



Distribution of Naturally Synthesized Alkaloids in Plant Kingdom

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INTRODUCTION

Organic compounds like carbohydrates, proteins, fats, lipids, chlorophylls and nucleic acids play central role in the plant metabolism. These compounds are primary plant products and commonly known as primary metabolites. Apart of these organic compounds, certain families and genera of plants synthesize number of organic compound which are not directly involved in the metabolism and they have no any direct function in the growth and development. These compounds are chemically diverse in nature and are called as secondary plant products or secondary metabolites. The well-known compounds like alkaloids, terpenoids, flavonoids, tannins and phenolics are the major classes of the plant secondary metabolites (Korkina et al., 2018). Most of the alkaloids are nitrogen containing organic compounds. Generally plant alkaloids are not named by unique method by which they are named by additional suffix “ine” to the name of genus or species from which they synthesized e.g. Strychnine is one of the best example of such type of the nomenclature, obtained from the seed of the Strychnine tree, atropine is another example of nomenclature on the behalf of additional suffix, isolated from the plant *Atropa belladonna etc* (Hesse, 2002). Moreover, alkaloids extracted from plants and names are other additional suffix “idine, anine, aline, inine” etc. More than 85 plant derived alkaloids obtained from the plant roots are named with additional suffix “vin” because of their extraction from vinca plants such as *Vinca rosea (Catharanthus roseus)*, such type of plant derived alkaloids are named as vinca alkaloids (Heijden et al., 2004; Ravina et al., 2011).

Distribution in plant kingdom

Alkaloids and their close relatives are naturally biosynthesized by the diverse species of the plant kingdom. Plant kingdom contain about 10 – 25 % of the alkaloids, so alkaloids are closely associated with the plant kingdom of various genera and species except the algae.

There are more than three thousand alkaloids have been isolated from plants. Plant alkaloids are especially common in the angiosperm families like *Solanaceae*, *Magnoliaceae*, *Papaveraceae*, *Leguminosae*, *Rubiaceae*, *Apocyanaceae*, *Ranunculaceae* etc. (Thakkar, 2014). Opium poppy is one of the wonder plants from which twenty different alkaloids have been isolated, e.g. morphine, codeine, thebaine etc. Moreover, biosynthetically derived plant alkaloids frequently distributed in the plant species on the earth and most of them are amino acid derivatives e.g. Indole alkaloids derived from tryptophan, Piperidine

alkaloids derived from lysine, Pyrrolidine alkaloid derived from ornithine, Phenyl ethylamine alkaloids derived from tyrosine, Imidazole alkaloids derived from histidine (Kumar, 2014). Only few per cent content of alkaloids is present in the plant tissue. The optimum alkaloid content has been obtained from the leaves in the form of black henbane, fruits and seeds from strychnine tree), root and root derivatives (*Rauvolfia serpentina*) or bark (cinchona) (Gangwar, et al., 2014). Some important plant alkaloids distributed in the plant kingdom is given in the table.

Table: Alkaloids distributed in plant kingdom

S. No.	Family	Plants	Alkaloids present
1.	<i>Acanthaceae</i>	<i>Adhatoda vasica</i>	Vasicine, Vasicinol, Vasicinone, Adhatodine
2.	<i>Asteraceae</i>	<i>Ageratum conyzoides</i>	Lycopsamine, Dihydrolycopsamine, Acetyllycopsamine
		<i>Centaurea Montana</i>	Montamine, Tryptamine, Moschamine, Centcyamine
		<i>Centaurea schischkinii</i>	Schischkinnin, Montamine
		<i>Tridax procumbens</i>	Akuammidine, Voacangine, Echitamine, Crimamidine, Echitamidine, Nitidine, Trigonelline,
3.	<i>Alaniaceae</i>	<i>Ailangium lamarckii</i>	Alangiside, Alangine, Isotubulosine, Proteometine, Proteometinol, Psychotrine, Tubulosine, Salsoline
4.	<i>Ancistrocladaceae</i>	<i>Ancistrocladus heyneanus</i>	Isoancistrocladine, Yaoundamine
5.	<i>Annonaceae</i>	<i>Annona squamosa</i>	N-nitrosoxylopinine, Roemerolidine, Duguevalline
		<i>Cananga odorata</i>	Sampangine, Liriodenine, Lysicamine, Copyrine
6.	<i>Aracaceae</i>	<i>Arisarum vulgare</i>	Bgugaine, Irniine
7.	<i>Aristolochiaceae</i>	<i>Aristolochia manshuriensis</i>	Manshurienine
8.	<i>Apocynaceae</i>	<i>Altonia angustiloba</i>	Alstophylline, Cabucraline, Cathafole, Lochnerine, Normacusine, Yohimbine, Vincamajine,
		<i>Alstonia scholaris</i>	Akuammicine, Alstonamine, Echitamine, Echitamidine, Rhazmanine, Strictamine, Tubotaiwine,
		<i>Aspidosperma williamsii</i>	Ellipticine
		<i>Aspidosperma ramiflorum</i>	Ramiflorines
		<i>Bleekeria vitensis</i>	Ellipticine, 9- methoxyellipticine, Isoreserpiline,
		<i>Catharanthu</i>	Catharanthine, Vindoline
		<i>Catharanthus roseus</i>	Vinblastine, Vincristine, Anhydrovinblasine,

			Vindoline, Catharanthine, Ajmalicine, Serpentine
		<i>Holarrhena floribunda</i>	Holarrhesine, Holadienne, Conessine
		<i>Tabernaemontanacorymbosa</i>	Jerantinine, Lirofolines, Criofolinine, Ervachinine,
		<i>Tabernaem divertica</i>	Cononitarine B, Conophylline
		<i>Voacanga africana</i>	Voacafrine, Voacafricine, Voacamine, Vobtusine,
9.	<i>Asclepiadaceae</i>	<i>Tylophora tanakae</i>	13- α -tylophorine, 13- α -7-Odesmethyl tylophorine
		<i>Tylophora indica</i>	Tylophorine, 3-O-demethyl tylophorinidine
10.	<i>Berberidaceae</i>	<i>Berberis vulgaris</i>	Berberine, Jatrorrhizine, Palmatine, Berbamine,
		<i>Mahonia manipurensis</i>	Berberine, Jatrorrhizine, Palmatine, Oxyacanthine
11.	<i>Boraginaceae</i>	<i>Helotropium indicum</i>	Helindicine, Lycopsamine
12.	<i>Crassulaceae</i>	<i>Bryophyllum piñata</i>	Briofilin, Omethylsolanoscapine
13.	<i>Cannabaceae</i>	<i>Cannabis sativa</i>	Cannabisativine, Anhydrocannabisativine
14.	<i>Caricaceae</i>	<i>Carica papaya</i>	Carpaine, Pseudocarpaine
15.	<i>Cucurbitaceae</i>	<i>Citrullus colocynthis</i>	Quinoline, 2-(nonan-8-one)-4 Methoxyquinoline
16.	<i>Solanaceae</i>	<i>Withania somnifera</i>	Tropine, Pseudotropine, Withanine, Visamine,
		<i>Solanum xanthocarpum</i>	Solasodine, Solasonine, Solasurine, Solanine,
		<i>Solanum torvum</i>	Solasodine, Solasonine, Solamargine
		<i>Solanum pseudocapsicum</i>	Solacatine
		<i>Solanum nigrum</i>	Solasodine
		<i>Solanum khasianum</i>	Solasonine, Solamargine, Khasianine
		<i>Solanum dulcamara</i>	Solanine, Solasodine, β -Solamarine
		<i>Solanum xanthocarpum</i>	Solasodine, Solasonine, Solasurine, Solanine,
		<i>Solanum khasianum</i>	Solasonine, Solamargine, Khasianine
		<i>Solanum dulcamara</i>	Solanine, Solasodine, β -solamarine
		<i>Physalis minima</i>	Withaminimim, Phygrine
		<i>Nicotiana glauca</i>	Anabasine, Nornicotine
		<i>Hyoscyamus muticus</i>	Atropine, Homatropine, Hyoscyamine, Hygrine, Scopolamine, Littorine, Tropine, Pseudotropine,
		<i>Duboisia myoporoides</i>	Apoatropine, Butropine, Hyoscyamine, Scopolamine, Valtropine, Hydroxyhyoscyamine
		<i>Datura metel</i>	Hyoscyamine, Hyoscyne, Littorine, Valtropine, Fastusine, Fastusinine, acetoxytropine
		<i>Datura innoxia</i>	acetylcopine, Scopolamine, Hyoscymine
17.	<i>Papaveraceae</i>	<i>Chelidonium majus</i>	Sanguinarine, Berberine, Stylophine, Protopine, Chelidonine, Coptisine, Chelerythrine
		<i>Fumaria Capreolata</i>	Reticuline, Pallidine, Protopine, Coclaurine, Dehydrocheilanthifoline
		<i>Glaucium Flavam</i>	Glaucine, Catalane, Oxoglaucine, Pontevedrine
		<i>Glaucium grandiflorum</i>	Corydine, Isocorydine, Protopine, Methyl canadine,
		<i>Macleaya cordata</i>	Cryptopine, Protopine, Chelidimerine,

			Macleayine, Norsanguinarine, Sanguidimerine,
		<i>Papaver rhoeas</i>	Rhoeadine, Isocorydine, Coptisine, Stylopine,
		<i>Papaver somniferum</i>	Morphine, Codeine, Noscapine
		<i>Sanguinaria Canadensis</i>	Sanguinarine, Chelerythrine, Sanguilutine, Chelilutine
18.	<i>Rutaceae</i>	<i>Aegle marmelos</i>	Aegeline, Marmeline, Shahidine, Skimmianine
		<i>Casimiroa edulis</i>	Edulein, Zapoterin, Casimiroedine, Isoimpinellin
		<i>Dictamnus albus</i>	Haplopine, Robustine, Dictamine, γ -fagarine
		<i>Evodia rutaecarpa</i>	Dehydroevodiamine, Evodiamine, Evodiakine, Rutaecarpine, Quinolone
		<i>Murraya koenigii</i>	Murrayacine, Murrayazolidine, Mahanimbine
		<i>Psychotria colorata</i>	Calycanthine, Chimonanthine, Quadrigemine C
		<i>Skimmia japonica</i>	Skimmianine
18.	<i>Rubiaceae</i>	<i>Uncaria tomentosa</i>	Pterodine, Isomitraphylline, Uncarine F
		<i>Psychotria colorata</i>	Calycanthine, Isocalycanthine, Chimonanthine
		<i>Nauclea orientalis</i>	Naucleficine, Naucleactonine, Naucleorals A & B
		<i>Morinda citrifolia</i>	Prexeronine
		<i>Mitragyna speciosa</i>	Corynoxine, Mitragynine, Speciogynine
		<i>Cinchona officinalis</i>	Quinine, Quinidine, cinchonine, Cinchonidine
19.	<i>Ranunculaceae</i>	<i>Thalictrum minus</i>	Desoxythaliastine, Isothalisopavine, Thaliadine
		<i>Thalictrum foliolosum</i>	Thalfoliolosumines A & B
		<i>Rhizoma coptidis</i>	Berberine, Palmatine, Epiberberine, Coptisine
		<i>Hydrastis Canadensis</i>	Berberine, Canadine, Hydrastine, Hydrastinine
20.	<i>Zingiberaceae</i>	<i>Aframomun meleguata</i>	10,12-dihydroxy-18-ethenyl-4-pyrido- β -carboline

Physical Property of alkaloids

Generally alkaloids are colourless, crystalline and non-volatile solids but some alkaloids like nicotine and coniine are found in the liquid form at room temperature. They are usually bitter in taste, insoluble or partially soluble in water and soluble in most of the aromatic or organic solvents like benzene, ether etc. The boundary between other nitrogen containing organic compounds and natural alkaloids are not clear, some compounds like protein, nucleotides, nucleic acid, amino acid polypeptides, amines etc. are not alkaloids but they contain nitrogen atom in their composition. Some other nitrogen containing natural compounds with property of alkaloids like mescaline, serotonin, and dopamine are

classified as amines. (Leland, 2006). The alkaloids naturally synthesized in the plants are actively involved in the several types of defense against insects, pests and diseases. Plant derived alkaloids have great importance because more than 60% plant derived drugs and pharmaceutical products are derived from alkaloids (Gowda, et al., 2014).

CONCLUSION

Most of the plant alkaloids are nitrogenous in nature because of the presence of one or more nitrogen atoms in the heterocyclic ring. Alkaloids are usually accumulated in the growing parts of the plants like bundle sheath, latex vessel, epidermal and hypodermal cells. The alkaloids in a particular plant species are

often confined to a certain plant organs such as root, leaves, bark. However, alkaloids are synthesized in specific organ but accumulate in other plant organ. Plant species with alkaloids have been used since ancient times by human beings for pharmaceutical and therapeutic purposes. Later it has been characterized that plant alkaloids allow the formation of salt with mineral and organic acid. Generally plant alkaloids and salts are insoluble in water and some of them in the diluted alcohol. Alkaloids are usually optically active and have been observed as laevorotatory. Some of them like coniine are dextrorotatory, while few like papaverine are optically inactive.

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