B. Myrtales – Medicinal Plants

Chapter 10

Medicinal Plants: need for detailed studies.

A thorough knowledge of the chemistry of medicinal plants is absolutely essential in the WTO regime for understanding the manifold activities of the plants, the quality of raw materials, extracts and formulations and for marketing the plant derived drugs. About eighty percent of the whole world depends on the herbal-based alternative systems of medicine. Except for homeopathy, the activities of these drug plants are evaluated by their chemical components. The Ayurveda systems of India utilize about 2000 plants for curing different ailments. Chinese system depends on the 5757 plants listed in the *Encyclopedia of Traditional Chinese Medicinal Substances*. Japanese and Korean systems of medicine also include a large number of medicinal herbs. The total number of medicinal herbs in the world is about 70,000 (including the lower plants). In WTO perspective, all these plants are our common heritage. Utilizing all these plants for human welfare mooted the concept of the herbal medicine or Phytotherapy. Herbal medicine is now expanding at an astonishing pace due to the great inputs from ethnomedicinal practices being pooled from all over the world.

Medicinal plants and herbal medicines is an area where India can become the No. 1 country in the world. The well acclaimed systems of medicine like Ayurveda and Sidha and the large number of medicinal plants (more than 2500) which are in practice and a lot many which are to be discovered (lying hidden in many of the inaccessible forest regions) India can after the world "panacea" for all diseases. China, which commands 45% of the world market of herbal medicines, does it only with the help of six acclaimed plants. India can have a much higher chance of dominating the world of herbs which will, in turn, alleviate the sufferings of countless millions, but also bring heavy revenues to the country which can be used for the overall improvement of people. But this is easy to say than done. There are a multitude of problems plaguing the Indian herbal industry (Daniel, 2004, 2008) which are to be solved before we try to reap the countless benefits of our herbal wealth. Some of these problems are mentioned below.

Biomarkers

Biomarkers are of immense importance in the quality control procedures of any plant or formulation. Knowledge on the quality and quantity of biomarkers in a sample of raw material, extract or formulation is a prerequisite for marketing the products. It is also useful in judging the amount of active components in a sample, on the genuineness of the drug and the bio-efficacy of a drug. The absence of a biomarker in a sample indicates that the drug is completely adulterated. Lesser quantities of biomarkers indicate poor quality of the raw material or the sample/preparation is adulterated. Compounds other than the biomarkers when present indicate that the drug contains some other adulterant plant/drug.

In India mostly the drugs obtained in the market are of very poor quality. This is the main reason by which the efficacy of the drug is doubted many times. Most of the raw materials are adulterated. The adulteration of the drug materials may be due to the ignorance of the part of the plant collector on the incorrect Botanical identity of the drug or due to the poor availability of the same plant in a particular area. All these lead to the production of substandard medicines and alternately it is the consumer who is hit below the belt.

Biomarkers are the compounds or the cells/tissues/cellular contents specific to a particular plant. They indicate the presence and the availability of the plant in a preparation. Two types of biomarkers are generally recognized.

(1) Chemical biomarker,

(2) Pharmacognostic biomarker.

Chemical biomarkers

A chemical marker is any compound, whether it is a primary or secondary metabolite, or an assortment of compounds which are seen in plant in detectable concentration. An ideal biomarker should be stable, easy to isolate and characterize and should be immune to ecological changes. Any compound occurring in appreciable concentration can be a reliable biomarker. In cases where two related/unrelated plants possess the same compound, a second compound present in any one of the two in combination with the first compound form the biomarkers. The two biomarkers in a plant

need not be of the same chemical class. They can be widely different. For example if two plants contain the same alkaloid (say berberine), a coumarin/flavone/monoterpene present in any one of the two plants will form a biomarker along with berberine. A number of biomarkers and their methods of analysis are given in '*Indian Herbal Pharmacopoeia*' volumes jointly brought out by RRL, Jammu and IDMA, Mumbai as well as the volumes of '*Quality Standards of Indian Medicinal Plants*' published by ICMR.

2.3.2. Pharmacognostic markers

These are the tissues, cells or cell inclusions characteristic to a particular drug/ plants. They are of immense use in finding out the purity and genuineness of raw material in the whole form or in the powder form. Even in extracts, due to the common methods of filtration (through clothes or filters) a few cell debris will be available at the base of the container which may be examined to diagnose the drug. A member of books on Pharmacognosy both by Indian and foreign authors are to be referred to get a basic understanding of this subject. But even now data on a large member of plants are not available and a concerted effort should be made to document all the pharmacognostic markers of all the drug plants, their substitutes and their adulterants.

Pharmacognostic markers can pinpoint the identity of the source plant, but are not of much use in analyzing the chemical constituents. Though the books on Pharmacognosy include TLC and PC methods in identifying drug samples, here we consider these methods separate in phytochemistry. Some generalizations on the analysis of a plant power are explained here.

Active Principles

Every medicine owes its activity to a single or a group of pharmacologically active compounds (pharmacophore/s). In many cases, the active principle is the major compound which occurs in appreciable quantities but in many cases the major compound need not be the pharmacophore. The famous *Vinca* (*Catharanthus*) alkaloids never exhibited any antineoplastic property. It was only when the alkaloid extract was fractionated and each individual alkaloid was subjected to chemical studies, the anticancerous properties of vincristine and vinblastine (which occur in very low

concentrations in roots) were discovered. The major alkaloids in *Catharanthus* are ajmalicine and serpentine and the antineoplastic alkaloids from a very minor fraction of the total alkaloids. Similarly *Allamanda cathartica* is known to contain triterpenes esters like plumericin, isoplumericin, plumieride etc. which are supposed to exhibit the cathartic action of the drug. But it was allamandin, an iridoid lactone, which was found to exhibit anti-leukemic properties.

In many herbal medicines the active component is not clearly defined/pinpointed. The existing data only indicate that the aqueous extract/lipid extract exhibits various pharmacological actions. In many cases the different components of a plant drug are found to exert widely different properties. In the case of Punarnava (*Boerhavia diffusa*), the roots are found to contain punarnavoside, rotenoids such as boeravinones A,B,C,D &E, lignans such as liriodendrin and syringaresinol, flavones, sterols, boeravine (an isofuroxanthone) and hypoxanthine-9-L-arabinofuranoside. Pharmacological studies proved that punarnavoside is the antifibrinolytic agent. Liriodendrin and hypoxanthine-9-L-arabinofuranoside are found to be antihypertensive and the former is a Ca++ channel antagonist but the whole plant extract exhibit anti-inflammatory, diuretic and hepatoprotective activities probably due to the other compounds present in the plant. This clearly proves that the compounds other than the so-called active principle also are active in the healing processes attributed to the drug. Similarly in *Withania somnifera*, the total alkaloidal fraction exhibits hypotensive, bradycardic and respiratory stimulant activities while the other major group of components withanolides possesses antiarthritic, immunosuppressive, antitumour and antibacterial properties.

It was customarily believed that the major compound present in a medicinal plant is the active component in its drug action. But this concept is changing these days. The major compounds need not be the active compound. A number of new compounds having pharmacological action are reported recently from the well-known medicinal plants as also new properties are discovered for some of the known compounds. Entirely new medicinal properties for certain compounds also are discovered these days. Another area of interest is that a large number of polysaccharides, polyphenols and lectins are found to exhibit distinct pharmacological properties. Some of these aspects are described below (Daniel, 2004).

a. New compounds reported from the known medicinal plants

1. *Strychnos nux-vomica* – main constituents are alkaloids. New compounds identified are iridoids such as 5-loganic acid, 6-0-acetyl loganic acid and 3-0 acetyl loganic acid.
2. *Cissampelos pereira* – Known for bis-benzyl isoquinoline alkaloids such as are hayatine, hayatinine, hayatidine, *l*-bebeerine etc. New compounds isolated area chalcone-flavone dimmer- cissampeloflavone.
3. *Apium graveolens* Known for volatile oils, is found to contain five sesquiterpenoid glycosides (celerioside A-E) along with nor-carotenoid glucosides and a lignan glycoside.
4. *Pimpinella anisum*- Known for volatile oils, now found to contain glycosides of 3- hydroxy anethole, 3-OH estragole, methyl syringate, hexane-1,5-diol and 1- deoxy –L-erythritol.
5. *Cuminum cyminum.* Principal components are volatile oil rich in cuminaldehyde, now found to contain water soluble sesquiterpene glycoside hydroxyguadienolide, dihydroxyeudesmenolide and alkyl glycosides.
6. *Sida spinosa,* known to contain mucilage and alkaloids like ephedrine, now known to contain ecdysone and glyceryl-1-eicosanoate.
7. *Allium cepa*- Known for sulphides, now known for 4-substitated carboxy pyranocyanidin
8. *Commiphora wightii* , Known for guggulusterols now contain an antifungal flavonone, muscanone [3-0-(1",8"14"- trimethylhexadecanyl)-naringenin]
9. *Pterocarpus marsupium.* Known for tannins, now found to contain glycoflavones based on aurones and flavonones.
10. *Humulus lupulus,* known for humulones and lupulones (Phenolics with isoprenoid side chains), is found to contain estrogenic prenylated chalcones and prenyl flavonones.
11. *Vitex negundo.* Found containing iridoids and flavones, this plant is now discovered with a phenyldihydronaphthalene type lignan (vitedoin), phenyl naphathalene type lignan alkaloid (vitedoamine A) and a new trinorlabdane

type diterpene (vitedoin) alongwith known lignans like detetrahydroconi dendrin, vitofolal E, F and cedrusin.

12. *Capsicum annum.* The chillies, known for the phenolic amides capsaicins are known known to yield 19 sesquiterpenes.
13. *Murraya koenigii* is well-known for the volatile oil and flavonoids. But now carbazole alkaloids like murrayanine and 8, 8" bis koenigine are isolated which are found to display cytotoxic activity against cultured KB cells.
14. *Picrorhiza kurroa.* Found to contain iridoids, picroside and kutkoside, this drug is now detected with cucurbitacin glycosides and phenol glycosides
15. *Randia spinosa* – Known to contain saponins (randialic acid A&B) and mannitol. New compounds identified are iridoids such as randinoside, galioside, deacetyl asperulosic acid methyl ester, scandoside methyl ester, geniposide and gardenoside.
16. *Emblica officinalis*- The principal components are tannins and ascorbic acid. A good amount of free amino acids such as free alanine, aspartic acid, glutamic acid, lysine and proline are reported now which may have therapeutic effects.

b. New types of active principles

1. Polysaccharides

1. A galacturonan isolated from *Nerium oleander* Linn. flowers has been found to possess antitumour and immunological activities. Polysaccharides from the leaves of the same plant was found of stimulate mitogen-induced T & B. Lymphocyte proliferation.

2. Cell wall derived arabinogalactan and fucogalactoxyloglucans are found to be immune-stimulating principles of *Echinacea*

3. An acetylated manner, acemannan, isolated from *Aloe vera* is found to be immune system modulating.

4. Polysaccharide fraction of the aqueous extracts of *Viscum album* is cytotoxic and immunostimulatory.

5. Xylans from *Phyllanthus niruri* .

6. Hexahydrodibenzopyrans (HHDBB) like machaeriol A,B,C, & D) and secohexahydrodibenzopyrans from *Machaerium multiflorum*

7. Wall polysaccharides such as arabinan, acidic rhamnogalacturonan, homogalacturonan, galactans, xyloglucans etc. of ginseng roots are found responsible for some of the immunostimulatory activity.

2. Lectins and Proteins

1. Trichosanthin, a protein produced in the roots of *Trichosanthes kirilowii* (Chinese cucumber plant) cause abortions. But now it is found to selectively inhibit replication of HIV virus *in vitro* by inhibiting ribosomal protein synthesis and cellular reproduction.

2. Aloe lectins purified from the leaf epidermis of *Aloe* is found to inhibit the growth of a fibrosarcoma in mice.

3. Lectins from mistletoe, are found to inhibit tumour growth due to the fragmentation of DNA in cancerous cells by the lectins

Other compounds

1. Piperidine alkaloids such as (-)–3-O-acetyl spectaline, (-)–7-hydroxy spectaline, iso-6-spectaline and spectaline are the new cytotoxic (DNA-damaging) principles isolated from the flowers and green fruits of *Cassia spectabilis.*

2. Cyclopentatetrahydrobenzofurans such as rocaglamide from *Aglaia* spp. (*Melia*) are strongly insecticidal and show pronounced cytostatic effects against human cancer cells in vitro.

3. Proteoglycans from *Convolvulus arvensis* are found to inhibit angiogenesis and stimulate immune responses.

New activities of known compounds

1. Triterpenes such as 3β-acetoxy-12,19-dioxo-13(18)-oleanene and related compounds isolated from aerial roots of *Ficus microcarpa* are found to be cytotoxic against three human cancer cell lines.

The large conglomerate of organic compounds present in a herbal extract, used for medication, cast a great doubt on the so-called "active component". This extract may contain a good number of oligosaccharides, polysaccharides, starches (if a tuber is used), sugar derivatives, aminoacids (both protein and non-protein including essential amino acids), peptides, proteins, fatty acids (including essential fatty acids), fatty alcohols, vitamins, and minerals besides the "privileged" secondary metabolites. It is these very same compounds, which make and regulate the body, when we take the plants as foods. Therefore these additional primary metabolites may have a very positive role when they are taken as a medicinal extract. Earlier every phytochemist was looking for active components like alkaloids, saponins and tannins in plants. Terpenoids and phenolics especially the latter, received very scanty attention.

Many a times, the group phenolics are cursorily mentioned in accounts of medicinal plants. But the renewed interest on antioxidants, after the realization of their active role in diseases such as atherosclerosis, stroke, cerebral thrombosis, diabetes, Alzheimer's and Parkinson's diseases and cancer (Tiwari, 2004) firmly put these compounds on a pedestal as pharmacologically active components. Since the phenolics are very effective antioxidants, besides their curative role, they play varied roles such as (1) protecting other active components in a medicinal preparation, (2) protect the membranes and tissues from oxidation at the site of medicinal action or (3) protect other antioxidants (needed elsewhere) from oxidation. The contribution of phenolics as antimicrobials providing a microbe-free environment, for the other drugs to act, also is significant. But for phenolics, no other group of compounds has a role in maintaining the system (from wear and tear). Alkaloids and terpenoids have mostly curative actions on

the system. The antimicrobial terpenes (mono- & sesquiterpenes) also, if present in an extract, support significantly the action of other drugs.

In contrast, when a herbal formulation (in Ayurveda a number of plants are involved in a formulation) is given, the multitude of components, including a large amount of primary metabolites, are available to the body for repairing all the systems. Body is a wonderful machine and therefore it repairs itself using all these components. And that is the reason why a person becomes healthy and remains so after a herbal (say Ayurvedic) treatment. To quote an analogy, herbal therapy is like a farmer enriching the field to get a better crop, whereas the other systems are like enriching the seed while neglecting the field.

3. Chemical spectrum.

A single metabolome, the sum total of primary and secondary metabolites in an organism, contains about 4,000 compounds (It may even go up to 10,000). The total number of compounds present in plant kingdom is about 2, 00,000. All these compounds are used by plants for various purposes like nutrition, maintenance, reproduction, healing, defense, offense, etc. We generally use the plants only as nutrient sources and to some extent for healing processes. When once we consume a plant/product as food we receive not only nutrients from them but also a large variety of "other compounds" the function of which in our system is relatively unknown. Many of the main food plants (cereals and pulses) contain a fairly good amount of polyphenolic antioxidants (Latha & Daniel, 2001). The vegetables, fruits, nuts etc also are good sources of secondary metabolites like polyphenols, carotenoids, volatile oils, organic acids, waxes etc. (Daniel, 1989). A review of the phenolics present in a large number of Indian medicinal plants is available (Daniel, 2005). Recently a number of phenolics especially flavonoids are found to exhibit diverse pharmacological properties. They are:

1. Rhein, an anthraquinone found in *Rheum* (Rhubarb is known for the purgative action it exhibits. But it is found to be anti neoplastic.

2. Kaempferol glycoside isolated from *Forsteronia refracta* (Apocynaceae) is tumour inhibitory in that it inhibits the action of cancer linked protein RSK

(ribosomal S6 kinase) which plays a role in cancer proliferation by blocking the cell cycle during Gl phase This compound is found of inhibit proliferation of breast cancer cell line MCF-7, producing a cell cycle block in the G1 phase with an efficacy paralleling its ability to inhibit RSK in intact cells

3. Kaempferol–3,7,-O-(α-)- dirhamnoside isolated from *Bauhinia forticata* leaves is found to be hypoglycemic

4. Vitexicarpin, a flavone isolated from leaves of *Vitex negundo* is found to be cytotoxic.

5. Murrayacoumarins A,B,C and other coumarins of *Murraya siamensis* are found to be anti-tumour promoting.

The data on the pharmacological action of some of the day-to-day compounds which we come across also are interesting. Duke (1997) describes ferulic acid, gentisic acid, kaempferol glycosides and salicylic acid as pain relievers while ascorbic acid, cinnamic acid, coumarin, myricetin, quercetin and resveratrol are explained antiinflammatory. Even the variety of chemicals and their richness (concentration) in a medicinal herb is of great value in assessing its property. Duke's data base states that both coriander and liquorice contain 20 chemicals with antibacterial action; Oregano and rosemary has 19; ginger 17; nutmeg 15; cinnamon and cumin 11; black pepper 14; bay 10 and garlic 13. Quantity wise liquorice contains up to 33% bactericidal compounds (dry weight basis), thyme 21%, Oregano 8.8% &, rosemary 4.8% coriander 2.2% and fennel, 1.5%. Needless to say the above data explains the drug action of the said plants.

The role of many of the compounds especially of polyphenolics, which are taken often unintentionally or unknowingly, in our body, is not assessed. All these compounds play a role in protecting and maintaining our system. The great role of "dietary fibre" (earlier known by a contemptuous term 'roughage') in reducing cholesterol and sugar levels in the body, and other digestive problems is realized only recently.

Synergism

The case of *Hypericum perforatum*, (St. John's Wort) wherein a number different molecules are found have the same activity is interesting. The plant is used for treating anxiety, depression and sleep disorders. The compounds present in the plant are, lipid soluble hypericins (up to 0.75%), flavonoids (2-4%), xanthones (0.0004%), procyanidins (8%), hyperforin (2.8%) and volatile oil (0.1 –1%), of which hypericins, xanthones and hyperforin are characteristic to St. John's Wort. It was shown earlier that hypericin inhibits monoamine oxidase (MAO) and thus increases the amount of neurotransmitters in the synapse between neurons and leads to enhanced mood. Recent studies have shown that flavonoids and xanthones in *Hypericum* extracts inhibit catechol-O-methyl transferase, another enzyme that catabolises neurotransmitters. It is also shown that Hypericum extract decreases the uptake of the neurotransmitter, serotonin, all rat synaptosomes. Thus it appears that a number of mechanisms act synergistically to increase,the neurotransmitter signal.

Antioxidant therapy

Free radicals are a necessary evil. They are fundamental to any biochemical process and form an integral part of aerobic life and metabolism. They are generally produced by respiration, which uses oxygen and some cell immune functions. In the body these compounds are counteracted and balanced by the natural antioxidants. According to the present knowledge, in addition to the traditional role of protecting the fats, proteins and carbohydrates, the biological antioxidants manage repair systems such as iron transport proteins (transferrin, ferrutin, caeruloplasmin etc), antioxidant enzymes and factors affecting signal transduction, vascular homeostasis and gene expression (Frankel and Mayer, 2000). But environmental pollutants such as air/water contaminants, radiation, pesticides etc produce a large influx of free radicals in the body and tip the balance between prooxidant (free radicals) and anti-free radical (antioxidicants) in favour of the former, resulting in a cumulative damage of protein, lipid, DNA, carbohydrates and membranes leading to **oxidative stress**. The oxidative stress, in which the free radicals outweigh antioxidants in number, is suggested to be the cause of aging and other diseases like atherosclerosis, stroke, diabetes, cancer and neuro-degenerative diseases

such as Alzheimer's disease and Parkinsonism. Studies conducted worldwide have provided enough evidence stating that providing the body systems with sizable amount of antioxidants may correct the vitiated homeostasis (Tiwari, 1999; Pietta, 2000) and a proper administration of antioxidants can treat or prevent the onset of ailments.

We normally receive a good amount of antioxidants through our diet consisting of spices, vegetables, pulses and cereals which contain a large variety of these compounds and their role in preventing human diseases, including cancer, atherosclerosis, stroke, rheumatoid arthritis, neurodegeneration and diabetes are currently being followed. But at the time of oxidative stress, a good amount of external antioxidants are to be pumped into, and this is the basis of various antioxidant-based therapeutics.

Atherosclerosis is considered mainly due to oxidation of low-density lipoproteins (LDL) leading to the accumulation of cholesterol in the atherosclerotic lesion. In addition, the high fat diet also is found to decrease the expression of genes which produce free-radical scavenging enzymes resulting in an oxidative stress (Sreekumar et al., 2002). Recently probucol and ∝-tocopherol-based compounds have been designed and developed to combat atherosclerosis, which are undergoing clinical trials. Similarly therapeutic formulations from Arjuna, Abana, Shosaikoto etc having antiatherosclerotic properties are of great promise (Inoue, 2000; Wasserman et al., 2003). Stroke and cerebral thrombosis are the other related diseases receiving attention in free radical scavenging and antioxidant based therapeutics.

The increased levels of sugar in blood, caused by **diabetes** also leads to the production of free radicals leading to oxidative stress. This paves ways to further cellular damage and late diabetic complications. In this case also antioxidants are found to decrease oxidative stress and further complications (Karazu et al., 1997). Supplements of antioxidants have shown to decrease oxidative stress and diabetic induced defects in diabetic animals. Since some of the plants used for diabetes are rich sources of antioxidants, the activities of these plants are now considered based on their antioxidant principles (Scartezzi and Speroni, 2000).

Oxidative stress also is found to induce neuronal damage, leading to neuronal death and cause to neurodegenerative diseases such as **Alzheimer's and Parkinson's diseases**. In the former case the characteristic histopathological alterations such as neutristic plaques composed largely of amyloid β-peptides and neuronal aggregates of abnormally phosphorylated cytoskeletal proteins, are found to be due to the overproduction of ROS (Reactive Oxygen Species). The free radical mediated selective degeneration of dopaminergic neurons in the nigrostriatal system, which results in loss of dopaminergic influence on other structures of basal ganglia, is found to result in normal Parkinsonian symptoms. A number of studies show that antioxidants like L-DOPA, tocopherols, ascorbate etc can block neuronal death and may have therapeutic properties.

Cancer is another disease in which antioxidants can play a beneficial role. Metabolic activation of a carcinogen is a free radical dependant reaction. It is also found out that endogenous DNA damages arise from a variety of intermediates of oxygen reduction and free radicals and this play a positive role in carcinogenesis. Misrepair of damaged DNA as also the oxidation of guanine by free radicals are other problems here. The higher amount of H_2O_2 and other reactive oxygen species in cancer cells also points to the persistent oxidative stress in cancer. Phenolics and isothiocyanates effectively used in inducing H_2O_2 and they activate stress genes, which in turn cause large scale irreparable damage to DNA and thus inhibit proliferation and act as anticancer agents (Loo, 2003). The anticancer activities of antioxidants involve (i) trapping the carcinogen, (ii) blocking the metabolic activation of carcinogens, (iii) scavenging the free radicals and their production, (iv) block lipoxigenase / cycloxygenase pathway etc.

From among the kinds of radicals (hydroxyl, alkoxyl, peroxyl and carbon centered) involved in oxidative stress, the peroxyl radicals are considered to be the major target radical for radical scavenging antioxidants in vivo (Niki et al., 1995). Peroxyl radicals are electrophilic in nature and therefore electron-donating substituents in phenolics increase the reactivity towards these radicals. Phenolics having substituents on the ortho-position are found to be better peroxyl scavengers. In addition flavonols are found to contain a strong nucleophilic centre that reacts with electrophilic species and thereby decreases the bioavailability of the ultimate carcinogens.

In plants phenolics form a very large group. They include, simple phenolics, phenolic acids, phenyl propanes, acetophenones, stilbenes, xanthones, flavones, flavonols, catechins, aurones, chalcones, isoflavonoids, flavans, neoflavonoids, tannins etc. All these types of phenolics are very effective antioxidants. The large number of medicinal plants containing phenolics (as active principles) will effectively support the role of these compounds in therapy. In addition the various phenolics found in other medicinal plants (as such there is no plant without phenolics) having different active principles will ably support the curative action of the latter compounds by providing a free radical- free environment.

Nutraceuticals

Most of the herbal drugs from India are not marketed as drugs in Western countries but are sold as food supplements having some pharmacological properties. Such products are known as Nutraceuticals.

Nutraceuticals are foods supplemented with compounds having pharmaceutical properties. They contain a sizable amount of nutrients in the form of carbohydrates or proteins (the major compounds) and dose of compounds having varied pharmacological properties. On developed countries the foods especially those which are canned, are fortified with a good dose of minerals, vitamins etc. and are prepared to take good care of health. Calcium enriched beverages, food bars, cereals, yogurt and fermented foods dominate the nutraceuticals market in Japan, while in Europe it is omega 3 fatty acids along with calcium.

Recently herbal medicines, in the form of plant parts (containing active components) are added to prepare nutraceuticals. Fenugreek (to prevent and treat diabetes), isoflavones (to prevent breast cancer and to reduce the incidence of osteoporosis), dietary fiber, proteins, amino acid supplements, β- glucans, antioxidants, vitamins from fruits, tocopherols from oilseeds, vegetable proteins especially texturised vegetable proteins from soybean, β- glucans from oat and barley (to reduce LDL, cholesterol and lower blood pressure), omega-3- fatty acids (precursors of prostaglandins , leukatrienes and brain lipids) anthocyanins etc. are other components added to the foods to prepare

nutraceuticals. Animals are fed with flax seeds (rich in omega 3 –fatty acids) are founds to produce eggs and milk rich in omega-3- fatty acids).

Phase II enzyme inducers from *Brassica* vegetables such as sulforphane and glucoraphanin present in broccoli and similar compounds seen in many other Brassicaceae members like *Lepidium* are also introduced in nutraceuticals (Phase II enzymes are part of the body's RDS defense system. They prevent or cellular damage).

Global market for nutraceuticals is 40-5- billion US dollars and this market is estimated to good at the rate of 6% per annum. Nutraceuticals also are subjected to the regulatory systems applied to pharmaceuticals or foods. "Prevention is better than cure" is the principle of nutraceuticals.

India can produce a wide variety of nutraceuticals .Foods can be prepared with all the "rasayana" drugs. The plants like Ashwagandha, Amrut, Punarnava, Shataveri, Amla etc. are general tonics which can be mixed with food materials. They will take care of all body functions and regulate all body systems. These provide principles active in normalizing the metabolism and contain, in addition, a number of vitamins, minerals, co-factors and antioxidants. Depending on the disease to be taken care of, different foods tailor made with the drugs prescribed for that disease can be prepared and sold as nutraceuticals. The well known preparations like "Chavanprash, Dhanwanthari rasayana, Ashwagandhadi" etc. contain plant drugs with energy rich ghee, suger etc. These preparations can be recommended as nutraceuticals.

Value addition

In general, one medicinal plant is known for only products based on one drug part, be it root, leaf, bark or seed and in the market only that product is sold and gives monetary benefit to the farmer who cultivates the plant in large scale. For example if *Sida* is cultivated by a farmer, he will get income only by the sale of roots which is the official drug. The remaining portions of *Sida* are thrown away as a waste. But it is seen that the leaves, stem and seeds of *Sida* possess distinct medicinal properties and are used for those benefits by many a rural folk. If somehow a demand can be created for these plant parts, they too can be sold by the farmer and he gets "added value" for the plant he grows. This will be an added incentive for growing medicinal plants by any grower.

Such value addition will also lessen the pressure on the acclaimed drug plants because alternative sources of many a chemical pharmacophore will become available. For example *Sida cordifolia* contains ephedrine in its leaves and stems. Normally ephedrine, a well-known bronchodilator, is obtained from various species of *Ephedra* which are now becoming threatened and/or endangered. A person who cultivates *Sida cordifolia* can sell the roots as *"Bala"*, an acclaimed drug, and use the stems and leaves of the same plant as sources of ephedrine. Same is the case with many of the medicinal plants used in Indian systems of medicine.

Another type of value addition can be achieved in terms of the "non- active principles" of a plant. The polyphenolics such as flavonoids and tannins which are present in many of the barks, leaves etc will provide antioxidant benefits in that they will protect the active principle from oxidative degradation as well as give a free- radical free environment on the site of action. Thus the knowledge of the "other compounds" in the herbal preparation will give an idea of the other benefits present in the crude drug.

Taking into all these aspects in mind, 15 medicinal plants belonging to the families included in Myrtales have been studied for their biomarkers (chemical as well as pharmacognostic) and chemical spectrum in parts which form the drug. Besides the specific parts used commonly in medicine, other plant parts used by many for medicinal purposes also are subjected to chemical and pharmacognostic studies. In chemical studies, emphasis is given to antioxidant polyphenols which are poorly studied in a conventional phytochemical treatment.

The medicinal plants taken up for studies are the following:

Family Myrtaceae:

1. *Psidium guajava* Linn
2. *Pimenta dioica* Merr.
3. *Syzygium malaccense* Miq.

Family Combretaceae:

4. *Terminalia chebula* Retz.
5. *Terminalia arjuna* W. & A.
6. *Combretum ovalifolium* Roxb.

Family Lythraceae:

7. *Ammania baccifera* Linn.

8. *Lagerstroemia flos-reginae* Roxb.

9. *Lawsonia inermis* Linn.

10. *Woodfordia floribunda* Salisb.

Family *Onagraceae*

11. *Ludwigia octavalvis* Roxb.

Family *Alangiaceae*

12. *Alangium salvifolium* Wang.

Family Melastomataceae

13. *Melastoma malabathricum* Linn.

Family Lecythidaceae:

14. *Barringtonia acutangula* Gaert.

15. *Careya arborea* Roxb.

Table 6.The distribution of various chemical markers in some members of the Punicaceae. Onagraceae, Lecythidaceae and Alangiaceae

Sr.No.	Name	Acacetin	Luteolin	3' - OMe Luteolin	Kaempferol	4' - OMe Kaempferol	Quercetin	3' - OMe Quercetin	3', 4' - diOMe Quercetin	Myricetin	Gossypetin	5' - OMe Gossypetin	Quinone	p-Hydroxy benzoic acid	Vanillic acid	Syringic acid	Gallic acid	Mellitic acid	p-Coumaric acid	o-Coumaric acid	Ferulic acid	Sinapic acid	Protocatechuic acid	Tannins	Alkaloids
	Family : **Punicaceae**																								
1	Punica granatum Linn.(leaves)	+	+	+									+		+	+	+	+						+	+
	——"—— (stem)								+		+	+	+		+	+	+							+	+
	Family : Onagraceae																								
2	Ludwigia octovalvis(Jacq.)Raven (leaves)						+								+	+	+								
	——"—— (stem)						+						+	+	+	+	+								
	Family : **Lecythidaceae**																								
3	Couropita guainensis Aubl.(leaves)				+		+						+		+	+						+			
	——"—— (stem)						+				+				+	+			+						
4	Careya arborea Roxb. (leaves)				+			+						+	+	+	+		+						
	——"—— (stem)		+												+	+	+		+						
5	Barringtonia acutangula (L.) Gaertn (leaves)								+			+	+		+	+	+	+	+						
	——"—— (stem)										+	+	+		+	+									
	——"—— (bark)									+	+				+	+									
	Family : **Alangiaceae**																								
6	Alangium saivifolium (Linn.f.)Wang (leaves)				+	+	+						+		+	+		+	+	+					+
	——"—— (stem)						+						+		+	+		+			+				+
	——"—— (bark)				+								+		+	+				+			+		+