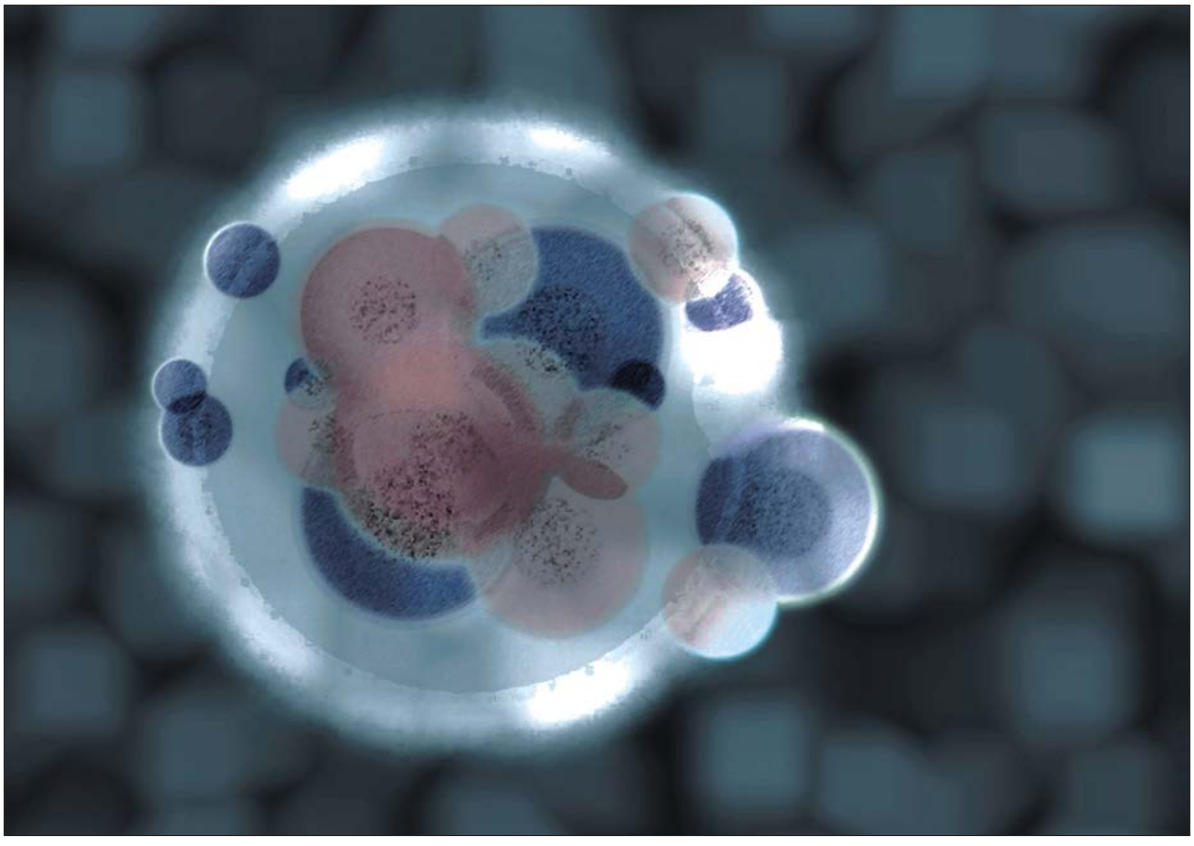

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# Essential Trace Metal (Zinc, Manganese, Copper and Iron) Levels in Plants of Medicinal Importance

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**Abstract:** In this study, concentrations of four essential trace metals, i.e., zinc, manganese, copper and iron have been estimated in thirty five different spices and plants having folk medicinal uses. A wet digestion procedure involving the use of *aqua regia* ($HNO_3$: HCl 1:3) has been used to solubilize metals from the plant samples. Flame atomic absorption spectrometry has been used to quantify metal levels. Results indicate the presence of variable amounts of metals in these plant samples. Order of concentration of metals in different spices and medicinal plants has been found to be as: Fe>Mn>Zn>Cu. Plant samples of Black Caraway (*Cuminum nigrium*), Cassia (*Cassia fistula*), Coriander (*Coriandrum sativum*), Chicory (*Cichorium intybus*), Castor (*Ricinus communis*), Basil (*Ocimum basilicum*), Small Cardamom (*Elettaria cardamomum*), Bishop's weed (*Trachyspermum ammi*), Musli (*Aneilema Scapiflorum*), Black cumin (*Nigella sativa*), Sensitive plant (*Mimosa pudica*), Water chestnut (*Trapa bispinosa*), Chaksu (*Cassia absus*) and Nuts-cooling (*Wathania coagulans*) contained comparatively higher amounts of zinc (i.e. > 50 μg $g^{-1}$) whereas clove (*Syzgium aromaticum*), Large cardamom (*Amomum subulatum*), Black pepper (*Pepper nigrium*), Cinnamon (*Cinnamomum zeylanicum*), Basil (*Ocimum basilicum*), Small Cardamom (*Elettarai cardamomum*), Fennel (*Foeniculum vulgare*), Syrian rue (*Peganum harmala*), Ginger (*Zingiber officinale*), Bishop's weed (*Trachyspermum ammi*), Musli (*Aneilema scapiflorum*), Black cumin (*Nigella sativa*), Sensitive plant (*Mimosa pudica*), Rhubarb (*Rheum emodi*), God Mar (*Gymnema sylveseter*), Water chestnut (*Trapa bispinosa*), Chaksu (*Cassia absus*) and Nuts-cooling (*Wathania coagulans*) showed manganese levels > 200 μg $g^{-1}$. Copper levels > 50 μg $g^{-1}$ were found in Basil (*Ocimum basilicum*), Liquorice (*Glycyrrhiza galbra*), Fennel (*Foeniculum vulgare*), Syrian rue (*Peganum harmala*), Bishop's weed (*Trachyspermum ammi*), Chilli (*Capcicum freutenscens*), Musli (*Aneilema scapiflorum*), Jujube fruit (*Ziziphus vulgaris*), Black cumin (*Nigella sativa*), Sensitive plant (*Mimosa pudica*), Colecynth (*Citrullus colocynthis*), God Mar (*Gymnema sylveseter*), Water chestnut (*Trapa bispinosa*), Chaksu (*Cassia absus*) and Nuts-cooling (*Wathania coagulans*). Iron levels in these plant samples were found to be comparatively higher than all other metals investigated but some of the plants including Mint (*Mentha arvensis*), Liquorice (*Glycyrrhiza galbra*), Syrian rue (*Peganum harmala*), Musli, (*Aneilema scapiflorum*), sensitive plant (*Mimosa pudica*), Rhubarb (*Rheum emodi*), God Mar (*Gymnema sylveseter*), Chaksu (*Cassia absus*) and Nuts-cooling (*Wathania coagulans*) showed very high Iron contents (i.e. > 4000 μg $g^{-1}$). The present study provides baseline data on essential trace metal levels in spices and medicinal plants commonly used for the treatment of different ailments. This data also suggests that use of various spices and herbs in food recipes and medicinal preparations is a source of essential trace metal supplements in addition to their antimicrobial characteristics.

**Key words:** Essential trace metals, spices, medicinal plants, AAS

## INTRODUCTION

Spices and herbs are the rich storehouses of different bioactive compounds and are well known for their beneficial effects on health. Pakistan is endowed with the wealth of medicinal plants. Folk medicinal uses of various spices and herbs are well documented in the literature[1-15]. There are grown wild or cultivated medicinal plants species which possess great potentient in Greco-Arab (Unani or Eastern) system of medicine but also in the light of active principles or biodynamic compounds being isolated from using ultra modern screening techniques available in our country. The necessity of exploitation of indigenous drugs has long been felt with the increasing need of drugs and medicines. Medicinal plants are being used in oriental medicine for the treatment of ailments ranging from the common cold to cancer[16]. Spices and medicinal plants are also known to

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contain trace metals which play vital role as structural and functional components of metalloprotiens and enzymes in the living cells[17]. Much work has been done on organic constituents of the medicinal plants[18-21] but little attention has been paid towards their trace metal contents. The present study was aimed to determine concentrations of four essential trace metals, *i.e.* zinc, manganese, copper and iron in thirty five spices and medicinal plants commonly used in Pakistan.

## MATERIALS AND METHODS

Samples of thirty five medicinal plants commonly used were collected from Multan city and were characterized taxonomically through literature[22,23]. Table 1 presents a list of themedicinal plants investigated in this study. These samples were dried in an oven at 60°C till constant weight was achieved. The dried samples were then crushed and powdered in an agate pestle and mortar. Samples were labeled and stored in pre-cleaned polyethylene bottles for further analysis.

**Digestion of plant samples and trace metal analysis:** Sample solutions were prepared following the standard procedure recommended by the Royal Committee of Experts for the digestion of plant materials[24] as " To 0.5 g of powdered plant sample, 10 ml of freshly prepared *aqua regia* was added. The solution was refluxed for 30 min. and then cooled down to room temperature (25°C). 20 ml of deionised water was added and solution was filtered (if necessary) using Whatman # 1 filter paper and then diluted up to 50 ml with deionised water. Sample solutions were then stored in clean polyethylene bottles for metal analysis". Some of the sample solutions were diluted for the determination of iron. Reagent blanks were also prepared. In order to check the reliability of analytical methods for trace metals, Citrus leaves SRM-1572 from National Bureau of Standards, Washington was also digested and then analyzed following the same procedure. Flame atomic absorption measurements were made with A-1800 atomic absorption spectrophotometer (Hitachi, Japan) following specific instrumental conditions (Table 2). Analysis of each sample was made in duplicate. Calibration of the instrument was repeated periodically during operation.

Table 1: List of medicinal plants studied

| Botanical name | Family | English name | Vernacular name | Part investigated |
|---|---|---|---|---|
| Curcuma longa | Zingiberaceae | Turmeric | Haldi | Roots |
| *Syzgium aromaticum* | Myrtaceae | Clove | Lounga | Flower buds |
| *Amomum subulatum* | Zingiberaceae | Large Cardamom | Badi Elaichi | Fruits |
| *Cuminum cyminum* | Umbelliferae | Cumin | Zira Safaid | Fruits |
| *Cuminum nigrium* | Umbelliferae | Black Caraway | Kalajira | Fruits |
| *Pepper nigrium* | Piperaceae | Black Pepper | Black Marich | Fruits |
| *Cinnamomum zeylanicum* | Lauraceae | Cinnamon | Dalchini | Bark |
| *Myristica fragrans* | Myristicaceae | Mace | Javitri | Seeds |
| *Mentha arvensis* | Labiatae | Mint | Pudina | Leaves |
| *Eucalyptns citriodora* | Myrtaceae | Encalyptus | Safaidah | Leaves |
| *Azadirachta indica* | Meliaceae | Neem | Neem | Leaves |
| *Cassia fistula* | Leguminosae | Cassia | Amaltas | Pods |
| *Coriandrum sativum* | Umbelliferae | Coriander | Dhania | Fruits |
| *Cichorium intybus* | Compositae | Chicory | Kasni | Seeds |
| *Ricinus communis* | Euphorbiaceae | Castor | Arand | Seeds |
| *Ocimum basilicum* | Labiteasea | Basil | Niyazbo | Seeds |
| *Glycyrrhiza galbra* | Leguminosae | Liquorice | Mulathi | Roots |
| *Foeniculum vulgare* | Umbelliferae | Fennel | Saunf | Seeds |
| *Elettaria cardamomum* | Zingiberaceae | Small Cardamom | Choti Ellaichi | Fruits |
| *Peganum harmala* | Zygophllaceae | Syrian me | Harmal | Seeds |
| *Zingiber officinale* | Zingiberaceae | Ginger | Adrak | Roots |
| *Trachyspermum ammi* | Umbelliferae | Bishop's weed | Ajwain | Seeds |
| *Capcicum frutenscens* | Solanoceae | Chilli | Surkh Mirch | Fruits |
| *Aneilema scapiflorum* | Commelinaceae | Musli | Musli siyah | Seeds |
| *Ziziphus vulgaris* | Rhamnaceae | Jujube Fruit | Uunab | Fruits |
| *Nigella sativa* | Renunculaceae | Black Cumin | Kalwanji | Seeds |
| *Mimosa pudica* | Leguminosae | Sensitive plant | Lajvanti | Seeds |
| *Syzigium cumin* | Myrtaceae | Black Plum | Jaman | Fruits |
| *Aloe barbedeusis* | Lilliaceae | Aloe | Mosabbar | Leaf Pulp |
| *Citrullus colocynthis* | Curcurbitaceae | Colecynth | Tumba | Fruits |
| *Rheum emodi* | Polygonaceae | Rhubarb | Revandchini | Root |
| *Gymnema sylveseter* | Asciepiabaceae | God Mar | Gurmar Buti | Leaves |
| *Trapa bispinosa* | Onagraceae | Water chestnut | Singhare | Fruits |
| *Cassia absus* | Leguminosea | Chaksu | Chaksu | Seeds |
| *Wathania coagulans* | Solenaceae | Nuts-cooling | Paneer Buti | Seeds |

Table 2: Instrumental conditions for trace metal analysis by FAAS

| Parameter | Zn | Mn | Cu | Fe |
|---|---|---|---|---|
| Wavelength (nm) | 213.8 | 279.6 | 324.8 | 248.3 |
| Band Pass (nm) | 1.3 | 0.4 | 1.3 | 0.2 |
| Lamp Current (mA) | 10.0 | 7.5 | 15.0 | 10.0 |
| Fuel Pressure (kg $cm^{-2}$) | 0.30 | 0.30 | 0.30 | 0.30 |
| Burner Height (mm) | 7.5 | 7.5 | 7.5 | 7.5 |
| Calibration Range (mg $L^{-1}$) | 0.3-3.0 | 1.0–7.0 | 0.3-5.0 | 1.0-10.0 |
| Detection Limit (mg $L^{-1}$) | 0.01 | 0.2 | 0.04 | 0.4 |
| Flame Composition [a] | | | | |
| Oxidant Pressure [b] (kg $cm^{-2}$) | | | | |
| Atomizer [c] | | | | |
| Measurement Mode [d] | | | | |

a Air : $C_2H_2$ ; b 1.60 ; c Standard Burner; d Absorbance

## RESULTS AND DISCUSSION

Atomic absorption spectrometry has been successfully used for the determination of four essential trace metals, i.e. zinc, manganese, copper and iron in thirty five spices and medicinal plants commonly used for the treatments of various ailments. Metals levels are given in Table 3. For the accuracy of the analytical results by FAAS, Citrus Leaves Standard Reference Material (SRM 1572, National Bureau of Standards, Washington) was also analyzed. Percent recoveries of analyzed metals in the SRM were found to be in the range 99-105%.

Results show the presence of variable amounts of metals in these medicinal plant samples. In general, the order of concentration of metals in different Pakistani spices and medicinal plants has been found to be as: Fe>Mn>Zn>Cu. Plant samples of Black Caraway (*Cuminum nigrium*), Cassia (*Cassia fistula*), Coriander (*Coriandrum sativum*), Chicory (*Cichorium intybus*), Castor (*Ricinus communis*), Basil (*Ocimum basilicum*), Small Cardamom (*Elettaria cardamomum*), Bishop's weed (*Trachyspermum ammi*), Musli (*Aneilema scapiflorum*), Black cumin (*Nigella sativa*), Sensitive plant (*Mimosa pudica*), Water chestnut (*Trapa bispinosa*), Chaksu (*Cassia absus*) and Nuts-cooling (*Wathania coagulans*) contained comparatively higher amounts of zinc (i.e. > 50 μg $g^{-1}$) whereas clove (*Syzgium aromaticum*), Large cardamom (*Amomum subulatum*), Black pepper (*Pepper nigrium*), Cinnamon (*Cinnamomum zeylanicum*), Basil (*Ocimum basilicum*), Small Cardamom (*Elettarai cardamomum*), Fennel (*Foeniculum vulgare*), Syrian rue (*Peganum harmala*), Ginger (*Zingiber officinale*), Bishop's weed (*Trachyspermum ammi*), Musli (*Aneilema scapiflorum*), Black cumin (*Nigella sativa*), Sensitive plant (*Mimosa pudica*), Rhubarb (*Rheum emodi*), God Mar (*Gymnema sylveseter*), Water chestnut (*Trapa bispinosa*), Chaksu (*Cassia absus*) and Nuts-cooling (*Wathania coagulans*) showed manganese levels > 200 μg $g^{-1}$. Copper levels > 50 μg $g^{-1}$ were found in Basil (*Ocimum basilicum*), Liquorice (*Glycyrrhiza galbra*), Fennel (*Foeniculum vulgare*), Syrian rue (*Peganum harmala*), Bishop's weed (*Trachyspermum ammi*), Chilli (*Capcicum freutenscens*), Musli (*Aneilema scapiflorum*), Jujube fruit (*Ziziphus vulgaris*), Black cumin (*Nigella sativa*), Sensitive plant (*Mimosa pudica*), Colecynth (Citrullus colocynthis), God Mar (*Gymnema sylveseter*), Water chestnut (*Trapa bispinosa*), Chaksu (*Cassia absus*) and Nuts-cooling (*Wathania coagulans*). Iron levels in these plant samples were found to be comparatively higher than all other metals investigated but some of the plants including Mint (*Mentha arvensis*), Liquorice (*Glycyrrhiza galbra*), Syrian rue (*Peganum harmala*), Musli, (*Aneilema scapiflorum*), sensitive plant (*Mimosa pudica*), Rhubarb (*Rheum emodi*), God Mar

Table 3: Trace metal levels in medicinal plants determined by flame atomic absorption spectrometry

| | Metal Concentration* (μg $g^{-1}$ of the dried plant material) | | | |
|---|---|---|---|---|
| Metal Detection limit (μg $g^{-1}$) | Zn 1.0 | Mn 10 | Cu 4.0 | Fe 40 |
| SRM 1572 | | | | |
| Certified value | 29.0±2.0 | 23.0±2.0 | 16.5+1.0 | 90.0±10.0 |
| Determined value | 30.4±1.6 | 23.0±0.6 | 16.3+0.2 | 89.0±1.3 |
| % Recovery | 105 | 100 | 99 | 99 |
| Curcnma longa | 18.3±3.8 | 16.5±2.2 | 5.3±0.9 | 800±103 |
| *Syzgium aromaticum* | 13.6±.6 | 539±26 | 4.7±1.7 | 235±48 |
| *Amomum subulatum* | 45.3±5.2 | 223±18 | 14.0±3.3 | 285±44 |
| *Cuminum cyminum* | 43.0±2.6 | 22.8±0.9 | 17.0±3.7 | 482±35 |
| *Cuminum nigrium* | 55.6±22.2 | 43.3±9.5 | 14.3±2.5 | 1726±138 |
| *Pepper nigrium* | 5.0±5.3 | 237±3 | 14.3±1.7 | 155±69 |
| *Cinuamomum zeylanicum* | 10.0±3.7 | 323±15 | 4.0±0.0 | 129±49 |
| *Myristica fragrans* | 28.0±11.5 | 4.3±3.4 | 32.6±4.9 | 222±44 |
| *Mentha arvensis* | 40.3±4.0 | 92.5±4.8 | 30.6±6.0 | 4144±193 |
| *Eucalyptns citriodora* | 32.3±6.5 | 19.1±2.7 | 14.3±2.05 | 501±15 |
| *Azadirachta indica* | 33.3±9.9 | 29.5±4.1 | BDL | 475±23 |
| *Cassia fistula* | 66.3±20.4 | 35.3±6.8 | 8.7±2.5 | 559±14 |
| *Coriandrum sativum* | 51.6±19.4 | 21.0±0.5 | 18.0±2.5 | 424±74 |
| *Cichorium intybus* | 89.6±31.6 | 67.9±6.6 | 21.3±3.1 | 2390±88 |
| *Ricinus communis* | 133±12 | 14.0±1.9 | 17.3±0.9 | 397±81 |
| *Ocimum basilicum* | 83.3±6.2 | 264±21 | 179±10 | 1237±124 |
| *Glycyrrhiza galbra* | 12.7±0.0 | 107±15 | 80.4±24.2 | 4823±1370 |
| *Foeniculum vulgare* | 37.5±3.0 | 877±85 | 117±22 | 1034±293 |
| *Elettaria cardamomum* | 50.6±2.4 | 2840±112 | 48.2±20.6 | 441±61 |
| *Peganum harmala* | 20.5±9.5 | 352±123 | 81.0±5.7 | 4954±684 |
| *Zingiber officinale* | 19.7±1.9 | 1014±52 | 49.4±2.7 | 2475±1110 |
| *Trachyspermum ammi* | 80.6±24.1 | 771±11 | 145±27 | 2792±304 |
| *Capcicum frutenscens* | 22.8±12.7 | 194±10 | 141±34 | 3708±919 |
| *Aneilema scapiflorum* | 61.2±20.6 | 330±41 | 316±315 | 4782±470 |
| *Ziziphus vulgaris* | 7.5±4.0 | 67±2 | 146±34 | 384±13 |
| *Nigella sativa* | 52.3±4.5 | 231±19 | 138±40 | 3355±333 |
| *Mimosa pudica* | 498±30 | 1102±99 | 293±52 | 5547±947 |
| *Syzigium cumin* | 1.1±0.4 | 88±9 | 42.3±21.3 | 2165±464 |
| *Aloe barbedeusis* | BDL | 34±3 | BDL | 269±127 |
| *Citrullus colocynthis* | 13.6±1.9 | 98±11 | 63.7±18.9 | 779±77 |
| *Rheum emodi* | 16.7±0.5 | 242±27 | 33.9±19.9 | 4507±776 |
| *Gymnema sylvestre* | 33.0±5.2 | 1599±179 | 102±24 | 16373±384 |
| *Trapa bispinosa* | 502±6 | 310±279 | 232±226 | 3300±1393 |
| *Cassia absus* | 451±145 | 582±52 | 100±25 | 11613±2691 |
| *Wathania coagulans* | 231±253 | 226±9 | 230±214 | 9293±1200 |

Mean of triplicate measurements ± standard deviation; BDL below detection limit

(*Gymnema sylveseter*), Chaksu (*Cassia absus*) and Nuts-cooling (*Wathania coagulans*) showed very high Iron contents (i.e. > 4000 μg $g^{-1}$).

Earlier reported data show very few studies related to the determination of mineral constituents in some medicinal plants of Pakistan. Syed *et al.*[25] estimated lead in turmeric by atomic absorption spectrometry. Ahmad *et al.*[26] reported the levels of major, minor and trace elements in Henna (*Lawsonia intermis*) leaves. Saleem *et al.* [12] reported chemistry of the medicinal plants of the genus acacia. They collected the data about 11 species of this genus and described the medicinal importance of the different part of the different species such as bark, root, stem, flower, leaves and their medicinal importance in treatment of various diseases. Sahito *et al.*[27] reported mineral constituents in leaves, stem and flowers of *Nerium indicum* (Kunair). Sahito *et al.*[27] determined mineral constituents in *Abutilon glaucua* (Pilibuti) by atomic absorption spectrometry.

The present study provides baseline data on essential trace metal levels in spices and medicinal plants commonly used for treatment of different ailments. This data also suggests that use of various spices and herbs in local food recipes and medicinal preparations is a source of essential trace metal supplements in addition to their antimicrobial characteristics. Further research is being carried out in our laboratory which is focused on determination of bioactive compounds and toxic metals, antibacterial characteristics and metal bioavailability *etc.* from various indigenous medicinal plants.

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## REFERENCES

1. Agarwal, V.S. and B. Ghosh, 1985. Drug Plants of India-Root Drugs. Kalyani Publishers, New Delhi, India.
2. Ali, M.S. and V.U. Ahmad, 1998. Some medicinally important plants and their uses. Hamdard J. Sci. Medicine, XL, 5354.
3. Krishna De, A., 2000. Recent Trends in Spices and Medicinal Plants Research. Associated Publishing Co., New Delhi, India.
4. Caius, J.F., 1986. The Medicinal and Poisonous Plants of India, Scientific Publishers, Jodhpur, India.
5. Chavellier, A., 1996. The Encyclopedia of Medicinal Plants. Dorling Kindersley Ltd., London.
6. Chopra, R.N., S.L. Nayar and I.C. Chopra, 1956. Glossary of Indian Medicinal Plants, Council of Scientific and Industrial Research, New Delhi, India.
7. Duke, J.A., 1985. CRC Handbook of Medicinal Herbs. CRC Press Inc. Boca Raton, F.L.
8. Leung, A.Y., 1980. Encyclopedia of Common Ingredients used in Food, Drugs and Cosmetics. John Wiley and Sons, New York, U.S.A.
9. Nizamuddin, S. and M. Qaiser, 1989. Flora of Pakistan. Vol. 190. Department of Botany, University of Karachi, Karachi, Pakistan.
10. Purseglove, J.W., E.G. Brown, C.L. Green and S.R. Robbins, 1981. Spices. Longman, London, United Kingdom.
11. Said, H.M., 1996. Medicinal Herbs. Hamdard Foundation Press, Karachi, Pakistan.
12. Saleem, M., M. Ahmad and A. Ahmad, 1998. Chemisrty of medicinal plants of genus acacia. Hamdard J. Sci. Med., XLI, 6367.
13. Shinwari, M.I. and M.A. Khan, 1999. Folk uses of medicinal herbs of Margalla Hills National Park, Islamabad J. Ethnopharmacol., 69: 4556.
14. Thomas, S.C. Li., 2000. Medicinal Plants. Technomic Publishing Company, Pennsylvania, U.S.A.
15. Zaman, M.B. and S.M. Khan, 1970. Medicinal Plants of West Pakistan. Ferozsons Ltd. Lahore, Pakistan.
16. Fisher, C., 2002. Spices of life. Chemistry in Britain, 38: 40-42.
17. Kawacski, S. and Schatcher, 1974. Amer. J. Physiol., 226: 401.
18. Grewal, R.C., 2000. Medicinal Plants. Campus Books International, New Delhi, India.
19. Balandrin, M.F. and J.A. Klocke, 1988. Medicinal, aromatic and industrial materials from plants. In: Bajaj, Y.P.S. (Ed.). Biotechnology in Agriculture and Forestry 4. Medicinal and Aromatic Plants I, Springer-Verlag, New York, U.S.A.
20. Garcia, T.M. and F.G.D. Heran, 1981. Medicinal Chemistry Advances, Pergamon Press. New York, U.S.A.
21. Fujita, E. and M. Node, 1984. Diterpenoids of Rahdosia species in Progresss in the Chemistry of Organic Natural Products, Ed. Herz, W., Griesbech H., Kirkby, G.W., Tam Ch., Springer-Verlag, New York, U.S.A.

22. Rajput, M.T., S.S. Hassney and K.M.I. Khan, 1996. Plant Taxonomy. Oxford Publishers Ltd. Pakistan.
23. Willis, J.C., 1985. A Dictionary of the Flowering Plants and Ferns, Eighth Edition (Revised by Shaw, H.K.A), Cambridge University Press, Cambridge, United Kingdom.
24. Standing Committee of Analysts, 1987. Method for the determination of metals in soils, sediments and sewage sludge and plants by hydrochloric-nitric acid digestion, with a note on the determination of the insoluble metal contents. Methods for the examination of waters and associated materials. Her Majesty's Stationary Office, London.
25. Syed, A.M.,M. Qadiruddin and A. Khan, 1987. Detection and estimation of lead in *Curcuma longa* bulbs (Turmeric) by atomic absorption spectrometry. J. Chem. Soc. Pak., 9: 387-390.
26. Ahmad, I., M.H. Siddiqui and Z.A. Khan, 1994. The major, minor and trace elements in Henna leaves. J. Chem. Soc. Pak., 16: 29-31.
27. Sahito, S.R., T.G. Kazi, G.H. Kazi and A.N. Memon, 2000. Determination of mineral constituents of *Nerium indicum* (Gul Zangi or Kunair) using atomic absorption Spectrometry. Pak. J. Anal. Chem., 1: 33-35.