



Ethnobotanical Leaflets



Strychnine

By George C. Johnson

Strychnine is a poisonous alkaloid, $C_{21}H_{22}N_2O_2$, obtained in colorless or white rhombic crystals. These have a bitter taste and melt at around $290^\circ C$ (4 p.1). Alkaloids are any class of naturally occurring organic nitrogen containing bases, usually containing one or more of these nitrogen atoms in a ring of atoms called a cyclic system. Alkaloids are primarily found in plants and are predominant in flowering plant species. The function of alkaloids in plants is thought to be simply a waste product of the plants metabolic processes, but current research may suggest a specific biological function. This is evident in some plants as the levels of alkaloid increase just prior to seed formation and then drops off after the seed is ripe. This evidence suggests possible mechanisms of maturation and possible defense, against certain insect species (5 p.2). Strychnine, being an alkaloid, is slightly soluble in water, but is more soluble in alcohol and is released from its salts by alkalis. Many of the commercial alkaloids are found in the genus *Strychnos*.

Strychnine was the first alkaloid to be identified in plants of the genus *Strychnos*, Family Loganiaceae. *Strychnos*, created by Linnaeus in 1753, is a genus of trees and climbing shrubs of the gentian order. From the standpoint of biological diversity, it is the most important genus of the Loganiaceae family (6 p.1). The genus contains 196 various species and is distributed throughout the warm regions of Asia (58 species), America (64) and Africa (75).

The *Strychnos* alkaloids were originally classified based solely on their geographic origin. Asian *Strychnos* was thought to contain strychnine and the American *Strychnos* were thought to contain curarizing ammonium salts (6 p.2).

Plants of the genus *Strychnos* have opposite leaves and bear cymes of white or yellowish flowers that have a four-lobed or five-lobed calyx, a four-parted or five-parted corolla, five stamens, a solitary pistil and bears fruit in the form of a berry. The seeds and bark of many plants in this genus contain the powerful poison (4 p.2). Strychnine is obtained commercially from the seeds of the Saint-ignatius's-bean and from the nux-vomica tree.

Strychnine was first discovered by French chemist Joseph-Bienaimé Caenou and Pierre-Joseph Pelletier in 1818 in the Saint-Ignatius'-bean (*S. ignatii*) (1 p.2). *Strychnos ignatii* is a woody climbing shrub of the Philippines. It was introduced into Cochin China and is highly esteemed there as a medicine. It got its name from the attention it attracted from the Jesuits. The beans of the plant grow to a length of one inch long, are ovulate, black/ brown in appearance and are very hard and horny. The endosperm is translucent, enclosing an irregular cavity with an oblong embryo (1p.3). The fruit of the plant contains twenty to twenty-five seeds embedded in the pulp. The beans contain more strychnine than other commercial alkaloid plants while they contain no starch or albumen. The beans are more costly than most of other commercial plants and is usually substituted for this reason. Folklore had many to believe that the beans were an effective remedy to cholera. They have been clinically proven to be effective in treating certain forms of heart disease, but must be used under great reservation in order to avoid poisoning. In general the beans have the same properties as the species *Strychnos nux vomica*.

The species *Strychnos nux vomica* is a tree of native Indonesia that attains a height of 12m. The tree has a crooked, short, thick trunk and the wood is close grained and very durable. The leaves are short stalked, opposite, smooth on both sides and about 4 inches long and 3 broad. The flowers on the plant are greenish-white, funnel shaped, in small terminal cones and blooming in the cold season (1 p.1). The fruit of the tree is about the size of a large apple with a hard rind and an orange color; and filled with a soft white jelly-like pulp. The fruit contains five seeds internally, which are covered with soft wool like substance. When the seeds are ripe they are cleansed, dried and exported to Cochin, Mandras and other Indian ports. The seeds were first imported and marketed in Europe to kill rodents and small predators. The ripe seed looks like flattened disks, which are very hard and covered with satiny hairs. The endosperm of the seeds is a dark grey color with a horny texture. The beans of the tree are the chief commercial source of strychnine (1 p. 1). Although these beans contain the same properties as the ignatius bean they are used as an alternative to the ignatius bean because they are more cost effective.

The properties of nux-vomica are substantially those of the alkaloid strychnine. The seeds are crushed and made into a powdered form that are employed in atonic dyspepsia, or indigestion caused by a lack of physiological tone of a contractile organ. The pigment of nux-nomica is often used in mixtures because it is known to act as a stimulant on the GI tract. In the mouth it acts as a bitter substance, alkaloids are the best-known bitter substances because they have an extremely low taste threshold and are detectable at weak concentrations. The bitter substance helps to increase appetite by stimulating peristalsis; causing successive waves of involuntary contraction passing along the walls of the intestine or esophagus forcing contents inside them forward (3 p. 1).

Strychnine, the main alkaloid component of the seeds, acts as a bitter substance, which increases the flow of gastric juices. Strychnine is rapidly absorbed into the intestines and exerts its characteristic effects on the central nervous system. Such effects as deepened respiration and decreased stroke volume of the heart through excitation of the vagal center are observed from contact of the alkaloid (1 p.1). The olfactory cortex, auditory cortex, somatosensory and visual cortexes are rendered more acute by stimulation of strychnine, respectively on the frontal, temporal, parietal and occipital lobes of the brain. The action of strychnine also raises epinephrine levels and thus increases systemic blood pressure by direct stimulation of the sympathetic nervous system on the smooth muscle of the arterioles. This action

can be of great value in reducing cardiac failure. The most direct symptoms caused by strychnine are violent convulsions due to the simultaneous stimulation of the motor or sensory ganglia of the spinal cord; this can be of value during chronic lead poisoning and during surgical shock. Strychnine can also be used as an antidote in chloroform (a volatile heavy toxic liquid used as a solvent or veterinary anesthetic) poisoning (3 p.1).

Many other alkaloids are found in the genus *Strychnos*. Some species contain brucine, which is also found in nux vomica, chloroquine and quinine. An experiment on a mutant *Paramecium caudatum* was conducted to find membrane potential responses to these alkaloids to find out similarities amongst the chemicals. The responses consisted of an initial transient depolarization when the strychnine, brucine and chloroquine concentration was low, followed by a transient hyperpolarization when the level of strychnine, brucine and chloroquine were raised. Because the cells used in the experiment were defective in voltage gated Ca^{2+} the membrane responses recorded were receptor potentials to the alkaloids and not the action potentials of calcium. The amplitude of the responses tended to increase as the alkaloid concentration was increased but tended to saturate at high concentrations. The experiments were also concentrated on finding the various locations of receptors when exposed to the stimulus. The cells were found to produce a depolarization in response to localized applications to the anterior region, whereas the cell produced a hyperpolarization in response to the application of the posterior region. Membrane potential responses with chloroquine declined with repeated application. The presence of chloroquine in the external bathing solution strongly inhibited the membrane potentials created by brucine and strychnine. The chloroquine did not affect the action of quinine. This suggests that chloroquine; strychnine and brucine share a common component of their transduction pathways, but are exclusive from quinine in their action (2 p.19).

Conclusions

Strychnine is a poisonous alkaloid, $C_{21}H_{22}N_2O_2$, obtained in colorless or white rhombic crystals, which have a bitter taste and melt at around $290^{\circ}C$. Strychnine is of the genus *strychnos*, of the family Loganiaceae first created by Linnaeus in 1753, containing 196 species of plants. The toxic and medicinal effects of Strychnine have been well known from the times of ancient china. The inhabitants of South East Asia and India had ancestral knowledge of the species nux vomica and Saint-ignatius bean. The first commercial exporting of the species nux-vomica, was to Europe as a poison to kill rodents and small predators. Strychnine was first discovered by French chemist Joseph-Bienaimé Caenoiu and Pierre-Joseph Pelletier in 1818 in the Saint-Ignatins'-bean. Strychnine was the first alkaloid to be found in *Strychnos*. It was isolated from the nux vomica tree in 1818, but its chemical structure was not known till the advance of stiochemesty in the early 1950's. Alkaloids are primarily found in plants and are predominant in flowering plant, species were originally classified based solely on their geographic origin. Asian *Strychnos* was thought to contain strychnine and the American *Strychnos* were thought to contain curarizing ammonium salts. Recent research has proven that there is no correlation between geographical distribution and alkaloid content. The properties of nux-vomica are substantially those of the alkaloid strychnine. The seeds are crushed and made into a powdered form that are employed in atonic dyspepsia, or indigestion caused by a lack of physiological tone of a contractile organ.

Strychnine is rapidly absorbed into the intestines and exerts its characteristic effects on the central nervous system. Such effects as deepened respiration and decreased stroke volume of the heart through excitation of the vagal center are observed from contact of the alkaloid. One experiment with a mutant form of *Paramecium caudatum* found that the alkaloid's chloroquine, brucine and strychnine all share a common component in their transduction pathways.

Sources Cited

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