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Major Classes of Naturally Occurring Plant Alkaloids as Secondary Metabolites

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INTRODUCTION

Alkaloids are largest groups of secondary plant products on the earth with broad range of the pharmaceutical properties. Plant alkaloids are the natural gifts with number of pharmaceutical properties for certain life-threatening diseases in the human beings and animals. It has also been observed after the chemical analysis and research, that some of the alkaloids have harmful effects on the human body such as asphyxia, paralysis or in some extreme conditions can lead to the death. In this review, it has been concluded that alkaloids extracted from plant sources utilized for medicinal purposes to cure several severe disorders in human beings. Though, research and development in the field of plant derived alkaloids have been carried out from long but there are always further research areas from the pharmaceutical point of view in the plant alkaloids. 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).

Classification of plant alkaloids

Alkaloids are classified mainly on the basis their synthesis but researches proposed various kinds of alkaloid classification on his own themes. The robust classification of the plant alkaloids are based on their natural biosynthesis. On the basis of natural biosynthesis, alkaloids are categorized as proto alkaloids, true alkaloids and pseudo alkaloids (Eagleson, 1994).

Plant alkaloids which are directly synthesized from amino acid and their derivatives are considered as Proto alkaloids and true alkaloids. Synthesis of plant alkaloids rather than amino acids, are considered as pseudo alkaloids.

Most of the proto alkaloids are considered as primitive classes of natural alkaloids because of the absence of heterocyclic ring in their chemical formulation. Generally proto alkaloids are originated from amino acids with at least one nitrogen atom. Many proto alkaloids contain nitrogen atom in their structure derived from an amino acid. Hordenine and ephedrine are the best suitable example of the proto alkaloids (Plemenkov, et al., 2001).

Other than proto alkaloids, some plant derived alkaloids evolved from amino acids and they contain heterocyclic ring in their structural formulation are called as true alkaloids. On the basis of the ring system present in their molecule, they are further categorized as sub-groups. Some of the important examples of true alkaloids are: Pyridine derived alkaloids e.g. nicotine, piperidine derivatives e.g. coniine, tropane e.g. atropine, indole alkaloids e.g. ergatomine, quinoline alkaloids e.g. quinine, isoquinoline and their relative alkaloids e.g. berberine and narcotine, imidazole and resembling alkaloids e.g. pilocarpine *(Aniszewski. et al., 2007).*

Some alkaloids are not truly derived from amino acid but have properties of alkaloids are considered as pseudo alkaloids. Pseudo alkaloids are of three type's *viz.* sterol alkaloids, phenanthrene alkaloids and tropane alkaloids. Sterol alkaloids are terpenoids containing alkaloids, found in the nature as glycosides (Hesse, 2002). They are found in the form of aglycone (i.e. the non-carbohydrate parts of the glycoside) as tomatidine in tomato and solanidine in the solanine. Moreover, phenanthrene alkaloids are morphine, codeine and thebaine while colchicine is found in the form of tropane alkaloids. Major classes of the plant alkaloids are given in the table.

Table: Alkaloid classes and their derivatives

S. No.	Classes	Alkaloids and their derivatives
1.	Biosynthetic classification of alkaloids	Tryptophan derived Indole alkaloids, Lysine derived piperidine alkaloids, Ornithine derived pyrrolidine alkaloid, Tyrosine derived phenyl ethylamine alkaloids, and Histidine derived imidazole alkaloids.
2.	Chemical classification of alkaloids	Pyrrolidine alkaloids i.e. hygiene, Diterpenes alkaloids i.e. Aconitine Amino alkaloids i.e. Ephedrine, Steroidal alkaloids i.e. Solanidine, Piperidine alkaloids i.e. Lobeline, Indole alkaloids i.e. Ergometrine, Purine alkaloids i.e. Caffeine, Diazocin alkaloids i.e. Lupanine, Pyrrolizidine, alkaloids i.e. Senecionine, Tropane alkaloids i.e. Atropine, Quiniline alkaloids i.e. Quinine, Aporphine alkaloids i.e. Boldine, Imidazole alkaloids i.e. Pilocarpine, Isoquinoline alkaloids i.e. Morphine
3.	Pharmacological classification of alkaloids	Morphine as narcotic analgesic, Ephedrine as bronchodilator, Quinine as antimalarial, Ergonovine as oxytocic, Pilocarpine as meiotic, Aconitine as neuralgia, Boldine as laxative, Lobeline as respiratory stimulant, Strychnine as reflex excitability
4.	Taxonomic classification of alkaloids	Cannabinaceous alkaloids extracted from *Cannabis Sativa*, Rubiaceous alkaloids extracted from Cinchona species & *Mitragyna speciosa*, Solanaceous alkaloids extracted from *Atropa belladonna*, *Datura candida*, *Nicotiana glauca*, *and Withania somnifera*.

Dimer alkaloids

Apart of monomeric natural originated alkaloids, plant alkaloids are found as dimeric, trimeric and tetrameric form. The forms of the alkaloids are derived from the monomeric alkaloids by the condensation of monomeric unit of the alkaloids. Dimeric alkaloids have pharmaceutical importance as compare to trimeric and tetrameric alkaloids.

Dimeric alkaloids have property to convert into the monomeric alkaloids because they are mostly derived from monomers unit through various means of chemical reaction by the Mannich reaction and Michael reaction (Hesse, 2002). Several evidences related to dimeric alkaloids formation from two or more distinct monomers are found in the plant sources. Formation of vinblastine and vincristine through stepwise coupling of catharanthine and vindoline are the best known example of the formation of dimer alkaloids (Gansauer, et al., 2007). Vinorelbine is the semi-synthetic chemotherapeutic dimer alkaloid. They have several pharmaceutical uses treatment of lungs cancer and other cancerous body cells. Another derivative dimer with broad capacity of pharmaceutical importance is vindoline and catharanthine, synthesised from anhydrovinblastine through number of enzymatic reactions (Ngo, et al., 2009; Keglevich et al., 2012).

CONCLUSION

Naturally biosynthesized alkaloids are derived from amino acids and play important role in the living organism. Alkaloids occurred to be extremely important for human beings for ages, besides they are secondary metabolites, what could suggest that they are useless. Alkaloids showed strong biological effects on animal and human organisms in very small doses. Alkaloids are present not only in human daily life in food and drinks but also as stimulant drugs. They showed anti-inflammatory, anticancer, analgesics, local anaesthetic and pain relief, neuropharmacologic, antimicrobial, antifungal, and many other activities. Alkaloids are useful as diet ingredients, supplements, and pharmaceuticals, in medicine and in other applications in human life. Alkaloids are also important compounds in organic synthesis for searching new semisynthetic and synthetic compounds with possibly better biological activity than parent compounds.

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