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Review on Plant Biomolecules: A Greener Alternative

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ABSTRACT:

There are some principles in Green Chemistry. By utilizing those principles one can restrict or control the use or generation of hazardous substances. It is necessary to develop alternative methods or to find greener reagents for minimum utilization of environmentally unfavorable substances. The secondary metabolites of plants are not necessary for the growth, development and reproduction of the plants but their use may be viewed as a greener alternatives. This review article is focused mainly on the three biomolecules (flavonoids, alkaloids and terpenoids) which give us social and environmental benefits. As the flavonoids have free radical scavenging property, they are mainly used in pharmaceuticals. Nowadays in agriculture and in food industry the flavonoids are also widely used. Generally alkaloids are poisonous; they are used as pesticides. Alkaloids itself protect the plants against the harmful insects or pests. Alkaloids also have physiological activities. Terpenoids, the essential oils of the plant are used as perfume, flavouring agents also helpful for good sleep and boosts the energy level. The terpenoids in medicinal plants are also used in pharmaceuticals. Due to the presence of special odour, terpenoids act as pollinator. Day by day, scientists are trying to find out the bioactive plant molecules from easily available plants in local area and searching their biological activity for reducing the environment pollution.

KEYWORDS: Flavonoids, Alkaloids, Terpenoids, Bioactivity

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INTRODUCTION:

Over a past few decades a significant attention has been paid for the use of plant products as well as the use of biological organism such as algae fungi yeast and bacteria for greener alternatives. However the main disadvantages of using direct biological species are seasonal availability, difficult and time consuming to maintain the culture medium and reproducibility of biological species. The advantages of using plant molecules over synthetic one is due to their low toxic to mammals as well as animals and environment easily biodegradability and minimum residual effect in the surrounding. Biomolecules are the substances produced by the plants or any living organisms. There are some plant biomolecules like protein, lipid, vitamins, lactic acids which are the primary metabolites. Some biomolecules like alkaloids, flavanoids, terpenoids, and steroids are the secondary metabolites. All of these are obtained from different parts and different family of the plants or living organism. These biomolecules are used in different areas like in pharmaceuticals, pesticides, metal chelating ligands or any substituted synthetic substances. Even now the researches are going on different areas for alteration of synthetic reagents by using the greener alternatives.

DISCUSSION:

Some biomolecules which are secondary metabolites of the plants are used as greener alternatives are discussed below.

Flavonoids:

Flavonoids are the polyphenolic compounds. Flavonoids are present in different parts of the plants like fruits, roots, pollen and vegetables. In plant the flavonoids are present as glycoside. The basic structure of flavonoid (Figure 1) is $C_6-C_3-C_6$ (2-phenyl-benzyl- γ -pyrone) where each C_6 is the benzene ring.

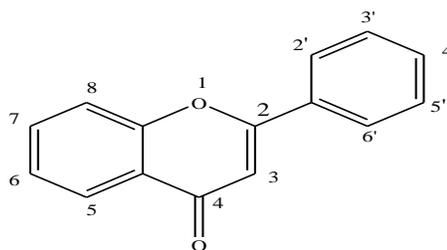
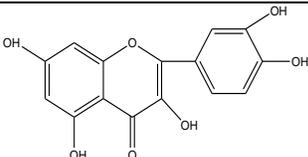
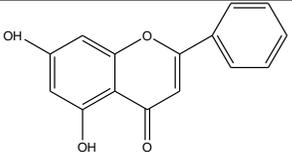
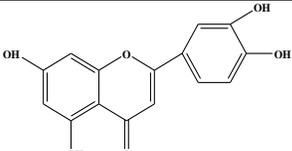
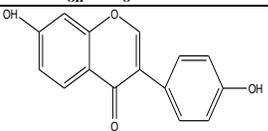
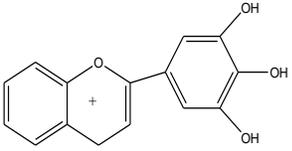
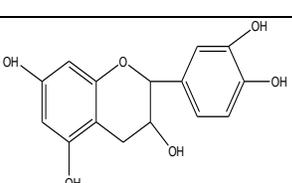


Fig. 1: Basic structure of flavonoid

The different oxidation states of the C3 moiety, flavonoids are again classified and the classification is shown in Table 1.

Table No. 1 Classification of flavonoids¹

Flavonoids	Structure	Example (Bio Activity)	Source
Flavonol		Quercetin (Antioxidant, neuro degenerator, metal chelating ligand)	Grapes, berries, cherries, broccoli, and citrus fruits
Flavanone		Hesperidin (Antiinflatroy, antialergeic)	Orange , lemon, tangerine
Flavone		Luteoline (Anticancer)	Broccoli, cabbages, onion leaves, carrots
Isoflavone		Daidzein (Menopausal relief)	Soyabeans, legumes
Anthocyanidin		Cyanidine (Metal estimation, antidiabetic)	Red berries, cherry, blackberry
Flavanol		Catechin (Antioxidant, anti microbial, antiinflammatory)	Tea, strawberry, red wine

Antioxidants help to neutralize the free radicals, which are produced in our bodies. Due to the production of excess free radicals during metabolic process different types of diseases are appeared. As the flavonoids have free radical scavenging property, it is consider that the flavonoids are act as antioxidant. So the flavonoid biomolecules can protect us from diseases and are most effective in pharmaceutical chemistry.² Jagetia et al. studied the flavonoid compounds present in *S. wallichii*. The neuroprotective as well as cardio protective effect was found in those flavonoid compounds.³ Some flavonols including quercetin and its derivative isolated from the fruits of cactus *Opuntia ficus-indica* have neuro protective activity.⁴ Traditonally this cactus fruits are used as folk medicine.^{4,5} As the

flavonoids are strong antioxidant, bioactive and pharmacological active in mammals, these compounds are also referred to use as nutraceuticals.⁶ One of the component of Green tea is catechine (flavonols). It is also known as epigallocatechin-3-gallate which helps to restrict cell damage and has other beneficial effects.^{7,8} Though flavonoids are naturally occurring compounds and regarded as nutraceuticals, it was found that catechin present in green tea acts as anti thyroid activity but the overdose of catechin causes diseases like goiter which was studied on rats.⁹

Another most important property of this flavonoid compounds is the formation of complex with different metal ions. There are numbers of possible coordination site of the ligand (flavonols) which can bind with metal ions is shown in the Figure 2.

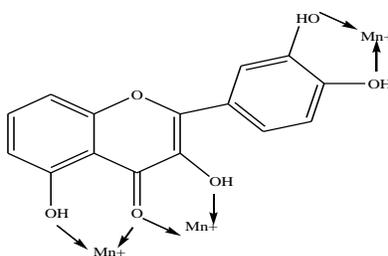


Fig.2: Possible binding sites of flavonoid compound

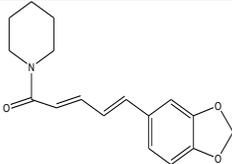
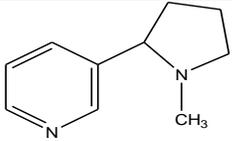
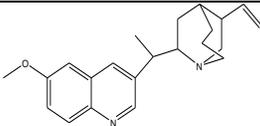
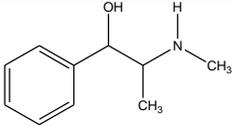
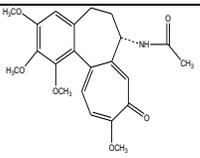
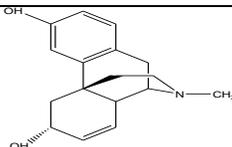
A numbers of metal ions in the periodic table can coordinate with some flavonoids like quercetin, rutin, morin, hesperidin.¹⁰ Catechin binds with some essential metal ions and increases the antioxidant property.¹⁰ Metal when forms complex with flavonoid increases the anti cancer activity¹¹. Flavonoids are important in agriculture also. As the colour of fruits and flowers are responsible for anthocyanine (one of the flavonoids), pollinators attracts them.¹² Flavonoids also have pesticidal activity. Flavonoids extracted from the fruits of *M paniculata* of Rutaceae family¹³, Brazilian endemic plant *Helicteres velutina*¹⁴ and the plant *Vitex negundo* and *Andrographis paniculata* have larvicidal activity.¹⁵

Alkaloids:

Alkaloids are basic organic compounds having nitrogen atom. Nitrogen is generally present as tertiary amine. Sometimes it presents as secondary amine but primary amine is rare. As they are basic in nature they form salt with the plant's acid. Alkaloid solanine is present in potatoes as glycoside and toxic to human and plant animals.¹⁶ Piperine present as amide where atropine or cocaine are present as ester. Alkaloids like colchicines, ricinine are neutral in nature. Alkaloids are optically active generally,

levorotatory and are mainly obtained from the different parts of the plants (fruit, leaf root, seed) but some alkaloids are obtained from many bio organisms like fungi, bacteria even animals like toads. The function of the alkaloids is the byproducts of metabolism. The alkaloids are generally poisonous, they may be present in the plant due to the protective action but uncertain. Some common alkaloid biomolecules and their functions are shown in the Table 2.

Table No. 2 Bioactive alkaloids¹⁷

Alkaloid	Structure	Source (family)	Use
Piperine		Fruits of Black pepper (Piperaceae)	Antitumor, anti-inflammatory insecticide etc.
Nicotine		Tobacco leaves (Solanaceae) Nicotiana tabacum	Pesticides
Quinine		Bark of chincona tree (Rubiaceae) Cinchona officinalis	Anti malaria
Ephedrin		Ephedra vulgaris (Ephedraceae)	Cardiac stimulant, hypertensive agent, hyperglycaemic, and bronchodilator.
Colchicine		Colchicum autumnale plant or autumn crocus (Colchicaceae)	Prevent gout attacks Treatment of inflammatory symptoms of Familial Mediterranean Fever (FMF)
Morphine		Papaver somniferum poppy plant	Psychoactive drug

It was said that an alkaloid from the hemlock (*Conium maculatum L*) plant was the main victim of the Greek Philosopher Socrates who died in 399 BC. Later it was found that coniine alkaloid from

hemlock plant can be used for medical purposes for the relief of pain without serious side effect.¹⁸ Alkaloids like morphine, cocaine act as narcotics. Morphine is used as narcotic analgesic (to relieve pain) and acts on central nervous system.¹⁹ Alkaloid rutaecarpine and their derivatives (*Evodia rutaecarpa*) have antiplatelet activity.²⁰ Depending on the nature of chemical structure and action, opium alkaloids are two types. Morphine, codeine, and thebaine are narcotics and Papaverine, noscapine are used as to relax involuntary muscles.²¹ The latex of poppy plant contain large amount of opiate alkaloid is used for pain relief.²² Alkaloid like brucine is also poisonous. But later it was found that brucine is pharmacologically active like anti tumor, anti inflammatory analgesic.²³

Alkaloids are mainly poisonous and bitter in taste. The alkaloids act as pesticides can kill or control harmful pests which are disturbing in our lifestyle day by day. Scientists are doing their research work on pesticide by using the plant biomolecules. Nicotine obtained from tobacco leaves, is used as insecticide, piperine from black pepper as larvicides, insecticides.²⁴ Alkaloids are the used mainly in agriculture and pharmacologically but some alkaloids have metal binding properties. Piperine alkaloid from fruits of black pepper is a good chelating ligand. Radiometrically studied by Lahiri et.al that piperine selectively binds with gold.²⁵

Terpenoids:

Terpenes are simple hydrocarbons. The basic structure of terpene (Figure 3) is composed of five carbon isoprene unit (2-methyl-1, 3 butadiene). But if they contain C, H and O they are called terpenoid compounds. In other word terpenoids are the derivatives of oligomers of isoprene unit. The isoprene units are joined generally in head to tail fashion in terpene molecule (Figure 4). But some exceptions are also present. In carotene there is tail to tail joining in the middle.²⁶

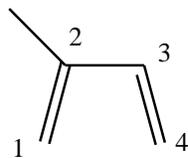


Fig. 3: Isoprene

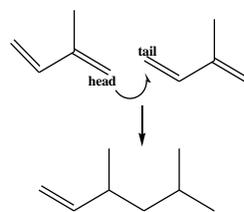


Fig. 4: Head to tail fashion

Terpenes are the plant materials. Generally they are main constituent of the essential oils and steam volatile. Terpenoids are classified on the basis of number of isoprene units. Terpenoids have biologically activities.

Table 3: Biological activity of different classes of terpenes^{27, 28}

Terpenes	Source	Use
Monoterpenes C ₁₀ H ₁₆	Fungi, bacteria, and gymnosperms, angiosperms,	Agricultural, pharmaceutical, cosmetic, and food applications
Sesquiterpene C ₁₅ H ₂₄	Hops plant, chamomile, rose lettuce	Antimicrobial, antifungal, Perfume industry
Diterpenes C ₂₀ H ₃₂	Rice plants	Protection against pathogens, pests, and weeds.
Triterpenes C ₃₀ H ₄₈	Bacteria and sea cucumber	Produce defense-related triterpene glycosides, ingredients in the food, health, and biotechnology industries.
Tetratepene C ₄₀ H ₆₄	Terrestrial plants, algae, and cyanobacteria	Light trapping, anti oxidative function, and plant protection against free radicals. ,ingredients of pharmaceutical and food industries
Polyterpenes (C ₅ H ₈) _n	Latex of rubber tree	Gloves, mattresses and many sporting goods.

Terpenoids from the genus *Cinnamomum* has immuno modulatory, anti-inflammatory, and antimicrobial, antioxidant, and anticancer activities.²⁹ Terpenoids are present in variety of scented flower and fruit and many of them are used as flavouring agents in food.³⁰ Citral is a monoterpene aldehyde extracted from the lemon grass oil and orange peel oil, is the mixture of two mono terpenes geranial and niral. Geranial was also present in rose oil, citronella, lemongrass, lavender and niral is obtained from oil of neroli (from the bitter orange trees). As all citral, geranial and niral are the constituents of essential oil, they are used in cosmetics perfumes, soaps scent etc.³¹ Some tepenoids are used as natural folk medicine.³²

Further investigation in this direction is necessary in future for finding out more specific biomolecules those are effective against particular diseases and to understand their mechanism of action. Clinical trial for those biomolecules is mandatory. The specific biomolecules are extracted from the locally available plants by maintaining the principles recommended by World Health Organization. The extraction of bio active molecules from plants is costly and after extraction generally small amount of bio active molecules are obtained. It should try to synthesis those biomolecules in large scale by modified greener method. So we can free our environment from pollution.

CONCLUSION:

The usage of biomolecules like flavonoids, terpenoids and alkaloids as greener alternatives in different areas like pharmaceuticals, agriculture, nutraceuticals etc. replacing the synthetic reagents must be promoted. At the same time, presence of biomolecules in our regular consumables like perfume, food flavor or cosmetics, etc must be encouraged. Scientists are regularly developing their research work extracting the different plant biomolecules from different parts of the plants in the modified method.

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