Chapter 9

Summary and Highlights

Substitution/Adulteration of herbal drugs is a rampant phenomenon at all places. Because the adulterants also share a number of characters with the genuine drugs, it becomes imperative to recognize them in the raw material, powder or extract form. Studies on these aspects are seldom conducted and for this reason, in the present work, an attempt is made to conduct a systematic study on substitutes/adulterants of five medicinally important plants widely used in Indian systems of medicine.

The parameters that can aid in rapid identification such as micromorphological studies, powder characteristics, phytochemical analysis, purity and variation in the HPTLC fingerprints were looked into during the present study. Micromorphology can be used to detect adulteration when the plant is obtained in fresh form. In case of dried plant powder, differences in powder characteristics as well as HPTLC fingerprint profiles can be utilized to ascertain the purity of the given plant powder.

The genuine drugs selected for the present study are 1) *Fumaria parviflora,* 2) *Bergenia ligulata,* 3) *Glycyrrhiza glabra,* 4) *Polygala senega,* and 5) *Saraca indica* and the substitutes/adulterants studied are *Oldenlandia corymbosa, Peristrophe bicalyculata, Polycarpea corymbosa, Justicia procumbens* and *Rungia repens* (all for *Fumaria*); *Aerua lanata, Ammannia baccifera, Celosia argentea, Coleus ambonicus* and *Glossocardia linearifolia* (all for *Bergenia*); *Taverniera cuneifolia, Abrus precatorius, Alysicarpus longifolius, Maerua arenaria* (for *Glycyrrhiza); Polygala chinensis,Acalypha indica, Adhatoda vasica, Xeromphis spinosa* (all for *Polygala*); and *Trema orientalis, Polyalthia longifolia, Bauhinia variegata, Bombax ceiba* and *Shorea robusta* (for *Saraca*). Standard procedures were followed for phytochemical, pharmacognostical, physicochemical and HPTLC fingerprint analysis.

The characteristic features of ***Fumaria parviflora*** which distinguished it from the substitutes/adulterants were light brown contents in cortical parenchyma and fan shaped vascular bundle in root. The diagnostic characters such as presence of raphide bundles in *Oldenlandia corymbosa,* acicular crystals in *Peristrophe bicalyculata* and presence of trichomes in *Polycarpea corymbosa, Justicia procumbens* and *Rungia*

repens which are specific to the plants are not found in *Fumaria parviflora* . All these characters could be used to distinguish *Fumaria parviflora* from their substitutes/adulterants. Chemically, syringic acidwhich is commonly found in all adulterants, is absent in *Fumaria parviflora.* The characters like presence of 3', 4'-di OMe quercetin, ferulic *(cis*-and *trans*- isomers), *p*-hydroxy benzoic, protocatechuic and melilotic acids in *Oldenlandia corymbosa,* 7'- OMe quercetin and kaempferol ,syringic, ferulic *(cis*- and *trans*-isomers), *p*-coumaric and *p*-hydroxybenzoic acids in *Rungia repens*, apigenin, acacetin, 3'- OMe luteolin and 7,3-diOMe quercetin in *Polycarpea corymbosa*, 6-0H kaempferol and 7- OMe 6- OH kaempferol, and ferulic (*cis*-and *trans*- isomers) acid in in *Justicia procumbens* and ferulic *(cis-and trans*-isomers) and *p*-hydroxy benzoic acids in *Peristrophe bicalyculata* are found absent in *Fumaria parviflora* and these could be used to distinguish all the substitutes/adulterants and their genuine drug plant. As all these compounds have various pharmacological effects, they could be considered as active principles of those plants. From among the substitutes/adulterants, *Oldenlandia corymbosa* is chemically more similar to *Fumaria parviflora* as both have same chemistry.

Similarly the characteristic features like cortical parenchyma with light brown deposits, 'V' shaped vascular bundles with cambium and various shaped starch grains typically having beak, of ***Bergenia ligulata*** were found absent in their substitutes/adulterants while rhomboidal crystals in *Aerua lanata,* presence of collenchyma between primary and secondary vascular bundles in *Ammannia baccifera*, microspheroidal crystals and angular boarded pitted vessels in *Celosia argentea* and stone cells in *Glossocardia linearifolia* which are specific to the plant used as distinguishing characters. Chemically the presence of *p*-hydroxy benzoic acid, found in high concentration in *Bergenia ligulata,* was found absent in their substitutes/adulterants this is the strong character differentiating the original drug. The phytochemical which are found absent in *Bergenia ligulata,* like ephedrine and melilotic acid in *Ammannia baccifera* and *Coleus*, ferulic *(cis-and trans*-isomers) acid in *Aerua lanata, p*-coumaric and melilotic acids in *Celosia*, and acacetin in *Glossocardia* are also can be used as the individual chemical characters of the substitutes.

The substitutes/adulterants of ***Glycyrrhiza glabra*** showed the more similarity except *Maerua arenaria* in having parenchyma with oil droplets and in the absence of starch grains and prismatic crystals, the characteristic of *Glycyrrhiza glabra.* The

minor difference among other adulterants are the presence of tyloses in *Glycyrrhiza glabra* was found absent in all substitutes/adulterants. Chemically *Taverniera cuneifolia* shared maximum number of common compounds with *Glycyrrhiza glabra* and can be differentiated in having *o*-coumaric and *p*-hydroxybenzoic acids while *Abrus* , *Maerua* and *Alysicarpus* in having melilotic acid

In case of substitutes/adulterants of *Polygala senega,* the diagnostic character such as broad 'V'- shaped medullary rays , collenchyma with oil droplets and thick walled wood parenchyma are conspicuously absent in all substitutes/adulterants. Other major differences are presence of rosette crystals in *Acalypha indica*, stone cells in *Adhatoda vasica,* deposition of pale yellow amorphous masses in some cortical and phloem parenchyma in *Polygala chinensis* and starch grains in *Xeromphis spinosa* which are found absent in *Polygala senega.* These characters could be used for differentiating the substitutes/adulterants. They can also be differentiated on basis of presence or absence of phenolic acids such as presence of ferulic(*cis*- and *trans*-isomers) acid in *Acalypha indica, p*-hydroxy benzoic acid in *Adhatoda vasica* , coumaric acid in *Polygala chinensis* and scopoletin in *Xeromphis spinosa.* All these compound were found absent in *Polygala senega.*

Microscopically, between ***Saraca indica*** and its substitutes/adulterants there are not much differences observed, except for the presence of continues bands of stone cells in *Saraca indica* which was absent in all their substitutes/adulterants. Other characteristic features like rosette crystals in *Bombax ceiba*, acicular crystals in *Polyalthia longifolia*, gum ducts in *Shorea robusta*, and parenchyma with yellow content and elongated stone cells with branched lumen in *Trema orientalis* were found absent in *Saraca indica.* Such characters could be used as their distinguishing characters. The phytochemicals such as kaempferol and *o*-coumaric acid in *Bauhinia variegata*, ferulic *(cis*- and *trans*- isomers) acid in *Bombax ceiba*, *Polyalthia longifolia* and *Trema orientalis* and 3'- OMe quercetin and *p*- hydroxy benzoic acid in *Shorea robusta* (which found absent in *Saraca indica*) are the distinguishing characters of the plants containing them.

Ash and extractive values of all the plants taken up in this study can be used as characters of those plants.

A chromatographic fingerprint profile can establish the identity of a plant. In view of this fact, the HPTLC fingerprints of the all five drug plants and their substitutes/adulterants developed during the course of this study and compared with

those of the respective adulterant plants were showing enough variations. Since all other experimental conditions were constant, the difference in the chromatographic profiles could be used to differentiate between two plants, and thus detect any adulteration in the given plant material

The present project resulted in finding out the pharmacognostic and phytochemical biomarkers and chemical diversity of all the drugs selected. The biomarkers are extremely useful in identifying the genuineness of the drug and also to find out adulteration.

Similarly ,the transverse sections of roots, leaves and stems will be of immense use in checking the identity of a medicinal plant. The powder study will help in finding out whether a powdered drug is genuine or adulterated. Locating a particular cell component, not reported from the source plant, in a powdered sample proves that the sample is adulterated. A little bit of plant debris settled at the bottom of a container having an extract will yield very valuable information on the source plant.

Highlights

The highlights of the present investigation are the following.

1. In terms of chemical constituents none of the substitutes/adulterants of five genuine drug selected are as potent as the genuine drug. However the adulterant *Oldenlandia corymbosa* chemically found to be more close to the genuine drug *Fumaria parviflora* and *Taverniera cuneifolia* to *Glycyrrhiza glabra.* All other substitutes/adulterants were found to show much differences and cannot be used as substitutes.

2. Though most of the substitutes/adulterants cannot replicate for the genuine drug, they contained biologically active compounds such as, flavonoids, phenolic acids, mucilages which exhibit a number of pharmacological properties and therefore can be used as separate drugs.

3. Flavonoids were absent in most of the roots, except for *Glossocardia linearifolia* where flavone acacetin was located. All the roots contained a good number of phenolic acids. The mucilages which were omnipresent were consisting of homopolysaccharides like galactans or heteropolysaccharides like glucomannans. The

phenolic acids and the mucilages present in the root are pharmacologically active and therefore may add to the clinical properties of the drug and in many cases may act synergistically with the alkaloids in improving the drug action.

4. The most important discovery was the isolation of Ephedrine from the roots of *Ammania baccifera.* Ephedrine is used to treat breathing problems (as a bronchodilator), nasal congestion (as a decongestant), low blood pressure problems (orthostatic hypotension), or myasthenia gravis. This drug has also been used to treat certain sleep disorders (narcolepsy), menstrual problems (dysmenorrhea), or urine-control problems (incontinence or enuresis). Ephedrine, is a CNS stimulant; its immediate effects are attributable to stimulation of dopamine release. Ephedrine is defined as a mixed sympathomimetic agent that acts by enhancing the release of norepinephrine from sympathetic neurons and by stimulating alpha and beta adrenergic receptors. Ephedrine stimulates the nervous system to enhance mood, reduce fatigue, and to make a person alert enough to smell their coffee in the morning. It also has the ability to increase energy and endurance; it does this through increase of blood flow to the muscles, resulting in an increase of oxygen and nutrient supply to the muscles. Ephedrine also increases basal metabolic rate (BMR), so that the body is spurred to burn calories faster, and so ephedrine is part of the thermogenic process that can result in substantial weight loss.

5. The present study unearthed a number of new sources of flavonoids, phenolic acids and polysaccharides like mucilages.

6. Chemical and pharmacognostical markers of twenty eight drug plants such as *Fumaria parviflora, Bergenia ligulata, Glycyrrhiza glabra, Polygala senega, Saraca indica, Oldenlandia corymbosa, Peristrophe bicalyculata, Polycarpea corymbosa, Justicia procumbens, Rungia repens, Aerua lanata, Ammannia baccifera, Celosia argentea, Coleus ambonicus, Glossocardia linearifolia, Taverniera cuneifolia, Abrus precatorius, Alysicarpus longifolius, Maerua arenaria, Polygala chinensis,Acalypha indica, Adhatoda vasica, Xeromphis spinosa, Trema orientalis, Polyalthia longifolia, Bauhinia variegata, Bombax ceiba* and *Shorea robusta* are developed in the present study.

7. HPTLC fingerprints of the all five drug plants and their substitutes/adulterants developed showed the enough variations.

8. The Ash and extractive values obtained in this study showed the purity and strength of that drug and extensive use in identifying the individual drugs and their quality control analysis.