distilled water. The reagents were mixed properly and absorbance was measured at 700 nm after 30 min incubation at room temperature (25 ± 2.0°C). Total tannin content of the extract (mg/g of sample) was

measured by using standard calibration curve of tannic acid.

Estimation of Total Soluble Sugars

Total soluble sugars in the hydro-alcoholic extracts were determined following an earlier published method with little modifications.[16] The hydro-alcoholic extracts (100 µl) were mixed with freshly prepared ice cold Anthrone reagent. The mixture was heated at 100°C in water bath for 10 min followed by rapidly cooling on ice. The total soluble sugars in the extracts (mg/g of plant sample) were determined based on absorbance at 620 nm using glucose as standard.

Estimation of Protein Contents

Total protein contents were determined from the hydro-alcoholic extracts (25 µl) using Bradford method.[17] Bradford reagent was mixed with the extract and absorbance was measured at 595 nm. The protein contents in the extracts (mg/g of plant sample) were determined using bovine serum albumin as standard.

Statistical Analysis

The biochemical constituents were estimated using three biological and two technical replicates of each plant sample. CropStat program developed at IRRI, Philippines was used for analysis of variance. The mean values were compared for statistical significance using Least Significant Difference (LSD) Test at a significance level of $P \leq 0.05$. Further, correlation coefficients were calculated for IC_{50} values (as a measure of total antioxidant activities) of the extract with that of contents of antioxidant constituents viz. phenolic, flavonoids, tannins, carotenoids and ascorbic acid using correlation function of Microsoft Excel. Mean (n = 3) values of the antioxidant constituents and the IC_{50} values were considered for the correlation analysis.

Results and Discussion

The present study reported significantly ($P \leq 0.05$) higher chlorophyll and carotenoid contents in the mature leaves of the musk rose than the other parts (Table 1). More specifically, the pigment contents of the mature leaves were higher than the younger leaves. Among the other plant parts, the petals harvested from fresh flowers had the least amounts of the pigments. Similarly, the carotenoids contents were significantly higher in the mature leaves (125.2 mg/g fresh weight) followed by the younger leaves (101.2 mg/g fresh weight). Earlier study by D'angiolillo *et al.*[7] reported seasonal variation in the chlorophylls and carotenoids contents in ethanolic extracts of leaves of wild rose species. The study revealed seasonal variation for chlorophylls and carotenoids contents in the leaves. The contents were higher in the month of June than that in October. On the contrary, Karami *et al.*[18] reported that the carotenoid content estimated from the petals of musk rose (*Rosa moschata* Hermm) remained unchanged with the harvest dates (0.20 and 0.14 mg/g) indicating no seasonal variation. The contradiction in the results might be due to the variation in genotype, plant part, harvesting season, environmental growth conditions and analytical techniques.

In the recent years, natural antioxidants from plant sources have gained the research attention mainly due to their dietary and curative properties. Use of different methods is suggested to determine the antioxidant activity of the plant extracts mainly because of the complex reactivity of phyto-chemicals and other natural antioxidants present in the extracts. Therefore, in the present study, total antioxidant capacity of the different plant parts were determined using DPPH and ABTS free radical scavenging assays (Table 2). The ability of the extract to scavenge the radicals was measured by the discoloration of the reaction mix. Greater the free radical scavenging higher is the antioxidant activity. Being

Table 1 — Estimation of chlorophyll and carotenoids contents from different plant parts of the musk rose (The mean values marked with different letters indicate statistically significant differences as per the least significant difference test at $P \leq 0.05$)

Plant Samples	Chlorophyll a µg/g	Chlorophyll b µg/g	Total Chlorophyll µg/g	Carotenoids mg/g
Petals of fresh flowers	12.0 g	12.4 e	24.4 e	1.8 f
Fresh flower without petals	170.8 e	100.7 d	286.3 d	33.9 d
Fertilized ovary with sepals	197.5 d	71.5 d,e	269.0 d	17.9 e
Dried petals	125.9 f	208.9 c	334.7 d	22.2 e
Dried flowers without petals	356.6 c	205.7 c	528.3 c	53.8 c
Young leaves	926.4 b	318.2 b	1227.4 b	101.2 b
Mature Leaves	1603.2 a	501.9 a	2113.1 a	125.2 a
SE (n=3)	18.8	18.2	34.0	1.7
5% LSD	58.0	56.0	104.7	5.3

quick, sensitive and responsive; DPPH and ABTS radical scavenging assays are frequently used to determine the antioxidant activity of the plant extracts. The antioxidant activity assay involves assessment of capacity for hydrogen atom or electron donation ability. The antioxidant activities of the extracts were determined in terms of IC_{50} values. Lower IC_{50} value indicates greater antioxidant activity. Earlier studies have reported effect of different solvents on total phenol content and antioxidant activity. Some studies reported ethanol as an effective solvent for extraction of antioxidant compounds from Rosa species.[4] However, the other study reported at par antioxidant activity in ethanol extract with that of water extract from *R. rugosa*.[19] Nadpal *et al.*[20] reported water as an effective solvent for the extraction of phenolic compounds in *R. arvensis* whereas Khurshid *et al.*[21] reported higher antioxidant activity in aqueous extracts from petals of Musk rose (*Rosa moschata*) than that from the other evaluated rose genotypes. Therefore, hydro-alcoholic extracts were prepared in the present study to determine total antioxidant activity based on ABTS and DPPH free radical scavenging ability (Table 2). The hydro-alcoholic extracts from all the plant parts were capable of scavenging ABTS•+ and DPPH in a concentration-dependent manner. The ABTS radical had low values of IC_{50} than that for DPPH (Table 2). In case of the ABTS assay, significantly higher antioxidant activity (as revealed by the lower IC_{50} value) was recorded in the extracts from dried petals and dried rest of the flowers (29.3 and 33.9 µg/ml respectively) followed by the extracts from mature leaves (45.9 µg/ml). The antioxidant activity was at par for the dried petals, rest of the dried flowers and mature leaves estimated through DPPH free radical scavenging assay. The results of both the ABTS and DPPH assay revealed lower antioxidant activity in the extract from petals from the fresh flowers (176.7 and 290.8 µg/ml respectively) than that from the other plant parts.

Table 2 — Total anti-oxidant activity of hydro-alcoholic extracts from different parts of musk rose (The total antioxidant activities were determined in terms of ABTS and DPPH free radical scavenging ability of the extracts; The mean values marked with different letters indicate statistically significant differences as per the least significant difference test at $P \leq 0.05$)

Plant Samples	IC 50 (µg/ml)	
	ABTS	DPPH
Petals of fresh flowers	176.7 e	290.8 d
Fresh flower without petals	91.5 c	138.2 b
Fertilized ovary with sepals	104.0 d	189.6 c
Dried petals	29.3 a	59.9 a
Dried flowers without petals	33.9 a	67.6 a
Mature Leaves	45.9 b	70.5 a
SE (n=3)	2.8	6.3
5% LSD	8.4	18.9

Table 3 — Determination of ascorbic acid contents in different plant parts of Musk Rose (The mean values marked with different letters indicate statistically significant differences as per the least significant difference test at $P \leq 0.05$)

Plant parts	Ascorbic Acid (mg/100 g)
Petals of fresh flowers	56.2 c,d
Fresh flower without petals	44.8 d,e
Fertilized ovary with sepals	67.7 c
Dried petals	141.6 b
Dried flowers without petals	41.0 e
Mature Leaves	227.0 a
SE (n=3)	3.9
5% LSD	12.2

Significantly higher amount of ascorbic acid was recorded in the mature leaves (227.0 mg/100 g sample) followed by the dried petals (141.6 mg/100 g sample) (Table 3). Fertilized ovary had higher ascorbic acid contents (67.7 mg/100 g) than the fresh flowers (44.8 mg/100 g). However, the ascorbic acid contents were at par for the petals from fresh flowers and the fresh flowers without petals. Analysis of the extracts revealed significantly higher phenolic contents in dried petals (62.9 mg/g) followed by the dried flowers without petals (52.6 mg/g) (Table 4). Mature leaves contained higher

Table 4 — Anti-oxidant constituents and bio-chemical compositions of hydro-alcoholic extracts from different parts of musk rose (The mean values marked with different letters indicate statistically significant differences as per the least significant difference test at $P \leq 0.05$)

Plant Samples	Phenolic Contents mg/g	Flavonoids (Quercetin equivalent) mg/g	Tanins (Tanic Acid equivalent) mg/g	Total Carbohydrates mg/g	Soluble Proteins mg/g
Petals of fresh flowers	12.7 c	4.0 c	27.1 e	34.8 d	21.2 c
Fresh flower without petals	24.6 d	2.5 d	38.6 d	40.0 c,d	30.4 b
Fertilized ovary with sepals	16.1 e	1.7 e	29.7 d,e	24.5 e	20.3 c
Dried petals	62.9 a	23.7 a	133.8 a	191.9 a	49.3 a
Dried flowers without petals	52.6 b	6.7 b	121.8 b	86.5 b	51.2 a
Mature Leaves	39.4 c	6.8 b	80.4 c	43.1 c	31.2 b
SE (n=3)	1.1	0.2	3.2	2.6	1.6
5% LSD	3.6	0.6	10.2	8.3	4.9

phenolics (39.4 mg/g) than the fresh petals (12.7 mg/g), fresh flower without petals (24.6 mg/g) and fertilized ovary (16.1 mg/g). Similarly, the higher flavonoids (quercetin equivalent) were estimated in dried petals (23.7 mg/g) followed by mature leaves (6.8 mg/g) and dried flowers without petals (6.7 mg/g). The fresh petals, flower without petals and fertilized ovary contained the least amounts of the flavonoids. Tannin (tannic acid equivalent) content was also significantly higher in extract prepared from dried petals (133.8 mg/g) followed by dried flowers without petals (121.8 mg/g) and mature leaves (80.4 mg/g). The tannin contents were lower in petals from fresh flowers, flowers without petals and fertilized ovary. The total carbohydrates content analyzed from the extracts was significantly higher in the dried petals (191.9 mg/g) than that of the other parts (Table 4). The carbohydrate content of dried flowers without petals was higher (86.5 mg/g) than the mature leaves (43.1 mg/g) and fresh flowers without petals (40.0 mg/g). The analysis revealed lower carbohydrate content in fertilized ovary (24.5 mg/g) than the rest of the parts. Soluble protein content was significantly higher in the extract from dried flowers (51.2 mg/g) and the petals (49.3 mg/g) than the rest plant parts analyzed (Table 4). The protein content from the mature leaves (31.2 mg/g) was at par with that of fresh flowers without petals (30.4 mg/g) but higher than petals from fresh flowers (21.2 mg/g) and fertilized ovary (20.3 mg/g). The local inhabitants are mainly dependent on the available plant diversity for food as well as medicines in the Himalayan regions. Besides the ornamental use of rose species, the plant parts (leaves, petals, rose hip) are also known to have valuable medicinal properties. Earlier, Roman *et al.*[22] reported fruits from the *Rosa canina* L. as a rich source for ascorbic acid, polyphenols and flavonoids content and, their antioxidant activity. Koczka *et al.*[4] reported that the rosehips are rich in constituents with antioxidant properties like vitamin C, carotenoids and phenolics. Ethanolic extracts of rosehips showed higher phenolic content and antioxidant activity than water extracts. In the present study, higher phenolic contents were estimated in dried petals, dried flowers and leaves. Similarly, flavonoids (quercetin equivalent) and tannin contents were also higher in these plant parts. Shan *et al.*[23] has also reported *Rosa moschata* as a richer source of flavonoids than the other wild edible fruits. Results of the present study are in agreement with the earlier study[18] which reported musk rose (*Rosa moschata* Hermm) petals as a rich source of phenols and ascorbic acid. Similarly, another study by Karim *et al.*[8] reported higher phenolic content in flowers than the other parts of dog rose (*Rosa canina*). Further, Kumar *et al.*[12] have reported dominance of quercetin, kaempferol and their glycosides in the phenolic constituents in methanolic extracts from the fresh flowers of rose species.

In mature leaves, ascorbic acid content was significantly higher than that of the dried petals, however contents of other polyphenolic antioxidant constituents viz. phenolic, flavonoids and tanins were significantly lower than in the dried petals. The antioxidant properties of the plant extracts cannot be attributed to activities/contents of single constituent. Higher antioxidant activities of the hydro-alcoholic extracts from dried petals in the present study are thus mainly attributed to the cumulative effects of the antioxidant constituents. The higher activities in the present study were associated with higher contents of ascorbic acid and polyphenolic compounds (phenols, flavonoids and tannins). Thus, the higher radical scavenging activity in the dried petals could be explained by individual as well as the synergistic effects of the antioxidant constituents. Khurshid *et al.*[21] also reported higher antioxidant activity in aqueous extracts from petals of the musk rose (*Rosa moschata*) than that from the other evaluated rose genotypes. The study attributed the higher antioxidant activity to the higher phenolics and flavonoids contents in the aqueous extracts. The study by D'angiolillo *et al.*[7] also reported that higher DPPH antioxidant activity and total flavonoids in the ethanolic extract from leaves of the wild rose species irrespective of harvesting period. Total polyphenol content was higher in leaves of all the studied species when harvested in the month of October. Earlier study by Samee *et al.*[24] reported positive correlation between the total antioxidant activity and the combination of total phenolic, total acid and ascorbic acid contents. In the present study, correlation coefficients calculated for the IC_{50} values (as a measure of total antioxidant activities) of the hydro-alcoholic extracts from different plant parts and the contents of antioxidant constituents were negative (Table 5). Among the antioxidant constituents, strong negative correlation coefficients were found for the phenolic (−0.89) and tannin (−0.85) contents with the IC_{50} values estimated based on the ABTS radical scavenging potential. Similarly, the constituents also showed strong negative correlation (−0.87 and −0.83

Table 5 — Correlation coefficients for the contents of antioxidant constituents and the inhibitory concentration (IC_{50}) values (as a measure of total antioxidant activity) of the hydro-alcoholic extracts from different parts of musk rose (The antioxidant activities were estimated in terms of IC_{50} values based on ABTS and DPPH radical scavenging potential of the extracts)

Antioxidant Constituents	Correlation coefficients	
	IC_{50} values	
	ABTS assay	DPPH assay
Phenolic	−0.89	−0.87
Flavonoids	−0.56	−0.53
Tannins	−0.85	−0.83
Carotenoids	−0.56	−0.61
Ascorbic Acid	−0.45	−0.48

respectively) with the IC_{50} values determined based on the DPPH radical scavenging assay. The lower the IC_{50} values indicate higher total antioxidant activities. Thus, the negative correlation of the IC_{50} values with the contents of antioxidant constituents suggests contribution of these compounds for the higher total antioxidant activity. Thus, these compounds viz. phenolic, flavonoids, tannins, carotenoids and ascorbic acid from the extracts determine the total antioxidant activity. The total antioxidant activity is contributed by the numerous antioxidant constituents however which one is more responsible to scavenge the free radicals is not clear.[25]

Conclusions

The analysis revealed that dried petals from musk rose are a rich source of soluble proteins, carbohydrates, and the antioxidant constituents such as ascorbic acid, phenolics, flavonoids and tannins. The higher antioxidant contents in the dried petals contributed in higher antioxidant activity determined in terms of ABTS and DPPH free radical scavenging ability. Besides the petals, mature leaves were also found as a good source of these constituents. Thus, our study revealed the petals and leaves of musk rose grown at the western Himalaya as a potential source of the health beneficial phyto-chemicals. Further, being rich in antioxidants, it holds significant potential to be an effective component of functional foods to treat free radical associated chronic diseases. Besides, the wild edible species may prove an important source for additional income generation to the local inhabitants of the area through sale of the plant biomass. The present study suggests further comprehensive analyses for phyto-chemical composition, bio-activity and *in vivo* antioxidant activity of the extracts from the local plant of the region.

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