



STUDIES ON THE PHYTOCHEMICAL VARIATION IN THE AQUEOUS EXTRACTS OF *AERVA LANATA* JUSS EX SCHULTES, *HEDYOTIS CORYMBOSA* (L.) LAM. AND *LEPTADENIA RETICULATA* (RETZ.) W & A

Mammen Denni^{*}, Daniel Mammen², Sane Ramesh³

^{*}Department of Chemistry, M.S. University of Baroda, Vadodara, India.

²Department of Botany, M.S. University of Baroda, Vadodara, India.

³Guru Nanak Institute for Research and Development, G.N. Khalsa College, Matunga, Mumbai, India.

*Corresponding author's E-mail: drdenni.mammen@gmail.com

Accepted on: 23-10-2011; Finalized on: 20-01-2012.

ABSTRACT

The objective of the present work was to study the effect of seasonal and geographical variations on the phytochemicals of three medicinal plants *Aerva lanata* Juss ex Schultes, *Hedyotis corymbosa* (L.) Lam., and *Leptadenia reticulata* (Retz.) W. & A. The aqueous extracts of the three plants were analyzed mainly for various flavonoids and phenolic acids using ascending paper chromatography techniques. Each plant was collected during three different seasons to study the seasonal variations, and from three different regions to study the geographical variations. *Aerva lanata* showed maximum variations in the phytochemicals present, whereas *Leptadenia reticulata* showed the least variation, indicating good consistency among its various samples. Seasonal and geographical changes have a powerful impact on the phytochemicals synthesized by a plant. Similar studies are required to be performed on all medicinal plants to check consistency and quality of the raw materials, before preparation of herbal formulations.

Keywords: *Aerva lanata*, *Hedyotis corymbosa*, *Leptadenia reticulata*.

INTRODUCTION

Secondary metabolites are a group of compounds in plants, which are synthesized by specially designed metabolic pathways. Since they are not involved with the primary metabolism of plants, their role has been grossly underestimated. Previously these compounds were misconceived as 'waste products' or 'excretory products'. But lately there is a genuine realization of the various roles of these compounds, most of which are adaptation and survival mechanisms. For instance, alkaloids are defensive agents, deterring herbivores due to their bitter taste; volatile oils attract insects to aid pollination; diterpenes and triterpenes protect the plant from microbial attack; limonoids and quassinoids act as insect repellents which thus protect the plant from insect attacks. The manifold functions of secondary metabolites show that they are not produced as a result of aberrations in biosynthesis in plants but their formation is due to genetically controlled mechanisms. It is now being accepted that plants evolve and survive due to the secondary metabolites. Each group of plants specializes in one or the other class of compounds that enable them to survive better, be it pollination of flowers, dispersal of seeds, warding off pathogens or herbivores as well as preventing competition by suppressing the development of neighbouring plants.^{1,2} Plant growth, development and reproduction depend on the interaction of environmental factors with the genetic makeup, the genotype. These two factors determine what an organism looks like, the phenotype. In nature, the phenotype responds to the biotic and abiotic environments. Soil factors, water content and sunlight must be adequate for the plant to complete its growth cycle during the right season.³

Aerva lanata Juss ex Schultes is a common weed found in all plains districts and up to 900 metres elevation. It is widespread in the drier parts of the tropics and subtropics of Africa and Asia.⁴ Plant decoction is diuretic and is given to remove bladder and kidney stones. It is also used to treat diarrhoea.⁵ Leaf paste is mixed with gingelly oil and given to treat piles. Leaf and root paste is applied to treat pimples and skin infections. Leaf decoction is given as anthelmintic and demulcent. Root and flower decoction is given to treat headache. Root decoction is used as an antidote for snakebite. Root powder is used as tooth paste to treat toothache. Whole plant is used to treat cough, boils, lithiasis (calculus formed by inorganic salts) and pus.

Hedyotis corymbosa is a spreading, suffruticose annual, frequently found especially during monsoon in fields throughout India, Sri Lanka, tropical East Asia to Java and the Philippines. The plant is known to clear heat and toxins, activate blood circulation, promote diuresis and relieve stranguria (urinary obstruction). It is also known to act against tumours of the digestive tract lymphosarcoma and carcinoma of the liver and larynx. It is also active against appendicitis, hepatitis, pneumonia, cholecystitis, urinary infection, cellulites and snake bite. Chinese folk medicine describes the plant to treat skin sores, ulcers, sore throat, bronchitis, gynaecologic infections and pelvic inflammatory diseases.⁶⁻⁹ It is usually administered in the form of a decoction in remittent fever with gastric irritability and nervous depression caused by deranged bile. It is also used to treat jaundice and diseases of liver. The juice of the plant is applied to palms and soles to relieve the burning sensation during fevers. The plant is used as an anthelmintic. In Philippines the plant is boiled



in water and the brew is used as a mouthwash for relief during toothache.

Leptadenia reticulata is a twining shrub found in Gujarat, Sub-Himalayan tracts from Punjab to Sikkim and Khasi hills and throughout peninsular India, ascending up to an altitude of 900 metres. It is also distributed in tropical and sub-tropical parts of Asia and Africa. It is considered to be a *Rasayana* (tonic) and is thus used to vitalize, nourish and rejuvenate the body. Its use as a galactagogue is well known. It is also used to cure weakness, chicken pox, dysentery, tuberculosis, cough, respiratory disorders, eye diseases and night blindness, as well as certain skin diseases.^{4,5}

Seasonal variation for all the three plants selected for the present work, *Aerva lanata*, *Hedyotis corymbosa* and *Leptadenia reticulata*, have been studied after collection of each plant during April (summer), August (monsoon) and December (winter). Vadodara (Gujarat) was selected as the place of collection for all the three plants and in all three seasons. Thus the place of collection was kept constant for collection in all three seasons. Geographical variation was similarly studied for all the three plants, for which collections were conducted in Gujarat, Maharashtra and Kerala, three different states in India. Summer season was selected for collection and only the regions of collection were varied. All the three plants were collected from Vadodara to represent collection from Gujarat. *Aerva lanata* and *Hedyotis corymbosa* were collected from Mumbai, while *Leptadenia reticulata* was collected from Aurangabad, to represent Maharashtra collections. For collection from Kerala, *Aerva lanata* and *Hedyotis corymbosa* were collected from Allapuzha, while *Leptadenia reticulata* was collected from Changanacherry. Thus keeping Vadodara as the place of collection constant, the plants were collected in three different seasons; and keeping summer season constant, the plants were collected from three different regions. Each of the three plants selected for the present research work was screened mainly for their flavonoid and phenolic acid contents. Collection of the plants in three different seasons from Vadodara provided three different samples to be analyzed for the same plant. The three regions selected for study of geographical variation were done on the basis of difference in temperature and humidity levels. Gujarat being hot and dry, Maharashtra being hot and humid, Kerala being wet and humid, all three places exhibited sufficient variation. Each sample was analyzed at least three times for confirmation of the results.

MATERIALS AND METHODS

The three plants collected were identified and authenticated by Dr. Manikandan, Botanical Survey of India, Pune. Voucher specimens of these plants (No.BSI/WC/Tech/2007/734) are deposited at the Herbarium, B.S.I., Pune, India. Fifty grams of plant powder was extracted in a Soxhlet's apparatus with methanol till the plant material became colourless. The methanolic

extract was concentrated to dryness in a water bath. 25-30 ml of water was added to the dry residue and the water soluble phenolic glycosides were filtered out. The filtrate was hydrolysed in a water-bath for one hour using 7% HCl. This hydrolysate was extracted with diethyl ether, whereby the aglycones got separated into ether fraction (fraction A). The remaining aqueous fraction was further hydrolysed for another 10 hours to ensure the complete hydrolysis of all the O-glycosides. Aglycones were once again extracted into diethyl ether (fraction B) and the residual aqueous fraction was neutralized and evaporated for the analysis of glycoflavones.

Ether fractions A and B were combined and analysed for aglycones using well established standard procedures.^[10] The combined concentrated extract was banded on Whatman No. 1 chromatographic paper. The solvent system employed was 30% glacial acetic acid. The developed chromatograms were dried in air, observed under ultra-violet light (360 nm) and the bands were marked. These marked bands of the compounds were cut out from the chromatograms and eluted with spectroscopic grade methanol. The UV absorption spectra of these compounds were recorded in methanol using 'Perkin- Elmer Lambda 25 UV/Vis' spectrophotometer. The aqueous fraction remaining after the separation of aglycones was neutralized by the addition of anhydrous BaCO₃. Precipitates of barium chloride were filtered out. The filtrate was concentrated to dryness. To this dried residue, ethanol was added to dissolve the glycoflavones. The alcoholic filtrate was concentrated, and was banded on Whatman No.1 paper and the chromatogram was developed in distilled water as solvent system. Glycoflavones were visualized by their colour under UV light & with 10% aqueous Na₂CO₃ spray. Further identification of flavones, flavonols and glycoflavones were done by measuring the λ max, as well as spectral shifts (both bathochromic & hypsochromic) when shift reagents such as aluminium chloride, sodium methoxide, sodium acetate and boric acid, were employed.¹¹

Analysis of phenolic acids in the combined ether fraction (A and B) was carried out by two-dimensional ascending paper chromatography. Toluene: acetic acid: water (6:7:3 v/v/v, upper organic layer) in the first direction and sodium formate: formic acid: water (10:1:200 w/v/v) in the second direction were used as mobile phase. The sprays used to locate the compounds on the chromatograms were diazotized *p*-nitroaniline and diazotised sulphanilic acid and a 10% Na₂CO₃ overspray.¹² For preparation of the diazotization reagents, 0.7gms of *p*-nitroaniline/sulphanilic acid was dissolved in 9 ml of HCl and the volume made up to 100 ml. Five ml of 1% NaNO₂ was taken in a volumetric flask and kept in ice till the temperature was below 4°C. The diazotized sprays were prepared by adding 4 ml of *p*-nitroaniline/sulphanilic acid stock solution to the cooled NaNO₂ solution. The volume was made up to 100 ml with ice-cold water. The various phenolic acids presents in the extract were identified based on the specific colour reactions they produce with



the spray reagents and the relative R_f values in the different solvent systems.

RESULTS

Seasonal and geographical variations in *Aerva lanata*

Aerva lanata collected during three different seasons from Vadodara revealed the existence of significant variations in the phytoconstituents, which are listed in Table 1. The plant showed the presence of vanillic acid, syringic acid, ferulic acid, *p*-coumaric acid and *p*-Hydroxy benzoic acid, common in all the three seasons. However, melilotic acid was one phenolic acid that was found to develop in the plant in during summers and winters, but absent during monsoon season. Flowers are scanty in *Aerva lanata* during the rains. The analysis of the plant collected during monsoons revealed the presence of only two flavonols, kaempferol and quercetin. However, though scanty, the flowers collected during the monsoon season were analyzed separately. This analysis revealed the presence of kaempferol as well as 4'-Methoxy kaempferol. Quercetin was found absent during this analysis. This showed that 4'-Methoxy kaempferol was restricted only to the flowers of *Aerva lanata*, while quercetin was present in all the parts of the plant except for the flowers. Kaempferol was present in every part of the plant. Thus during summers and winters, 4'-Methoxy kaempferol was found present due to abundance of flowers, while it was absent during the rains due to lack of flowers. Kaempferol and quercetin were present in all the three seasons. The development of betacyanins requires the presence of strong sunlight. In case of *Aerva lanata*, the pigment betanin was found to develop only during the summer and winter seasons due to availability of strong sunlight. This pigment was not visible in plant during the monsoons, probably due to the lack of adequate sunlight.

Aerva lanata collected from three different regions during summer season revealed variations as shown in Table 2. Phenolic acid analysis of the Gujarat sample of *Aerva lanata* showed the presence of vanillic acid, syringic acid, ferulic acid, *p*-coumaric acid, *p*-hydroxy benzoic acid and melilotic acid. The sample from Maharashtra did not contain *p*-coumaric acid and melilotic acid. Kerala sample showed the presence of only three phenolic acids, vanillic acid, syringic acid and ferulic acid. *Aerva lanata* collected from Gujarat contained flavonols such as kaempferol, 4'-methoxy Kaempferol and quercetin. A very striking observation made for the plant collected from Maharashtra as well as Kerala, was that they were devoid of quercetin. Instead of quercetin both the samples showed the presence of a dimethoxy derivative of kaempferol, apart from kaempferol and 4'-methoxy kaempferol. *Aerva lanata* collected from all the three regions showed the development of red betacyanin pigmentation especially in the stems.

Seasonal and geographical variations in *Hedyotis corymbosa*

Hedyotis corymbosa collected during three different seasons from Vadodara revealed the existence of a few variations in the phytoconstituents, as shown in Table 3. The plant showed the presence of vanillic acid, syringic acid, ferulic acid, *p*-coumaric acid, *p*-hydroxy benzoic acid and gentisic acid, all of which were identified to be common in all the three seasons. However, caffeic acid was one phenolic acid that was found to develop in the plant only during winter. Flavonols were quite abundant in the plant in all the three seasons during which the plant was collected. The flavonols did not vary from season to season for the plant. Quercetin was the most abundant flavonol, present along with its derivatives 3'-Methoxy quercetin and 3', 4'-Dimethoxy quercetin. The development of anthocyanins was observed in all the three seasons. In case of *Hedyotis corymbosa*, the pigments cyanidin and pelargonidin were found to develop in all young plants during the monsoons. However, the pigments were found on the stems of the plant during the summer and winter seasons only in places with availability of strong sunlight. Thus the pigments that develop in the young plants during the monsoons require strong sunlight for their sustenance during the summer and winter seasons.

Variations in phytochemicals in *Hedyotis corymbosa* collected during three different regions were observed as shown in Table 4. Phenolic acid analysis of the Gujarat sample of *Hedyotis corymbosa* showed the presence of vanillic acid, syringic acid, ferulic acid, *p*-coumaric acid, *p*-hydroxy benzoic acid and gentisic acid. The sample from Maharashtra did not contain *p*-coumaric acid. However, it showed the presence of another compound, melilotic acid. Kerala sample was similar to that of Gujarat except for the fact that gentisic acid was replaced by melilotic acid. All the samples collected from Gujarat, Kerala and Maharashtra, were similar in flavonol content in having quercetin, 3'-methoxy quercetin and 3', 4'-dimethoxy quercetin. *Hedyotis corymbosa* collected from all the three regions showed the development of the same anthocyanidin pigments cyanidin and pelargonidin, in the stems.

Seasonal and geographical variations in *Leptadenia reticulata*

Summer, monsoon and winter collections of *Leptadenia reticulata* analyzed yielded results as shown in Table 5. Variation in phenolic acid content in samples of *Leptadenia reticulata* collected in various seasons was not very significant. Phenolic acids such as vanillic acid, syringic acid, ferulic acid, *p*-coumaric acid and *p*-hydroxy benzoic acid were found common to all seasons. The only variation observed was the presence of phloretic acid in the sample collected during the rains. Similarly no variation was observed in the flavone content of the plant in different seasons. Flavones such as apigenin, acacetin, diosmetin, chrysoeriol, and 3', 4'-dimethoxy luteolin were



found to be present in all the three samples of the plant collected during three different seasons. The glycoflavone 6C-Glucosyl acacetin was found to be constant in the plant irrespective of the change of seasons.

Leptadenia reticulata collected during three different parts of the country during summer season revealed results as shown in Table 6. Phenolic acid content of this plant did not change with respect to different regions of the country. Phenolic acids such as vanillic acid, syringic

acid, ferulic acid, *p*-coumaric acid and *p*-hydroxy benzoic acid were found common to all the three regions. The plant did not contain any flavonol but only flavones. Flavones such as apigenin, acacetin, diosmetin, chrysoeriol and 3', 4'-dimethoxy luteolin were found to be present in all the samples collected from three different parts of the country. The glycoflavone 6C-Glucosyl acacetin was found to be present in the plant irrespective of the place of collection.

Table 1: Seasonal variation in phytochemicals in *Aerva lanata*

Summer	Monsoon	Winter
Phenolic acids		
Vanillic acid, syringic acid, ferulic acid, <i>p</i> -coumaric acid, <i>p</i> -hydroxy benzoic acid, melilotic acid	Vanillic acid, syringic acid, ferulic acid, <i>p</i> -coumaric acid, <i>p</i> -hydroxy benzoic acid	Vanillic acid, syringic acid, ferulic acid, <i>p</i> -coumaric acid, <i>p</i> -hydroxy benzoic acid, melilotic acid
Flavonols		
Kaempferol, 4'-Methoxy Kaempferol, quercetin	Kaempferol, quercetin	Kaempferol, 4'-Methoxy Kaempferol, quercetin
Betacyanins		
Betanin	-	Betanin

Table 2: Geographical variation in phytochemicals in *Aerva lanata*

Gujarat	Maharashtra	Kerala
Phenolic acids		
Vanillic acid, syringic acid, ferulic acid, <i>p</i> -coumaric acid, <i>p</i> -hydroxy benzoic acid, melilotic acid	Vanillic acid, syringic acid, ferulic acid, <i>p</i> -hydroxy benzoic acid	Vanillic acid, syringic acid, ferulic acid
Flavonols		
Kaempferol, 4'-Methoxy Kaempferol, quercetin	Kaempferol, 4'-Methoxy Kaempferol and 4', 7-Dimethoxy Kaempferol	Kaempferol, 4'-Methoxy Kaempferol and 4', 7-Dimethoxy Kaempferol
Betacyanins		
Betanin	Betanin	Betanin

Table 3: Seasonal variation in phytochemicals in *Hedyotis corymbosa*

Summer	Monsoon	Winter
Phenolic acids		
Vanillic acid, syringic acid, ferulic acid, <i>p</i> -coumaric acid, <i>p</i> -hydroxy benzoic acid, gentisic acid	Vanillic acid, syringic acid, ferulic acid, <i>p</i> -coumaric acid, <i>p</i> -hydroxy benzoic acid, gentisic acid	Vanillic acid, syringic acid, ferulic acid, <i>p</i> -coumaric acid, <i>p</i> -hydroxy benzoic acid, gentisic acid, caffeic acid
Flavonols		
Quercetin, 3'-Methoxy quercetin and 3', 4'-Dimethoxy quercetin	Quercetin, 3'-Methoxy quercetin and 3', 4'-Dimethoxy quercetin	Quercetin, 3'-Methoxy quercetin and 3', 4'-Dimethoxy quercetin
Anthocyanidins		
Cyanidin, pelargonidin	Cyanidin, pelargonidin	Cyanidin, pelargonidin

Table 4: Geographical variation in phytochemicals in *Hedyotis corymbosa*

Gujarat	Maharashtra	Kerala
Phenolic acids		
Vanillic acid, syringic acid, ferulic acid, <i>p</i> -coumaric acid, <i>p</i> -hydroxy benzoic acid, gentisic acid	Vanillic acid, syringic acid, <i>p</i> -hydroxy benzoic acid, ferulic acid, melilotic acid	Vanillic acid, syringic acid, ferulic acid, <i>p</i> -coumaric acid, <i>p</i> -hydroxy benzoic acid, melilotic acid
Flavonols		
Quercetin, 3'-Methoxy quercetin and 3', 4'-Dimethoxy quercetin	Quercetin, 3'-Methoxy quercetin and 3', 4'-Dimethoxy quercetin	Quercetin, 3'-Methoxy quercetin and 3', 4'-Dimethoxy quercetin
Anthocyanidins		
Cyanidin, pelargonidin	Cyanidin, pelargonidin	Cyanidin, pelargonidin



Table 5: Seasonal variation in phytochemicals in *Leptadenia reticulata*

Summer	Monsoon	Winter
Phenolic acids		
Vanillic acid, syringic acid, ferulic acid, <i>p</i> -coumaric acid, <i>p</i> -hydroxy benzoic acid	Vanillic acid, syringic acid, ferulic acid, <i>p</i> -coumaric acid, <i>p</i> -hydroxy benzoic acid, phloretic acid	Vanillic acid, syringic acid, ferulic acid, <i>p</i> -coumaric acid, <i>p</i> -hydroxy benzoic acid
Flavones		
Apigenin, acacetin diosmetin, chrysoeriol and 3',4'-dimethoxy luteolin	Apigenin, acacetin diosmetin, chrysoeriol and 3',4'-dimethoxy luteolin	Apigenin, acacetin diosmetin, chrysoeriol and 3',4'-dimethoxy luteolin
Glycoflavones		
6C-Glucosyl acacetin	6C-Glucosyl acacetin	6C-Glucosyl acacetin

Table 6: Geographical variation in phytochemicals in *Leptadenia reticulata*

Gujarat	Maharashtra	Kerala
Phenolic acids		
Vanillic acid, syringic acid, ferulic acid, <i>p</i> -coumaric acid, <i>p</i> -hydroxy benzoic acid	Vanillic acid, syringic acid, ferulic acid, <i>p</i> -coumaric acid, <i>p</i> -hydroxy benzoic acid	Vanillic acid, syringic acid, ferulic acid, <i>p</i> -coumaric acid, <i>p</i> -hydroxy benzoic acid
Flavones		
Apigenin, acacetin diosmetin, chrysoeriol and 3',4'-dimethoxy luteolin	Apigenin, acacetin diosmetin, chrysoeriol and 3',4'-dimethoxy luteolin	Apigenin, acacetin diosmetin, chrysoeriol and 3',4'-dimethoxy luteolin
Glycoflavones		
6C-Glucosyl acacetin	6C-Glucosyl acacetin	6C-Glucosyl acacetin

DISCUSSION

Aerva lanata collected during monsoon season lacked melilotic acid, 4'-Methoxy kaempferol as well as the red pigment betanin, all three of which were found to be present in the samples collected during summer and winter. Therefore one may generalize that collection of the plant should be avoided during monsoons. Since the present phytochemical analysis involved only the analysis of flavonoids, phenolic acids and betacyanins, and the other phytochemicals being not analyzed, a definite recommendation on the time of collection for the plant can be made only after more detailed studies are conducted on the plant. The presence of quercetin from samples collected from Gujarat is very encouraging. Quercetin is a well known flavonol exhibiting cardiovascular protection, anticancer and anti-ulcer effects, anti-allergic activity and cataract prevention as well as antiviral and anti-inflammatory effects. It is anti-arthritis, anti-asthmatic, antibacterial, anti-cataract, antidiabetic, anti-herpetic, antiviral, hepatoprotective and antimalarial in nature. It is known to act against tumours in the bladder, colon, lung, ovary and skin. Therefore, the presence of Quercetin in plants of Gujarat imparts the pharmacological properties of this flavonol to the plant samples collected from this area. The absence of this compound from samples collected from Maharashtra as well as Kerala is noteworthy. But they possess another flavonol, 4', 7-Dimethoxy Kaempferol, in place of quercetin. Kaempferol and its methoxy derivatives present in these plants are anti-inflammatory, antiherpetic, antileukemic, antiseptic, antiviral, hepatoprotective and acts as a vasodilator. On the whole, the variety and content of flavonols as well as phenolic acids were found to be higher in case of the Gujarat

sample. Betanin was observed in all the three samples. The red pigment Betanin, responsible for the colour in beet roots (*Beta vulgaris*), is extensively commercialised for colouring foodstuffs, milk products and icecreams.¹³ Betacyanins are currently used in place of the delisted FD&C Reds 2 & 4. The red pigments from *Phytolacca Americana* and *Amaranthus tricolor*, have been legally used as food and wine colourants.¹⁴

Melilotic acid was found only in the Gujarat sample. Phenolic acids found in Gujarat sample were six in number, four in Maharashtra sample, and just three in Kerala sample. Thus the study brings to light a very important factor which went unnoticed so far that the samples of plants collected from different localities and in different seasons differ in chemical composition and that will have a bearing on the quality of the drugs produced.

The phytochemical classes analyzed for *Hedyotis corymbosa* showed hardly any significant differences. It may be generalized that the chemistry of this plant is stable to change in seasons. This claim however needs to be supported by studies on the remaining compounds also. Samples collected from three different regions showed minor differences in the phenolic acid content. The flavonols and anthocyanins identified were found to be similar for the three samples. Gentisic acid is analgesic, antibacterial, anti-inflammatory, antioxidant, anti-rheumatic and antiviral. It inhibits oxidation of low density lipoproteins. Caffeic acid is known to be antihyperglycemic, antioxidant, anti-inflammatory, and has shown significant decrease in the growth in colon tumours in rats. Anthocyanins are found to delay cataract and related eye problems as well improves night vision. Red anthocyanins in wine are considered to be the reason



for low occurrence of cardiac problems in people who consume red wine. The absence of *p*-coumaric acid from samples of Maharashtra is noteworthy. *P*-coumaric acid is antibacterial, antiseptic and antitumour. The compound is also antiseptic, antioxidant and fungicidal. It is proved to inhibit the oxidation of L-tyrosine, which is an important precursor for the biosynthesis of a number of compounds. Ferulic acid is analgesic, antiallergic, anti-inflammatory, hepatoprotective and antihepatotoxic. It is antiviral, immunostimulant, antiallergic and acts as an arteriodilator. It is also found to act against cancer in the colon, forestomach, liver and skin. More samples from different regions need to be screened further to find out the plant with the greatest efficacy.

The phytochemicals in *Leptadenia reticulata*, such as flavonoids and phenolic acids showed no significant variations indicating that the plant physiology was not affected either by change of season or by change of place of collection. This observation is very important and significant with respect to the quality control of the plant. Acacetin is antiaflatoxin, antimalarial, hepatoprotective, anticancer and antihistaminic. It possesses antiperoxidative, anti-inflammatory and antiHIV properties. A number of studies have shown that acacetin induces apoptosis in human lung, human prostate and human breast cancer cells. Chrysoeriol and diosmetin are cancer preventive, radical scavenger and antiviral in nature. Luteolin is antiallergic, antibacterial, anti-inflammatory, antipolio and antiherpetic. Luteolin is found to have profound effect against tumours in the colon, kidney, lung, ovary, skin, stomach, pancreas, thyroid and brain. Apigenin is antiaflatoxin, antileukemic and antimelanomic. The compound is antibacterial, antiallergic, anti-inflammatory, antileukemic, antioxidant, antiviral, diuretic and is a good vasodilator. It is also known to act against cancer in the lungs, as well as against tumours in skin and breasts.

CONCLUSION

The present study brings to light the effect of change in season and geography in the biosynthesis of phytochemicals. Temperature, humidity, availability of water, minerals etc. all play a major role in deciding the chemical spectrum of the plant. This challenges the

common notion that a plant can be harvested at any time or any place.

REFERENCES

1. Daniel M. Medicinal Plants- Chemistry and Properties. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. 2006.
2. Daniel, M. Herbal Technology- Concepts and Approaches. Satish Serial Publishing House, New Delhi. 2008.
3. David NK, Goodin JR. The Botanical World. Times Mirror/ Mosby College Publishing, Toronto. 1984.
4. Sivarajan VV, Indira B. Ayurvedic Drugs and their Plant Sources. Oxford and IBH Publishing Co. Pvt. Ltd, Delhi. 1994.
5. Warriar PK, Nambiar VPK, Ramankutty C. Indian Medicinal Plants- A Compendium of 500 Species. Volume 1. Orient Longman Pvt. Ltd.; 1994.p 67-69.
6. Chang HM, But PPH. Pharmacology and Applications of Chinese Materia Medica. Volume II. World Scientific, Singapore. 1986.
7. Bensky D, Gamble A. Chinese Herbal Medicine: Materia Medica. Eastland Press, Seattle, WA. 1990.
8. Chang M. Anticancer Medicinal Herbs. Human Science and Technology Publishing House, Changsha. 1992.
9. Ou M. An Illustrated Guide to Antineoplastic Chinese Herbal Medicine. The Commercial Press, Hong Kong. 1990.
10. Harborne JB. Phytochemical methods. 2nd edition. Chapman and Hall, London. 1984.
11. Mabry TJ, Markham KR, Thomas MB. The systematic identification of flavonoids. Springer-Verlag, New York. 1970.
12. Ibrahim RK, Towers GHN. The identification by paper chromatography of plant phenolics. Arch. Biochem. Biophys. 87: 1960; 125-128.
13. Von Elbe JH, Schwartz SJ. Colorants. In: O.R. Fennema (Ed.), Food Chemistry. Dekker, New York. 1996.
14. Forni E, Polesello A. Research on the utilization of the pigment from *Phytolacca decandra* L. as a food colorant: Part I-Preparation of an extract free from toxic substances. Food Chemistry. 10(1): 1983; 35-46.

