

CHAPTER II

HISTORICAL

1. Botanical Generalities

Strychnos is a member of the Family Loganiaceae. This genus is pantropical in distribution, comprising about 200 species which can be classified into three groups according to their geographical origin: African *Strychnos* with 75 species (Leeuwenberg, 1969), American *Strychnos* with 75 species and Asian *Strychnos* with 44 species. Members in the three groups are almost totally separated. Only *Strychnos potatorum* belongs to both Asian and African groups.

Botanically, *Strychnos* species are organized into 12 sections (Scheme 1) based on combination of such features as the length of the corolla tube, the nature of the indumentum on the inner surface of the corolla, the arrangement of the tendrils, the shape and indumentum of the seeds, and the insertion of the stamens and indumentum of the pistils (Leeuwenberg, 1980). The membership of this species are summarized in Table 2.

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Table 2. *Strychnos* species

Section	African Species	American Species	Asian Species
Aculeatae	<i>S. aculeata</i> Solered.		
Breviflorae	<i>S. afzelii</i> Gilg	<i>S. acuta</i> Prog.	
	<i>S. angolensis</i> Gilg	<i>S. atlantica</i> Krukoff & Barneby	
	<i>S. campicola</i> Gilg ex Leeuwenberg	<i>S. brachistantha</i> Standley	
	<i>S. chromatoxylon</i> Leeuwenberg	<i>S. brasiliensis</i> (Spreng.) Mart.	
	<i>S. dolichothyrsa</i> Gilg et Hepper	<i>S. castelnaeana</i> Wedd.	
	<i>S. henningsii</i> Gilg	<i>S. cerradoensis</i> Krukoff & Barneby	
	<i>S. icaia</i> Baill.	<i>S. fendleri</i> Sprangue & Sandw.	
	<i>S. malacoclados</i> C.H. Wright	<i>S. fulvotomentosa</i> Gilg	
	<i>S. malchairii</i> De Wild.	<i>S. grayi</i> Grisbach	
	<i>S. mimiflensis</i> Gilg ex Leeuwenberg	<i>S. malacosperma</i> Ducke & Froes	
	<i>S. mitis</i> S. Moore	<i>S. mattogrossensis</i> S. Moore	
	<i>S. urceolata</i> Leeuwenberg	<i>S. neglecta</i> Krukoff & Barneby	
		<i>S. nigricans</i> Prog.	
		<i>S. oiapocensis</i> Froes	
		<i>S. pachycarpa</i> Ducke	
			(continued)

Section	African Species	American Species	Asian Species
Breviflorae	<p><i>S. cuminodora</i> Leeuwenberg</p> <p><i>S. cuniculina</i> Leeuwenberg</p> <p><i>S. johnsonii</i> Hutch. et M.B. Moss</p> <p><i>S. mellodora</i> S. Moore</p> <p><i>S. millepunctata</i> Leeuwenberg</p> <p><i>S. samba</i> Duvign.</p> <p><i>S. xylophylla</i> Gilg</p> <p><i>S. densiflora</i> Bail.</p> <p><i>S. innocua</i> Del.</p> <p><i>S. lucens</i> Bak.</p> <p><i>S. madagascariensis</i> Poir.</p>	<p><i>S. parviflora</i> Spruce ex Benth</p> <p><i>S. poeppingii</i> Prog.</p> <p><i>S. progeliana</i> Krukoff & Barneby</p> <p><i>S. rubiginosa</i> A. DC.</p> <p><i>S. schultesina</i> Krukoff</p> <p><i>S. tarapotensis</i> Sprangue & Sandw.</p>	<p><i>S. bicirrhosa</i> Lesch. et. Wall</p> <p><i>S. flavescens</i> King et Gamble</p> <p><i>S. luzonensis</i> Elmer</p> <p><i>S. tetragona</i> A. W. Hill</p> <p><i>S. umbellata</i> (Lour.) Merr</p> <p><i>S. vanprukii</i> Craib</p> <p><i>S. vitiensis</i> A. W. Hill</p>
Brevitubae			
Densiflorae			

(continued)

Section	African Species	American Species	Asian Species
Densiflorae	<p><i>S. nigritana</i> Bak.</p> <p><i>S. pungens</i> Solered</p> <p><i>S. standtii</i> Gilg</p> <p><i>S. zenkeri</i> Gilg ex Bak.</p>		
Dolichanthae	<p><i>S. asterantha</i> Leeuwenberg</p> <p><i>S. barteri</i> Solered.</p> <p><i>S. canthioides</i> Leeuwenberg</p> <p><i>S. gossweileri</i> Exell</p> <p><i>S. melastomatoides</i> Gilg</p> <p><i>S. odorata</i> A. Chev.</p> <p><i>S. perminervis</i> A. Chev.</p> <p><i>S. tricalyssiodes</i> Hutch. et M.B. Moss</p>		
Lanigerae	<p><i>S. xantha</i> Leeuwenberg</p> <p><i>S. chrysophylla</i> Gilg</p> <p><i>S. dinklagei</i> Gilg</p> <p><i>S. fallax</i> Leeuwenberg</p> <p><i>S. kasangaensis</i> De Wild</p> <p><i>S. memecyloides</i> S. Moore</p>		<p><i>S. andamanensis</i> A. W. Hill</p> <p><i>S. borneensis</i> Leenh.</p> <p><i>S. coriacea</i> Thwaites</p> <p><i>S. curtisii</i> King et Gamble</p> <p><i>S. hypogyna</i> C.B. Clarke</p>

(continued)

Section	African Species	American Species	Asian Species
Lanigeae	<p><i>S. moandoensis</i> De Wild</p> <p><i>S. ngouniensis</i> Pellegr.</p> <p><i>S. panganensis</i> Gilg</p> <p><i>S. scheffleri</i> Gilg</p> <p><i>S. soubrensis</i> Hutch. et Dalz.</p> <p><i>S. splendens</i> Gilg</p> <p><i>S. talbotiae</i> S. Moore</p>		<p><i>S. minor</i> Dennst.</p> <p><i>S. maingayi</i> C.B. Clarke</p> <p><i>S. myrioneura</i> Gilg</p> <p><i>S. oleifolia</i> A.W.Hill</p> <p><i>S. ovata</i> A.W.Hill</p> <p><i>S. polyantha</i> Pierre ex Dop</p> <p><i>S. polytrichantha</i> Gilg</p> <p><i>S. rufa</i> C.B. Clarke</p> <p><i>S. thorelii</i> Pierre ex Dop</p> <p><i>S. villosa</i> A.W. Hill</p>
Penicillatae	<p><i>S. bifurcata</i> Leeuwenberg</p> <p><i>S. diplotricha</i> Leeuwenberg</p> <p><i>S. longicaudata</i> Gilg</p> <p><i>S. matopensis</i> S. Moore</p>		<p><i>S. axillaris</i> Colebr.</p> <p><i>S. benthamii</i> C.B. Clarke</p> <p><i>S. daltellii</i> C.B. Clarke</p> <p><i>S. melanocarpa</i> Gilg et Bened</p>

(continued)

Section	African Species	American Species	Asian Species
Penicillatae	<p><i>S. mostueoides</i> Leeuwenberg</p> <p><i>S. myrtoides</i> Gilg et Busse</p> <p><i>S. pentantha</i> Leeuwenberg</p> <p><i>S. tchibangensis</i> Pellegr.</p> <p><i>S. trichoneura</i> Leeuwenberg</p> <p><i>S. phaeotricha</i> Gilg</p>		<p><i>S. ridley</i> King et Gamble</p> <p><i>S. trichocalyx</i> A. W. Hill</p>
Phaeotrichae			
Rouhamon	<p><i>S. boonei</i> De Wild.</p> <p><i>S. dale</i> De Wild.</p> <p><i>S. decussata</i> (Pappe) ex Gilg</p> <p><i>S. elaeocarpa</i> Gilg ex Leeuwenberg</p> <p><i>S. floribunda</i> Gilg</p> <p><i>S. gnetifolia</i> Gilg ex Onochie et Hepper</p> <p><i>S. ndengensis</i> Pellegr</p> <p><i>S. potatorum</i> L.</p> <p><i>S. retinervis</i> Leeuwenberg</p> <p><i>S. usambarensis</i> Gilg</p> <p><i>S. variabilis</i> De Wild.</p>	<p><i>S. bicolor</i> Prog.</p> <p><i>S. cogens</i> Benth.</p> <p><i>S. duckei</i> Krukoff & Monachino</p> <p><i>S. glabra</i> Sagot ex Prog.</p> <p><i>S. goiasensis</i> Kurkoff & Barneby</p> <p><i>S. guianensis</i> (Aubl.) Mart.</p> <p><i>S. hirsuta</i> Spruce ex Benth.</p> <p><i>S. melinoniana</i> Baill.</p> <p><i>S. panurensis</i> Sprague & Sandw.</p> <p><i>S. subcordata</i> Spruce et Benth.</p>	<p><i>S. potatorum</i> L.f.</p>

Section	African Species	American Species	Asian Species
Spinosae	<p><i>S. cocculoides</i> Bak.</p> <p><i>S. congolana</i> Gilg</p> <p><i>S. spinosa</i> Lam.</p> <p><i>S. ternata</i> Gilg ex Leeuwenberg</p> <p><i>S. camptoneura</i> Gilg et Busse</p>		
Scyphostrychnos	<p><i>S. amazonica</i> Krukoff</p> <p><i>S. araguaensis</i> Kruoff & Barneby</p> <p><i>S. asperula</i> Sprague & Sandw.</p> <p><i>S. bahiensis</i> Krukoff & Barneby</p> <p><i>S. barnhartiana</i> Krukoff</p> <p><i>S. brachiata</i> Ruiz & Pavon</p> <p><i>S. bredemeyeri</i> (Schultes) Sprague & Sandw.</p> <p><i>S. chlorantha</i> Prog.</p> <p><i>S. colombiensis</i> Krukoff & Barneby</p> <p><i>S. darienensis</i> Seem.</p> <p><i>S. diaboli</i> Sandw.</p> <p><i>S. divaricans</i> Ducke</p> <p><i>S. erichsonii</i> Rich. Schomb</p>		
Strychnos			<p><i>S. angustiflora</i> Benth.</p> <p><i>S. cathayensis</i> Merr.</p> <p><i>S. cheliensis</i> Hu</p> <p><i>S. henyi</i> Merr. et Yamamoto</p> <p><i>S. ignatii</i> Berg.</p> <p><i>S. lucida</i> R.Br.</p> <p><i>S. narcondamensis</i> A.W. Hill</p> <p><i>S. nitida</i> G. Don</p> <p><i>S. nux-blanda</i> A.W. Hill</p> <p><i>S. nux-vomica</i> Linn.</p> <p><i>S. rupicola</i> Pierre ex Dop</p> <p><i>S. wallichiana</i> Steud ex DC.</p> <p>(continued)</p>

Section	African Species	American Species	Asian Species
Strychnos	<p><i>S. eugenifolia</i> Monachino</p> <p><i>S. froesii</i> Ducke</p> <p><i>S. gardneri</i> A.Dc.</p> <p><i>S. javariensis</i> Krukoff</p> <p><i>S. jobertiana</i> Baill.</p> <p><i>S. krukoffiana</i> Ducke</p> <p><i>S. lobelioides</i> Krukoff & Barneby</p> <p><i>S. macrophylla</i> Barb. Rodr.</p> <p><i>S. medeola</i> Sagot ex Prog.</p> <p><i>S. mitscherlichii</i> Rich. Schomb.</p> <p><i>S. panamensis</i> Seem.</p> <p><i>S. peckii</i> B.L. Robinson</p> <p><i>S. pseudo-quina</i> A. St. Hil.</p> <p><i>S. pubiflora</i> Krukoff</p> <p><i>S. ramentifera</i> Ducke</p> <p><i>S. romeu-belenii</i> Krukoff & Barneby</p> <p><i>S. rondeletioides</i> Spruce ex Benth.</p> <p><i>S. sandwithiana</i> Krukoff & Barneby</p>		

(continued)

Section	African Species	American Species	Asian Species
Strychnos	<i>S. solerederi</i> Gilg. <i>S. solimoesana</i> Krukoff <i>S. tabascana</i> Sprague & Sandw. <i>S. tomentosa</i> Benth. <i>S. toxifera</i> Rob. Schomb. <i>S. trinervis</i> (Vell.) Mart. <i>S. xinauensis</i> Krukoff		

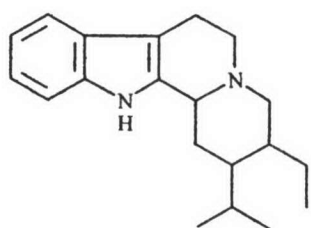
Members of the genus *Strychnos* have proven to be rich sources of indole alkaloids. Phytochemical studies on this species indicated that they contain varieties of other chemical constituents such as steroids, benzenoids, lignans, iridoids and miscellaneous compounds.

2.1 *Strychnos* alkaloids

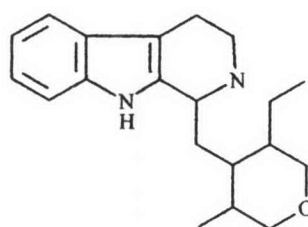
The majority of compounds in *Strychnos* species are alkaloids, most of which are terpenoid indole bases which contain two structural elements in the molecule: a β -carboline moiety arising from tryptamine and a C₉ or C₁₀ monoterpene unit derived from secologanin. According to the structural characteristics of their skeletons, Kisakurek and Hesse have arranged the terpenoid indole alkaloids into 8 types as shown in Scheme 2 (Kisakurek and Hesse, 1980). They are corynanthean-(C-), vincosane-(C-), vallesianchotaman-(V-), strychnan-(S-), and aspidospermantane-(A-) types with a nonrearranged secologanin moiety, together with eburnane-(E-), plumerane-(P-) and ibogane-(J-) types with a rearranged secologanin moiety. In addition, combination between the two units of the same or different indole alkaloid types would generate the bisindole alkaloids (Pingsuthiwong, 1986).

The indole alkaloids of *Strychnos* species comprise of 5 alkaloid types: C-, D-, V-, S- and A-types. The majority of these alkaloids belong to the S-type.

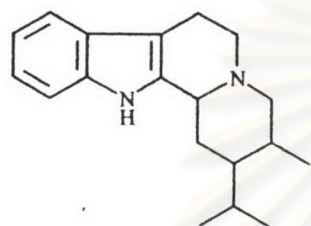
The terpenoid indole alkaloids found in *Strychnos* species can be organized into groups as follows.



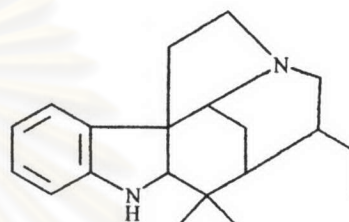
Corynanthean
(C-type)



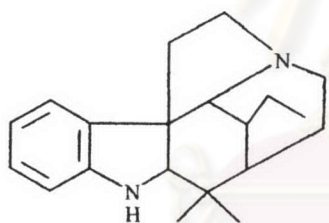
Vincosan
(D-type)



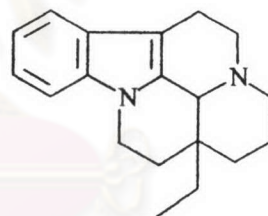
Vallesiachotaman
(V-type)



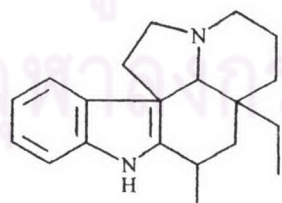
Strychnan
(S-type)



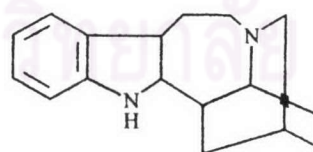
Aspidospermatan
(A-type)



Eburnan
(E-type)



Plumeran
(P-type)



Ibogan
(J-type)

Scheme 2. The indole alkaloid structural types

I. Monomeric alkaloids

1. Corynanthean-(C-) type
 - 1.1 Corynantheine group eg. geissoschizine, 16 (R) -isositsirikine
 - 1.2 Ajmalicine group eg. alstonine, serpentine
 - 1.3 Yohimbine group eg. decarbomethoxydihydrogambirtannine
 - 1.4 Sarpagine group eg. macusine B, normacusine B
 - 1.5 Mavacurine group eg. mavacurine, C-fluorocurine
 - 1.6 Akagerine group eg. akagerine, kribine

2. Vincosan -(D-) type
 - 2.1 Strictosidine group eg. dolichantoside, palicoside
 - 2.2 Decussine group eg. decussine, camptoneurine

3. Vallesiachotaman-(V-) type
 - 3.1 Antirrhine group eg. antithine, *N*₆-methylantirrhine
 - 3.2 Angustine group eg. angustine, angustoline, angustidine

4. Strychnan -(S-) type
 - 4.1 Akuammicine group eg. retuline, isoretuline
 - 4.2 Rosibiline group eg. rosibiline
 - 4.3 Diaboline group eg. diaboline, Wieland-Gumlich aldehyde
 - 4.4 Tsilanine group eg. tsilanine
 - 4.5 Strychnosilidine group eg. strychnosilidine, alviminine
 - 4.6 Spermostrychnine group eg. spermostrychnine, strychnospermine
 - 4.7 Isostrychnine group eg. isostrychnine, isobrucine
 - 4.8 Strychnine group eg. strychnine, brucine, α -colubrine
 - 4.9 Strychnobrasiline group eg. strychnobrasiline
 - 4.10 Holstiine group eg. holstiine
 - 4.11 Icajine group eg. icajine

5. Aspidospermantan -(A-) type

Condylocarpine group eg. condylocarpine, tubotaiwine

II. Dimeric alkaloids

1. Quasi dimeric alkaloids (Corynanthean type with an additional β -carboline unit)

1.1 Usambarensine group eg. usambarensine, tchibangensine

1.2 Strychnofoline group eg. strychnofoline, strychnophylline

2. Strychnan-corynanthean type

2.1 Retuline-corynantheine group eg. longicaudatine Y

2.2 Diaboline-corynantheine group eg. longicaudatine

3. Strychnan-strychnan type

3.1 Retuline-retuline group

- Toxiferine group eg. toxiferine, C-alkaloid H
- Calebassine group eg. calebassine, C-alkaloid F
C-alkaloid A
- Curarine group eg. curarine, C-alkaloid G,
C-alkaloid E
- Matopensine group eg. matopensine

3.2 Diaboline-diaboline group eg. caracurine II, caracurine V

3.3 Isostrychnine-isostrychnine group eg. sangucine

3.4 Diaboline-Isostrychnine group eg. strychnogucine A, strychnogucine B

4. Miscellaneous

eg. janussine A, strellidimine

The information on *Strychnos* alkaloids is summarized in Table 3.

Table 3 *Strychnos* alkaloids

Alkaloids	<i>Strychnos</i> species	References
Monomeric alkaloid		
1. Corynanthean type		
1.1 Corynantheine group		
10-Hydroxy- <i>N</i> ₆ -methyl-corynantheol	<i>S. usambarensis</i>	Quetin-Leclercq and Angenot, 1988
2,7-Dihydroapogeissochizine	<i>S. gossweileri</i>	Quetin-Leclercq <i>et al.</i> , 1994
9-Methoxygeissochizol	<i>S. guianensis</i>	Mavar-Manga <i>et al.</i> , 1996
9-Methoxy- <i>N</i> ₆ -methyl-geissochizol	<i>S. guianensis</i>	Penelle <i>et al.</i> , 2000
De-carbomethoxygeissochizine	<i>S. mux-vomica</i>	Baser, 1978
Dihydrocorynantheol	<i>S. johnsonii</i>	Massiot <i>et al.</i> , 1987
Geissochizal	<i>S. mux-vomica</i>	Baser, 1978
Geissochizine	<i>S. mux-vomica</i>	Baser, 1978
Geissochizol	<i>S. ignatii</i>	Pingsuthiwong, 1986
Melinonine B	<i>S. melinoniana</i>	Souhton and Buckingham, 1989
Normelinonine B	<i>S. ignatii</i>	Datta and Bisset, 1990.
	<i>S. mux-vomica</i>	Baser and Bisset, 1982

Alkaloids	Strychnos species	References
(16R)-Isositosirikine	<i>S. kasengaensis</i>	Delaude, 1984
16-Epidiploceline	<i>S. gossweileri</i>	Coune and Angenot, 1980.
Diploceline	<i>S. gossweileri</i>	Coune, 1978.
Strychnorobigine	<i>S. rubiginosa</i>	Marini-Bettolo <i>et al.</i> , 1980a
1.2 Ajmalicine group		
Alstonine	<i>S. camptoneura</i>	Verpoorte and Sandberg, 1971.
Serpentine	<i>S. gossweileri</i>	Coune, 1978.
1.3 Yohimbine group		
Decarbomethoxydihydrogambirtannine	<i>S. camptoneura</i>	Verpoorte and Sandberg, 1971.
	<i>S. johnsonii</i>	Massiot <i>et al.</i> , 1987
1.4 Sarpagine group		
Macusine B	<i>S. amazonica</i>	Galeffi <i>et al.</i> , 1973

Alkaloids	Strychnos species	References
Macusine B	<i>S. brachiata</i>	Galeffic <i>et al.</i> , 1973
	<i>S. decussata</i>	Rolfesen <i>et al.</i> , 1981
	<i>S. guianensis</i>	Penelle <i>et al.</i> , 2000
	<i>S. ignatii</i>	Datta and Bisset, 1990
	<i>S. toxifera</i>	Aimi, Sakai and Ban, 1989
	<i>S. usambarensis</i>	Angenot, 1975
O-Methyl-macusine B	<i>S. decussata</i>	Rolfesen <i>et al.</i> , 1981
	<i>S. ignatii</i>	Datta and Bisset, 1990
	<i>S. mix-vomica</i>	Angenot, 1975
	<i>S. usambarensis</i>	Angenot, Dideberg and Dupont, 1975
O-Methyl-dihydromacusine B	<i>S. usambarensis</i>	Baser and Bisset, 1982
Normacusine B (Tombozine)	<i>S. dolichothrysa</i>	Verpoorte, Verzijl and Svendsen, 1982
	<i>S. lucida</i>	Bavovada, 1983
	<i>S. malacoclados</i>	Verpoorte, 1978
	<i>S. nitida</i>	Vejjajiva, 1996
	<i>S. mix-vomica</i>	Baser and Bisset, 1982
	<i>S. potatorum</i>	Massiot <i>et al.</i> , 1992
	<i>S. rubiginosa</i>	Marini-Bettolo <i>et al.</i> , 1980a
3-Hydroxy-19(Z)-normacusine B	<i>S. nitida</i>	Vejjajiva, 1996

(continued)

Alkaloids	Strychnos species	References
Erichsonine	<i>S. erichsonii</i>	Forgacs <i>et al.</i> , 1986
1.5 Mavacurine group		
C-Mavacurine (Mavacurine)	<i>S. amazonica</i>	Marini-Bettolo, 1970
	<i>S. divaricans</i>	Marini-Bettolo, 1970.
	<i>S. froseii</i>	Marini-Bettolo, 1970.
	<i>S. macrophylla</i>	Marini-Bettolo, 1970.
	<i>S. melinoniana</i>	Marini-Bettolo, 1970.
	<i>S. mitscherlichii</i>	Marini-Bettolo, 1970.
	<i>S. parvifolia</i>	Marini-Bettolo, 1970.
	<i>S. scheffleri</i>	Caprasse and Angenot, 1981
	<i>S. subcordata</i>	Marini-Bettolo, 1970
	<i>S. variabilis</i>	Tits <i>et al.</i> , 1981
	<i>S. guianensis</i>	Penelle <i>et al.</i> , 2000
	<i>S. guianensis</i>	Penelle <i>et al.</i> , 2000
	<i>S. melinoniana</i>	Souhnton and Buckingham, 1989
	<i>S. nux-vomica</i>	Baser and Bisset, 1982
	<i>S. panamensis</i>	Souhnton and Buckingham, 1989

Alkaloids	Strychnos species	References
C-Fluorocurine (Fluorocurine)	<i>S. scheffleri</i>	Tits <i>et al.</i> , 1981
	<i>S. toxifera</i>	Marini-Bettolo, 1970.
	<i>S. variabilis</i>	Tits, 1981
1.6 Akagerine group		
Akagerine	<i>S. barteri</i>	Nicoletti, Okuakwa and Messana, 1980.
	<i>S. camptoneura</i>	Verpoorte, Baerhim-Svendsen and Sanberg, 1975
	<i>S. dale</i>	Rolfsen <i>et al.</i> , 1978
	<i>S. decussata</i>	Rolfsen, Olaniyi and Hylands, 1980b
	<i>S. elaeocarpa</i>	Rolfsen <i>et al.</i> , 1978
	<i>S. floribunda</i>	Verpoorte <i>et al.</i> , 1981
	<i>S. gardneri</i>	Marini-Bettolo <i>et al.</i> , 1980b
	<i>S. jobertiana</i>	Marini-Bettolo <i>et al.</i> , 1980b
	<i>S. nigriflora</i>	Oguakwa <i>et al.</i> , 1978
	<i>S. usambarensis</i>	Angenot <i>et al.</i> , 1975
	<i>S. decussata</i>	Olaniyi and Rolfsen, 1980
10-Hydroxyakagerine	<i>S. spinosa</i>	Verpoorte <i>et al.</i> , 1975

Alkaloids	Strychnos species	References
10-Hydroxy-17-O-methylakagerine	<i>S. decussata</i>	Rolfson <i>et al.</i> , 1980b
17-O-Methylakagerine	<i>S. dale</i>	Rolfson <i>et al.</i> , 1978
17-O-Ethylakagerine	<i>S. johnsonii</i>	Massiot <i>et al.</i> , 1987
Akagerine lactone	<i>S. johnsonii</i>	Massiot <i>et al.</i> , 1987
Kribine	<i>S. decussata</i>	Olaniyi and Rolfson, 1980
	<i>S. camptonoura</i>	Ohiri <i>et al.</i> , 1983a
	<i>S. dale</i>	Rolfson <i>et al.</i> , 1978
	<i>S. elaeocarpa</i>	Rolfson <i>et al.</i> , 1978
	<i>S. nigritiana</i>	Oguakwa <i>et al.</i> , 1978
21-O-Methylkribine	<i>S. spinosa</i>	Oguakwa <i>et al.</i> , 1980
	<i>S. dale</i>	Rolfson <i>et al.</i> , 1978
21-Epi-O-methylkribine	<i>S. elaeocarpa</i>	Rolfson <i>et al.</i> , 1978
	<i>S. dale</i>	Rolfson <i>et al.</i> , 1978
10-Hydroxy-21-O-methylkribine	<i>S. elaeocarpa</i>	Rolfson <i>et al.</i> , 1978
10-Hydroxy-21-epi-O-methylkribine	<i>S. decussata</i>	Rolfson <i>et al.</i> , 1980b
	<i>S. decussata</i>	Rolfson <i>et al.</i> , 1980b

Alkaloids	Strychnos species	References
2. Vincosan type		
2.1 Strictosidine group		
Desoxycordifoline	<i>S. mellodora</i>	Brandt <i>et al.</i> , 1999
Dolichantoside	<i>S. gossweileri</i>	Coune, 1978
3,4,5,6-Tetrahydrodolichantoside	<i>S. mellodora</i>	Tits <i>et al.</i> , 1996
Isodolichantoside	<i>S. tricalysoides</i>	Quetin-Leclercq and Angenot, 1984
Palicoside	<i>S. mellodora</i>	Brandt <i>et al.</i> , 1999
3,4,5,6-Tetrahydropalicoside	<i>S. gossweileri</i>	Coune and Angenot, 1980
Strictosidine	<i>S. mellodora</i>	Tits <i>et al.</i> , 1996
2.2 Decussine group		
Decussine	<i>S. dale</i>	Rolfsen <i>et al.</i> , 1981
	<i>S. decussata</i>	Rolfsen <i>et al.</i> , 1980b
	<i>S. elaeocarpa</i>	Rolfsen <i>et al.</i> , 1981

Alkaloids	Strychnos species	References
Decussine	<i>S. floribunda</i>	Verpoorte <i>et al.</i> , 1981
3,14-Dihydrodecussine (Mostueine)	<i>S. dale</i>	Rolfsen <i>et al.</i> , 1981
	<i>S. decussata</i>	Rolfsen <i>et al.</i> , 1981
	<i>S. elaeocarpa</i>	Rolfsen <i>et al.</i> , 1981
	<i>S. johnsonii</i>	Massiot <i>et al.</i> , 1987
10-Hydroxy-3,14-dihydrodecussine	<i>S. decussata</i>	Rolfsen <i>et al.</i> , 1981
Camptoneurine	<i>S. camptoneura</i>	Verpoorte <i>et al.</i> , 1975
3 Vallesiachotaman type		
3.1 Antirhine group		
Antirhine	<i>S. johnsonii</i>	Massiot <i>et al.</i> , 1987
	<i>S. potatorum</i>	Massiot <i>et al.</i> , 1992
	<i>S. camptoneura</i>	Verpoorte <i>et al.</i> , 1975
<i>N</i> ₆ -Methylantirhine	<i>S. usambarensis</i>	Caprassé <i>et al.</i> , 1984a
	<i>S. camptoneura</i>	Bisset and Phillipson, 1974

Alkaloids	Strychnos species	References
3.2 Angustine group		
Angustine	<i>S. angustiflora</i>	Au, Cheung and Sternhell, 1973.
Angustidine	<i>S. camptoneura</i>	Verpoorte <i>et al.</i> , 1975
	<i>S. angustiflora</i>	Au <i>et al.</i> , 1973
Angustoline	<i>S. trichoneura</i>	Phillipson <i>et al.</i> , 1974
	<i>S. samba</i>	Phillipson <i>et al.</i> , 1974
	<i>S. odorata</i>	Phillipson <i>et al.</i> , 1974
	<i>S. xantha</i>	Phillipson <i>et al.</i> , 1974
	<i>S. schefferi</i>	Phillipson <i>et al.</i> , 1974
	<i>S. trichoneura</i>	Phillipson <i>et al.</i> , 1974
Malindine	<i>S. angustiflora</i>	Au <i>et al.</i> , 1973
	<i>S. decussata</i>	Rolfson <i>et al.</i> , 1981
Isomalindine	<i>S. usambarensis</i>	Caprasse <i>et al.</i> , 1984a
	<i>S. usambarensis</i>	Caprasse <i>et al.</i> , 1984a

Alkaloids	Strychnos species	References
4 Strychnan type		
4.1 Akuammicine group		
Retuline	<i>S. camptoneura</i> <i>S. henningsii</i> <i>S. kasengaensis</i> <i>S. nitida</i> <i>S. variabilis</i>	Verpoorte <i>et al.</i> , 1975 Massiot <i>et al.</i> , 1991 Thepenier <i>et al.</i> , 1984 Vejajjiva, 1996 Tits and Tavernier, 1978
11-Methoxyretuline	<i>S. kasengaensis</i> <i>S. nitida</i>	Thepenier <i>et al.</i> , 1984 Vejajjiva, 1996
O-Acetylretuline	<i>S. henningsii</i> <i>S. kasengaensis</i>	Angenot and Tits, 1981 Nuzillard <i>et al.</i> , 1996
N_a -Deacetylretuline	<i>S. pungens</i> <i>S. kasengaensis</i> <i>S. matopensis</i> <i>S. pangarensis</i> <i>S. potatorum</i> <i>S. variabilis</i>	Thepenier <i>et al.</i> , 1990a Thepenier <i>et al.</i> , 1984 Massiot <i>et al.</i> , 1988 Thepenier <i>et al.</i> , 1984 Massiot <i>et al.</i> , 1992 Massiot <i>et al.</i> , 1983a

Alkaloids	Strychnos species	References
Retuline- <i>N</i> ₆ -oxide (<i>N</i> -Oxyretuline)	<i>S. camptoneura</i>	Verpoorte <i>et al.</i> , 1975
Retulinal	<i>S. henningii</i>	Souhton and Buckingham, 1989
12-Hydroxyretulinal	<i>S. variabilis</i>	Tits and Angenot, 1980
Isoretuline	<i>S. variabilis</i>	Tits and Angenot, 1980
18-Hydroxyisoretuline	<i>S. kasengaensis</i>	Thepenier <i>et al.</i> , 1984
11-Methoxyisoretuline	<i>S. usambarensis</i>	Frederich <i>et al.</i> , 1998
<i>O</i> -Acetylisoretuline	<i>S. variabilis</i>	Tits and Tavernier, 1978
<i>N</i> _a -Deacetylisoretuline	<i>S. henningii</i>	Koch, Fellion and Plat, 1976
	<i>S. kasengaensis</i>	Thepenier <i>et al.</i> , 1984
	<i>S. variabilis</i>	Thepenier <i>et al.</i> , 1990b
	<i>S. kasengaensis</i>	Thepenier <i>et al.</i> , 1984
	<i>S. variabilis</i>	Thepenier <i>et al.</i> , 1990b
	<i>S. floribunda</i>	Verpoorte <i>et al.</i> , 1981
	<i>S. henningii</i>	Koch <i>et al.</i> , 1976
	<i>S. kasengaensis</i>	Thepenier <i>et al.</i> , 1984
	<i>S. scheffleri</i>	Caprassé and Angenot, 1981
	<i>S. variabilis</i>	Tits and Tavernier, 1978
	<i>S. henningii</i>	Koch <i>et al.</i> , 1976
<i>N</i> _a -Deacetyl-18-hydroxyisoretuline	<i>S. kasengaensis</i>	Thepenier <i>et al.</i> , 1984

(continued)

Alkaloids	Strychnos species	References
<i>N</i> _a -Deacetyl-17- <i>O</i> -acetyl-18-hydroxyisoretuline	<i>S. henningii</i>	Koch <i>et al.</i> , 1976
<i>N</i> _a -Deacetyl-18- <i>O</i> -hydroxyisoretuline	<i>S. kasengaensis</i>	Thepenier <i>et al.</i> , 1984
Isoretuline	<i>S. kasengaensis</i>	Thepenier <i>et al.</i> , 1984
12-Hydroxyisoretuline	<i>S. variabilis</i>	Tits and Angenot, 1980
16-Hydroxyisoretuline	<i>S. variabilis</i>	Tits and Angenot, 1980
Tsilanimbine	<i>S. variabilis</i>	Tits, Tavernier and Angenot, 1980
18-Deoxy Weiland-Gumlisch aldehyde	<i>S. henningii</i>	Koch <i>et al.</i> , 1976
	<i>S. amazonica</i>	Aimi <i>et al.</i> , 1989
	<i>S. dolichothyrsa</i>	Verpoorte <i>et al.</i> , 1982
	<i>S. froesii</i>	Aimi <i>et al.</i> , 1989
	<i>S. kasengaensis</i>	Thepenier <i>et al.</i> , 1984
	<i>S. matopensis</i>	Souhton and Buckingham, 1989
	<i>S. mimfiensis</i>	Delaude <i>et al.</i> , 1992
	<i>S. variabilis</i>	Tits <i>et al.</i> , 1980
	<i>S. mitscherlichii</i>	Souhton and Buckingham, 1989
	<i>S. panamensis</i>	Tits, Tavernier and Angenot, 1985
	<i>S. dolichothyrsa</i>	Verpoorte <i>et al.</i> , 1982
	<i>S. mimfiensis</i>	Delaude <i>et al.</i> , 1992
	<i>S. ngoumiensis</i>	Massiot <i>et al.</i> , 1983a
Strychnopivotine		
Fluorourarine (C-Fluorourarine)		
Nor-C-fluorourarine		

(continued)

Alkaloids	Strychnos species	References
Strychnozairine	<i>S. variabilis</i>	Tits <i>et al.</i> , 1985
4.2 Rosibiline group		
Rosibiline	<i>S. variabilis</i>	Tits <i>et al.</i> , 1980
Isorosibiline	<i>S. floribunda</i>	Verpoorte <i>et al.</i> , 1981
	<i>S. matopensis</i>	Massiot <i>et al.</i> , 1988
4.3 Diaboline group		
Diaboline	<i>S. afzelii</i>	Verpoorte, Groenink and Baerheim-Svendsen, 1980
	<i>S. castelneana</i>	Galeffi <i>et al.</i> , 1980a
	<i>S. cathayensis</i>	Lu and Liu, 1985
	<i>S. chlorantha</i>	Aimi <i>et al.</i> , 1989
	<i>S. diaboli</i>	Aimi <i>et al.</i> , 1989
	<i>S. fendleri</i>	Galeffi and Marni-Bettolo, 1980
	<i>S. froesii</i>	Aimi <i>et al.</i> , 1989
	<i>S. henningssii</i>	Chapya, 1983

Alkaloids	Strychnos species	References
	<i>S. ignatii</i>	Bisset, 1972a
	<i>S. jobertiana</i>	Marini-Bettolo <i>et al.</i> , 1980b
	<i>S. longicaudata</i>	Massiot <i>et al.</i> , 1983a
	<i>S. lucida</i>	Bavovada, 1983
	<i>S. matopensis</i>	Massiot <i>et al.</i> , 1988
	<i>S. mimfensis</i>	Delaude <i>et al.</i> , 1992
	<i>S. nux-blanda</i>	Bisset, 1972a
	<i>S. nux-vomica</i>	Souhton and Buckingham, 1989
	<i>S. panamensis</i>	Aimi <i>et al.</i> , 1989
	<i>S. potatorum</i>	Massiot <i>et al.</i> , 1992
	<i>S. pseudo-quina</i>	Nicoletti <i>et al.</i> , 1984
	<i>S. pungens</i>	Thepenier <i>et al.</i> , 1990a
	<i>S. rondeletioides</i>	Aimi <i>et al.</i> , 1989
	<i>S. solerederi</i>	Aimi <i>et al.</i> , 1989
	<i>S. castelnaeana</i>	Galeffi <i>et al.</i> , 1980a
	<i>S. angolensis</i>	Bohlin <i>et al.</i> , 1979
	<i>S. brachiata</i>	Galeffi <i>et al.</i> , 1973
	<i>S. cathayensis</i>	Lu and Liu, 1985
	<i>S. cocculoides</i>	Delaude <i>et al.</i> , 1992
3-Hydroxydiabolone		
11-Methoxydiabolone		

Alkaloids	<i>Strychnos</i> species	References
11-Methoxydiaboline	<p><i>S. dolichothyrsa</i></p> <p><i>S. gardneri</i></p> <p><i>S. henningstii</i></p> <p><i>S. malacoclados</i></p> <p><i>S. matopensis</i></p> <p><i>S. potatorum</i></p> <p><i>S. pseudo-quina</i></p> <p><i>S. pungens</i></p> <p><i>S. romeu-beleenii</i></p> <p><i>S. rubiginosa</i></p> <p><i>S. spinosa</i></p> <p><i>S. staudtii</i></p> <p><i>S. urceolata</i></p> <p><i>S. wallichiana</i></p> <p><i>S. panganensis</i></p> <p><i>S. potatorum</i></p> <p><i>S. pungens</i></p> <p><i>S. spinosa</i></p> <p><i>S. staudtii</i></p>	<p>Verpoorte <i>et al.</i>, 1982</p> <p>Marini-Bettolo <i>et al.</i>, 1980b</p> <p>Massiot and Delaude, 1988</p> <p>Verpoorte and Baerheim-Svendsen, 1974</p> <p>Massiot <i>et al.</i>, 1988</p> <p>Massiot <i>et al.</i>, 1992</p> <p>Nicoletti <i>et al.</i>, 1984</p> <p>Thepenier <i>et al.</i>, 1990a</p> <p>Aimi <i>et al.</i>, 1989</p> <p>Marini-Bettolo <i>et al.</i>, 1980a</p> <p>Ohiri, Verpoorte and Baerheim-Svendsen, 1984</p> <p>Thepenier <i>et al.</i>, 1988</p> <p>Verpoorte <i>et al.</i>, 1982</p> <p>Strombom, Huy and Bisset, 1982</p> <p>Nuzillard <i>et al.</i>, 1996</p> <p>Massiot <i>et al.</i>, 1992</p> <p>Thepenier <i>et al.</i>, 1990a</p> <p>Delaude <i>et al.</i>, 1992</p> <p>Thepenier <i>et al.</i>, 1988</p>
12-Hydroxy-11-methoxydiaboline		

Alkaloids	<i>Strychnos</i> species	References
17-Epi-O-methyl-11-methoxydiabolone	<i>S. angolensis</i>	Bohlin <i>et al.</i> , 1979
2,16-Dehydrodiabolone	<i>S. henningssii</i>	Massiot and Delaude, 1988
11-Methoxy-2,16-dehydrodiabolone	<i>S. henningssii</i>	Massiot and Delaude, 1988
Jobertine	<i>S. jobertiana</i>	Galeffi and Marni-Bettolo, 1980
Henningsamine	<i>S. fendleri</i>	Galeffi and Marni-Bettolo, 1980
	<i>S. henningssii</i>	Massiot and Delaude, 1988
	<i>S. potatorum</i>	Massiot <i>et al.</i> , 1992
	<i>S. pungens</i>	Thepenier <i>et al.</i> , 1990a
11-Methoxyhenningsamine (Condensamine)	<i>S. cocculoides</i>	Delaude <i>et al.</i> , 1992
	<i>S. henningssii</i>	Massiot and Delaude, 1988
	<i>S. potatorum</i>	Massiot <i>et al.</i> , 1992
	<i>S. pungens</i>	Thepenier <i>et al.</i> , 1990a
	<i>S. spinosae</i>	Delaude <i>et al.</i> , 1992
	<i>S. staudtii</i>	Thepenier <i>et al.</i> , 1988
12-Hydroxy-11-methoxyhenningsamine	<i>S. pungens</i>	Thepenier <i>et al.</i> , 1990a
	<i>S. staudtii</i>	Thepenier <i>et al.</i> , 1988
Henningsoline	<i>S. cathayensis</i>	Lu and Liu, 1985
	<i>S. henningssii</i>	Massiot and Delaude, 1988
	<i>S. minor</i>	Sotanaphum, 1990

(continued)

Alkaloids	<i>Strychnos</i> species	References
O-Acetylhenningsoine	<i>S. henningii</i>	Massiot and Delaude, 1988
Weiland-Gumlich aldehyde (Caracurine VII)	<i>S. afzelii</i>	Verpoorte <i>et al.</i> , 1980
	<i>S. brachiata</i>	Galeffi <i>et al.</i> , 1973
	<i>S. chrysophylla</i>	Souhton and Buckingham, 1989
	<i>S. dolichothyrsa</i>	Verpoorte <i>et al.</i> , 1982
	<i>S. froesii</i>	Aimi <i>et al.</i> , 1989
	<i>S. jobertiana</i>	Aimi <i>et al.</i> , 1989
	<i>S. kasengaensis</i>	Thepenier <i>et al.</i> , 1984
	<i>S. longicaudata</i>	Massiot <i>et al.</i> , 1983a
	<i>S. matopensis</i>	Massiot <i>et al.</i> , 1988
	<i>S. subcordata</i>	Aimi <i>et al.</i> , 1989
	<i>S. toxifera</i>	Souhton and Buckingham, 1989
11-Methoxy Weiland-Gumlich aldehyde	<i>S. angolensis</i>	Bohlin <i>et al.</i> , 1979
17-O-Methyl-11-methoxy Weiland-Gumlich aldehyde	<i>S. angolensis</i>	Bohlin <i>et al.</i> , 1979
Alviminine	<i>S. alvimiana</i>	Marini-Bettolo <i>et al.</i> , 1982

(continued)

Alkaloids	Strychnos species	References
4.4 Tsilanine group		
Tsilanine	<i>S. henningii</i>	Starfati, Paris and Jarreau, 1970
<i>O</i> -Demethyltsilanine	<i>S. henningii</i>	Starfati, Paris and Jarreau, 1970
10-Methoxytsilanine	<i>S. henningii</i>	Starfati, Paris and Jarreau, 1970
10-Methoxy- <i>O</i> -demethyltsilanine	<i>S. henningii</i>	Starfati, Paris and Jarreau, 1970
4.5 Strychnosilidine group		
Alvimine	<i>S. alvimiana</i>	Marini-Bettolo <i>et al.</i> , 1982
Strychnosilidine	<i>S. alvimiana</i>	Marini-Bettolo <i>et al.</i> , 1982
	<i>S. brasiliensis</i>	Aimi <i>et al.</i> , 1989
	<i>S. tabascanana</i>	Aimi <i>et al.</i> , 1989
Strychnosiline	<i>S. alvimiana</i>	Marini-Bettolo <i>et al.</i> , 1982
	<i>S. brasiliensis</i>	Aimi <i>et al.</i> , 1989
Tabascanine	<i>S. alvimiana</i>	Marini-Bettolo <i>et al.</i> , 1982
	<i>S. tabascanana</i>	Aimi <i>et al.</i> , 1989

Alkaloids	Strychnos species	References
4.6 Spermostrychnine group		
Spermostrychnine	<i>S. aculeata</i>	Weeratunga <i>et al.</i> , 1984
	<i>S. brasiliensis</i>	Aimi <i>et al.</i> , 1989
	<i>S. fendleri</i>	Galeffi and Marni-Bettolo, 1980
	<i>S. henningsii</i>	Massiot <i>et al.</i> , 1991
	<i>S. mostueoides</i>	Rasonaivo <i>et al.</i> , 1991
	<i>S. psilosperma</i>	Aimi <i>et al.</i> , 1989
12-Hydroxy-11-methoxyspermostrychnine	<i>S. brasiliensis</i>	Aimi <i>et al.</i> , 1989
23-Hydroxy spermostrychnine	<i>S. henningsii</i>	Massiot <i>et al.</i> , 1991
23-Hydroxy spermostrychnine-N-oxide	<i>S. henningsii</i>	Massiot <i>et al.</i> , 1991
19-Epi-23-hydroxyspermostrychnine	<i>S. henningsii</i>	Massiot <i>et al.</i> , 1991
17,23-Hydroxyspermostrychnine	<i>S. henningsii</i>	Massiot <i>et al.</i> , 1991
Strychnospermine	<i>S. psilosperma</i>	Aimi <i>et al.</i> , 1989
Strychnosplendine	<i>S. splendens</i>	Massiot and Delaude, 1988
<i>N</i> _a -Acetylstrychnosplendine	<i>S. aculeata</i>	Weeratunga <i>et al.</i> , 1984
	<i>S. fendleri</i>	Galeffi and Marni-Bettolo, 1980
	<i>S. henningsii</i>	Chapya, 1983
	<i>S. scheffleri</i>	Caprasso and Angenot, 1981

Alkaloids	<i>Strychnos</i> species	References
<i>N_a</i> -Acetyl-11-methoxystrychnosplendine	<i>S. henningssii</i>	Chapya, 1983
<i>N_a</i> -Acetyl-12-hydroxy-11-methoxystrychnosplendine	<i>S. fendleri</i>	Galeffi and Marni-Bettolo, 1980
<i>O</i> -Methyl- <i>N_a</i> -acetylstrychnosplendine	<i>S. aculeata</i>	Weeratunga <i>et al.</i> , 1984
Splendoline	<i>S. scheffleri</i>	Caprasse and Angenot, 1981
	<i>S. tabascana</i>	Aimi <i>et al.</i> , 1989
<i>N_a</i> -Acetyl-3-deoxy-isostrychnosplendine	<i>S. henningssii</i>	Massiot <i>et al.</i> , 1991
	<i>S. splendens</i>	Massiot and Delaude, 1988
Isostrychnosplendine	<i>S. splendens</i>	Aimi <i>et al.</i> , 1989
	<i>S. splendens</i>	Massiot and Delaude, 1988
<i>N_a</i> -Acetyl-isostrychnosplendine	<i>S. aculeata</i>	Goonetilleke, Rolfsen and Rajapakse, 1980
	<i>S. splendens</i>	Massiot and Delaude, 1988
Isosplendoline	<i>S. splendens</i>	Aimi <i>et al.</i> , 1989
4.7 Isostrychnine group		
Isostrychnine	<i>S. icaja</i>	Frederich <i>et al.</i> , 2000
	<i>S. ignatii</i>	Datta and Bisset, 1990
	<i>S. mix-vomica</i>	Baser, Bisset and Hylands, 1979
19,20-Dihydroisostrychnine	<i>S. mix-vomica</i>	Baser and Bisset, 1982

(continued)

Alkaloids	Strychnos species	References
Protostrychnine	<i>S. ignatii</i> <i>S. mix-vomica</i>	Datta and Bisset, 1990 Baser <i>et al.</i> , 1979
4.8 Strychnine group		
Strychnine	<i>S. icaja</i> <i>S. ignatii</i> <i>S. lucida</i> <i>S. mux-vomica</i> <i>S. panamensis</i> <i>S. wallichiana</i>	Kambu, Coune and Angenot, 1979 Datta and Bisset, 1990 Bisset, 1972a De and Bisset, 1991 Marini-Bettolo <i>et al.</i> , 1972 Bisset, 1973
Strychnine- <i>N</i> -oxide	<i>S. ignatii</i> <i>S. lucida</i> <i>S. mux-vomica</i>	Datta and Bisset, 1990 Asai <i>et al.</i> , 1982 Bisset and Choudhury, 1974a
10-Hydroxystrychnine	<i>S. wallichiana</i> <i>S. ignatii</i>	Bisset and Choudhury, 1974b Datta and Bisset, 1990
12-Hydroxystrychnine (4-Hydroxystrychnine)	<i>S. mux-vomica</i> <i>S. icaja</i> <i>S. mux-vomica</i> <i>S. wallichiana</i>	Baser and Bisset, 1982 Aimi <i>et al.</i> , 1989 Baser and Bisset, 1982 Bisset, 1973

(continued)

Alkaloids	Strychnos species	References
12-Hydroxystrychnine- <i>N</i> -oxide	<i>S. nux-vomica</i>	Baser and Bisset, 1982
15-Hydroxystrychnine	<i>S. nux-vomica</i>	Aimi <i>et al.</i> , 1989
<i>N</i> ₆ -Methylstrychnine	<i>S. icaja</i>	Kambu <i>et al.</i> , 1979
10-Hydroxy-11-methoxystrychnine	<i>S. nux-vomica</i>	Cai <i>et al.</i> , 1990
12-Hydroxy-11-methoxystrychnine	<i>S. nux-vomica</i>	Baser and Bisset, 1982
12-Hydroxy-11-methoxystrychnine- <i>N</i> -oxide	<i>S. wallichiana</i>	Bisset, 1973
Brucine	<i>S. nux-vomica</i>	Baser and Bisset, 1982
	<i>S. ignatii</i>	Bisset and Walker, 1974
	<i>S. lucida</i>	Bavovada, 1983
	<i>S. nux-vomica</i>	Cai <i>et al.</i> , 1990
	<i>S. panamensis</i>	Marini-Bettolo <i>et al.</i> , 1972
	<i>S. wallichiana</i>	Bisset, 1973
	<i>S. ignatii</i>	Bisset and Walker, 1974
	<i>S. lucida</i>	Bavovada, 1983
	<i>S. nux-vomica</i>	Cai <i>et al.</i> , 1990
	<i>S. wallichiana</i>	Bisset, 1973
	<i>S. gauthierana</i>	Bisset, 1973
	<i>S. ligustrina</i>	Pingsuthiwong, 1986
	<i>S. nux-vomica</i>	De and Bisset, 1991
α -Colubrine		

Alkaloids	Strychnos species	References
β -Colubrine	<i>S. lucida</i>	Asai <i>et al.</i> , 1982; Bavovada, 1983
Pseudostrychnine	<i>S. mux-vomica</i>	De and Bisset, 1991
	<i>S. icaja</i>	Bisset, Das and Parello, 1973
	<i>S. ignatii</i>	Datta, and Bisset, 1990
	<i>S. lucida</i>	Asai <i>et al.</i> , 1982; Bavovada, 1983
	<i>S. mux-vomica</i>	Cai <i>et al.</i> , 1990
Pseudobrucine	<i>S. wallichiana</i>	Bisset and Choudhury, 1974b
	<i>S. ignatii</i>	Bisset and Walker, 1974
	<i>S. lucida</i>	Asai <i>et al.</i> , 1982; Bavovada, 1983
	<i>S. mux-vomica</i>	De and Bisset, 1991
3-Hydroxy- α -colubrine	<i>S. wallichiana</i>	Bisset and Choudhury, 1974b
3-Hydroxy- β -colubrine	<i>S. mux-vomica</i>	Aimi <i>et al.</i> , 1989
	<i>S. lucida</i>	Asai <i>et al.</i> , 1982
3-Methoxystrychnine	<i>S. mux-vomica</i>	Aimi <i>et al.</i> , 1989
(16-Methoxystrychnine)	<i>S. icaja</i>	Bisset <i>et al.</i> , 1973
3-Ethoxystrychnine (16-Ethoxystrychnine)	<i>S. ignatii</i>	Aimi <i>et al.</i> , 1989

(continued)

Alkaloids	Strychnos species	References
4.9 Strychnobrasiline group		
Isosplendine	<i>S. aculeata</i>	Weeratunga <i>et al.</i> , 1984
	<i>S. splendens</i>	Aimi <i>et al.</i> , 1989
	<i>S. soubrensis</i>	Ohiri <i>et al.</i> , 1983b
Strychnofendlerine	<i>S. aculeata</i>	Mirand <i>et al.</i> , 1979
	<i>S. fendleri</i>	Galeffi and Marni-Bettolo, 1980
	<i>S. scheffleri</i>	Caprasse and Angenot, 1981
	<i>S. soubrensis</i>	Ohiri <i>et al.</i> , 1983b
11-Methoxystrychnofendlerine	<i>S. fendleri</i>	Galeffi and Marni-Bettolo, 1980
12-Hydroxy-11-methoxystrychnofendlerine	<i>S. fendleri</i>	Galeffi and Marni-Bettolo, 1980
<i>N</i> _a -Deacetylstrychnofendlerine	<i>S. aculeata</i>	Mirand <i>et al.</i> , 1979
Strychnobrasiline	<i>S. brasiliensis</i>	Iwataki and Comin, 1971
	<i>S. mattogrossensis</i>	Angenot <i>et al.</i> , 1990
	<i>S. sheffleri</i>	Caprasse and Angenot, 1981
10-Methoxystrychnobrasiline	<i>S. soubrensis</i>	Ohiri <i>et al.</i> , 1983b
10,11-Dimethoxystrychnobrasiline	<i>S. tabascanana</i>	Souhton and Buckingham, 1989
12-Hydroxy-11-dimethoxystrychnobrasiline	<i>S. brasiliensis</i>	Iwataki and Comin, 1971
	<i>S. brasiliensis</i>	Iwataki and Comin, 1971

Alkaloids	<i>Strychnos</i> species	References
12-Hydroxy-11-dimethoxystrychnobrasiline	<i>S. mattogrossensis</i>	Angenot <i>et al.</i> , 1990
4.10 Holstiine group		
Holstiine	<i>S. hemmingsii</i>	Massiot <i>et al.</i> , 1991
Holstiine	<i>S. hemmingsii</i>	Angenot and Tits, 1981
Rindline	<i>S. hemmingsii</i>	Bisset <i>et al.</i> , 1975
4.11 Icajine group		
Icajine (<i>N</i> -Methyl-sec-pseudostrychnine)	<i>S. mux-vomica</i>	Cai <i>et al.</i> , 1990
Icajine- <i>N</i> -oxide	<i>S. wallichiana</i>	Bisset and Choudhury, 1974b
15-Hydroxycajine (14-Hydroxycajine)	<i>S. wallichiana</i>	Bisset and Choudhury, 1974b
11-Methoxycajine	<i>S. wallichiana</i>	Bisset, 1973
12-Hydroxy-11 Methoxycajine	<i>S. mux-vomica</i>	Bisset and Knolil, 1976
Vomicine	<i>S. wallichiana</i>	Bisset, 1973
	<i>S. mux-vomica</i>	Bisset and Knolil, 1976
	<i>S. wallichiana</i>	Cai <i>et al.</i> , 1990
	<i>S. wallichiana</i>	Bisset, 1973

Alkaloids	Strychnos species	References
Novacaine	<i>S. icaja</i>	Bisset and Knolil, 1976
	<i>S. nux-vomica</i>	Cai <i>et al.</i> , 1990
15-Hydroxynovacaine	<i>S. wallichiana</i>	Bisset and Choudhury, 1974b
N-Methyl-sec-pseudo- β -colubrine	<i>S. wallichiana</i>	Bisset, 1973
	<i>S. nux-vomica</i>	Bisset and Choudhury, 1974a
19,20 α -Epoxy-10-methoxyicajine	<i>S. wallichiana</i>	Bisset and Choudhury, 1974b
19,20 α -Epoxy-12-methoxyicajine	<i>S. icaja</i>	Massiot and Delaude, 1988
19,20 α -Epoxy-12-hydroxy-11-methoxyicajine	<i>S. icaja</i>	Bisset and Knolil, 1976
19,20 α -Epoxy-15-methoxy-12-methoxyicajine	<i>S. icaja</i>	Bisset and Knolil, 1976
19,20 α -Epoxy-10,11-dimethoxyicajine	<i>S. icaja</i>	Bisset and Knolil, 1976
19,20 α -Epoxy-11,12-dimethoxyicajine	<i>S. icaja</i>	Bisset and Knolil, 1976
19,20 α -Epoxy-15-hydroxy-10,11-dimethoxyicajine	<i>S. icaja</i>	Bisset and Knolil, 1976
19,20 α -Epoxy-12,15-dihydroxy-11-methoxyicajine	<i>S. icaja</i>	Bisset and Knolil, 1976
19,20 α -Epoxy-15-hydroxyicajine	<i>S. icaja</i>	Bisset and Knolil, 1976
19,20 α -Epoxyvomicine	<i>S. icaja</i>	Massiot and Delaude, 1988
19,20 α -Epoxy-15-hydroxyvomicine	<i>S. icaja</i>	Massiot and Delaude, 1988
19,20 α -Epoxyovacine	<i>S. icaja</i>	Bisset and Knolil, 1976
19,20 α -Epoxy-15-hydroxynovacine	<i>S. icaja</i>	Kambu <i>et al.</i> , 1979

Alkaloids	Strychnos species	References
<i>N</i> -Cyano- <i>sec</i> -pseudostrychnine	<i>S. ignatii</i>	Bisset and Walker, 1974
<i>N</i> -Cyano- <i>sec</i> -pseudobrucine	<i>S. wallichiana</i>	Bisset and Choudhury, 1974b
<i>N</i> -Cyano- <i>sec</i> -pseudocolubrine	<i>S. wallichiana</i>	Bisset and Choudhury, 1974b
	<i>S. ignatii</i>	Bisset and Walker, 1974
5. Aspidospermatan Type		
Condylocarpine	<i>S. dolichothyrsa</i>	Verpoorte <i>et al.</i> , 1982
Tubotaiwine	<i>S. nux-vomica</i>	Heimberger and Scott, 1973
	<i>S. angolensis</i>	Bohlin <i>et al.</i> , 1979
	<i>S. dolichothyrsa</i>	Verpoorte <i>et al.</i> , 1982
6. Miscellaneous group		
Brafouledine	<i>S. dinklagei</i>	Michel, Tillequin and Koch, 1986
Isobrafouledine	<i>S. dinklagei</i>	Michel <i>et al.</i> , 1986
6,7-Dihydroflavoperirine	<i>S. usambarensis</i>	Caprasse, Coune and Angenot, 1983a

(continued)

Alkaloids	Strychnos species	References
Strychnoxanthine	<i>S. gossweileri</i>	Coune, 1978
Melinonine E	<i>S. melinoniana</i>	Aimi <i>et al.</i> , 1989
Strychnohirsutine	<i>S. hirsuta</i>	Galeffi and Marini-Bettolo, 1981
Tetrahydrostrychnohirsutine	<i>S. hirsuta</i>	Galeffi and Marini-Bettolo, 1981

(continued)

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Alkaloid	Strychnos species	References
Dimeric alkaloids		
1. Quasi-dimeric alkaloids		
1.1 Usambarensine group		
Usambarensine	<i>S. dale</i>	Massiot and Delaude, 1988
<i>N</i> ₆ -Methyl usambarensine	<i>S. memecloides</i>	Massiot and Delaude, 1988
Tchibangensine (5',6'-dihydrousambarensine)	<i>S. usambarensis</i>	Angenot <i>et al.</i> , 1975
	<i>S. usambarensis</i>	Angenot <i>et al.</i> , 1975
	<i>S. dale</i>	Massiot and Delaude, 1988
	<i>S. tchibangensis</i>	Richard <i>et al.</i> , 1978
	<i>S. usambarensis</i>	Quetin-Leclercq and Tits, 1991
3,17-tetrahydrousambarensine	<i>S. dale</i>	Caron <i>et al.</i> , 1988
10'-Hydroxy-tetrahydrousambarensine	<i>S. dale</i>	Caron <i>et al.</i> , 1988
10,10'-Dimethoxytetrahydrousambarensine	<i>S. dale</i>	Caron <i>et al.</i> , 1988

(continued)

Alkaloid	<i>Strychnos</i> species	References
10,10'-Dihydroxy- <i>N</i> ₆ -tetrahydrousambarensine	<i>S. dale</i>	Caron <i>et al.</i> , 1988
10,10'-Dimethoxy- <i>N</i> ₆ -methyl-tetrahydrousambarensine	<i>S. dale</i>	Caron <i>et al.</i> , 1988
10-Hydroxy-10'-methoxy- <i>N</i> ₆ -methyl-tetrahydrousambarensine	<i>S. dale</i>	Caron <i>et al.</i> , 1988
10'-Hydroxyusambarensine	<i>S. usambarensis</i>	Frederich <i>et al.</i> , 1999b
Usambarine	<i>S. barrette</i>	Nicoletti <i>et al.</i> , 1980
	<i>S. nigrimana</i>	Nicoletti <i>et al.</i> , 1980
Usambaridine Vi (10-Hydroxyusambarine)	<i>S. usambarensis</i>	Quetin-Leclercq and Tits, 1991
	<i>S. barteri</i>	Nicoletti <i>et al.</i> , 1980
	<i>S. nigrimana</i>	Nicoletti <i>et al.</i> , 1980
	<i>S. usambarensis</i>	Quetin-Leclercq and Tits, 1991
Usambaridine Br (11-Hydroxyusambarine)	<i>S. usambarensis</i>	Quetin-Leclercq and Tits, 1991
<i>N</i> ₆ -Methyl-10-hydroxyusambarine	<i>S. usambarensis</i>	Caprasso, Tavernier and Angenot, 1983b
<i>N</i> ₆ -Methyl-11-hydroxyusambarine	<i>S. usambarensis</i>	Caprasso <i>et al.</i> , 1983b
Nigritanine (18,19-Dihydroxyusambarine)	<i>S. barteri</i>	Nicoletti <i>et al.</i> , 1980
	<i>S. nigrimana</i>	Nicoletti <i>et al.</i> , 1980
	<i>S. usambarensis</i>	Bassleer <i>et al.</i> , 1982
11-Hydroxynigritanine (18,19-Dihydroxyusambarine Br)	<i>S. usambarensis</i>	Massiot and Delaude, 1988

(continued)

Alkaloid	Strychnos species	References
Strychnopentamine	<i>S. usambarensis</i>	Quetin-Leclercq and Tits, 1991
Isostrychnopentamine	<i>S. usambarensis</i>	Quetin-Leclercq and Tits, 1991
Strychnobaridine	<i>S. usambarensis</i>	Massiot and Delaude, 1988
1.2 Strychnofoline group		
Strychnofoline	<i>S. usambarensis</i>	Quetin-Leclercq and Tits, 1991
Strychnophylline	<i>S. usambarensis</i>	Angenot, 1978.
2. Strychnan-Corynanthean type		
2.1 Retuline-Corynantheine group		
Afrocurarine	<i>S. usambarensis</i>	Capresse <i>et al.</i> , 1984b
Guiachry sine	<i>S. guianensis</i>	Penelle <i>et al.</i> , 2001
5',6'-Dehydroguiachry sine	<i>S. guianensis</i>	Penelle <i>et al.</i> , 2001
Guianensine	<i>S. guianensis</i>	Quetin-Leclercq <i>et al.</i> , 1995
Longicaudatine F (18-Hydroxy longicaudatine Y)	<i>S. matopensis</i>	Massiot <i>et al.</i> , 1988

(continued)

Alkaloid	<i>Strychnos</i> species	References
Longicaudatine Y	<i>S. longicaudata</i>	Massiot <i>et al.</i> , 1983b
Dihydrolongicaudatine Y	<i>S. matopensis</i>	Massiot <i>et al.</i> , 1988
Longicaudatine Z	<i>S. longicaudata</i>	Massiot <i>et al.</i> , 1983b
3',4',5',6'-Tetrahydrolongicaudatine	<i>S. potatorum</i>	Massiot <i>et al.</i> , 1992
Strychnochrysin	<i>S. matopensis</i>	Massiot <i>et al.</i> , 1988
	<i>S. usambarensis</i>	Frederich <i>et al.</i> , 1998
	<i>S. nux-vomica</i>	Biala <i>et al.</i> , 1998
2.2 Diaboline-Corynantheine group		
Longicaudatine	<i>S. afzeli</i>	Massiot <i>et al.</i> , 1983b
	<i>S. chrysophylla</i>	Massiot <i>et al.</i> , 1983b
	<i>S. dolichothyrsa</i>	Massiot <i>et al.</i> , 1983b
	<i>S. ignatii</i>	Pingsuthiwong, 1986
	<i>S. longicaudata</i>	Massiot <i>et al.</i> , 1983a
	<i>S. lucida</i>	Massiot <i>et al.</i> , 1983b
	<i>S. matopensis</i>	Massiot <i>et al.</i> , 1988
	<i>S. ngouniensis</i>	Massiot <i>et al.</i> , 1983b
	<i>S. urceolata</i>	Massiot <i>et al.</i> , 1983b

Alkaloid	Strychnos species	References
Guiaflavine	<i>S. trinervis</i>	Mukherjee <i>et al.</i> , 1990
5',6'-Dehydroguiaflavine	<i>S. guianensis</i>	Penelle <i>et al.</i> , 2001
	<i>S. guianensis</i>	Penelle <i>et al.</i> , 2001
3. Strychnan-Strychnan type		
3.1 Retuline-Retuline group		
C-Toxiferine (Toxiferine V)	<i>S. froesii</i>	Aimi <i>et al.</i> , 1989
C-Alkaloid H	<i>S. toxifera</i>	Aimi <i>et al.</i> , 1989
Bisnor-C-alkaloid H	<i>S. afzelii</i>	Verpoorte <i>et al.</i> , 1980
	<i>S. dolichothyrsa</i>	Verpoorte <i>et al.</i> , 1982
	<i>S. longicaudata</i>	Massiot <i>et al.</i> , 1983a
	<i>S. malacoclados</i>	Massiot and Delaude, 1988
	<i>S. matopensis</i>	Massiot <i>et al.</i> , 1988
	<i>S. trinervis</i>	Mukherjee <i>et al.</i> , 1990
Bisnor-C-alkaloid H-mono-N-oxide	<i>S. urceolata</i>	Verpoorte, Kodde and Baerheim-Svendsen, 1978a
	<i>S. afzelii</i>	Aimi <i>et al.</i> , 1989
	<i>S. dolichothyrsa</i>	Verpoorte <i>et al.</i> , 1982

Alkaloid	<i>Strychnos</i> species	References
Bisnor-C-alkaloid H-di-N-oxide	<i>S. dolichothyrsa</i>	Verpoorte <i>et al.</i> , 1982
C-Alkaloid K (C-Dihydrotoxiferine)	<i>S. longicaudata</i>	Soulton and Buckingham, 1989
	<i>S. panamensis</i>	Aimi <i>et al.</i> , 1989
Bisnordihydrotoxiferine	<i>S. toxifera</i>	Soulton and Buckingham, 1989
	<i>S. usambarensis</i>	Massiot and Delaude, 1988
	<i>S. afzelii</i>	Verpoorte <i>et al.</i> , 1980
	<i>S. decussata</i>	Rolfsen <i>et al.</i> , 1981
	<i>S. dolichothyrsa</i>	Verpoorte and Baerheim-Svendsen, 1976
	<i>S. elaeocarpa</i>	Rolfsen <i>et al.</i> , 1981
	<i>S. floribunda</i>	Verpoorte <i>et al.</i> , 1981
	<i>S. froesii</i>	Aimi <i>et al.</i> , 1989
	<i>S. icaja</i>	Kambu <i>et al.</i> , 1979
	<i>S. kasengaensis</i>	Thepenier <i>et al.</i> , 1984
	<i>S. longicaudata</i>	Massiot <i>et al.</i> , 1983a
	<i>S. malacoclados</i>	Massiot and Delaude, 1988
	<i>S. matopensis</i>	Massiot <i>et al.</i> , 1988
<i>S. potatorum</i>	Massiot <i>et al.</i> , 1992	
<i>S. pseudoquina</i>	Aimi <i>et al.</i> , 1989	
<i>S. scheffleri</i>	Caprasse and Angenot, 1981	

Alkaloid	<i>Strychnos</i> species	References
Bisnordihydrotoxiferine	<i>S. toxifera</i>	Aimi <i>et al.</i> , 1989
	<i>S. trinervis</i>	Mukherjee <i>et al.</i> , 1990
Bisnordihydrotoxiferine mono-N-oxide	<i>S. urceolata</i>	Verpoorte <i>et al.</i> , 1978a
	<i>S. variabilis</i>	Tits and Tavernier, 1978.
Matopensine	<i>S. wallichiana</i>	Strombom <i>et al.</i> , 1982
	<i>S. afzelii</i>	Verpoorte <i>et al.</i> , 1980
Matopensine-N-oxide	<i>S. kasengaensis</i>	Thepenier <i>et al.</i> , 1984
	<i>S. matopensis</i>	Massiot <i>et al.</i> , 1988
C-Alkaloid D	<i>S. kasengaensis</i>	Thepenier <i>et al.</i> , 1984
	<i>S. matopensis</i>	Massiot <i>et al.</i> , 1988
C-Calebassine	<i>S. matopensis</i>	Massiot <i>et al.</i> , 1988
	<i>S. mitcherlichii</i>	Aimi <i>et al.</i> , 1989
C-Alkaloid F	<i>S. divaricans</i>	Aimi <i>et al.</i> , 1989
	<i>S. mitcherlichii</i>	Aimi <i>et al.</i> , 1989
	<i>S. solimoesana</i>	Aimi <i>et al.</i> , 1989
	<i>S. trinervis</i>	Aimi <i>et al.</i> , 1989
	<i>S. usambarensis</i>	Massiot and Delaude, 1988
	<i>S. panamensis</i>	Aimi <i>et al.</i> , 1989

Alkaloid	<i>Strychnos</i> species	References
C-Alkaloid F	<i>S. solimoesana</i>	Aimi <i>et al.</i> , 1989
C-Alkaloid A	<i>S. toxifera</i>	Aimi <i>et al.</i> , 1989
C-Curarine	<i>S. divaricans</i>	Aimi <i>et al.</i> , 1989
	<i>S. froesii</i>	Aimi <i>et al.</i> , 1989
	<i>S. mitcherlichii</i>	Aimi <i>et al.</i> , 1989
	<i>S. solimoesana</i>	Aimi <i>et al.</i> , 1989
	<i>S. trinervis</i>	Aimi <i>et al.</i> , 1989
	<i>S. usambarensis</i>	Caprasse <i>et al.</i> , 1984a
C-Alkaloid G	<i>S. panamensis</i>	Aimi <i>et al.</i> , 1989
	<i>S. solimoesana</i>	Aimi <i>et al.</i> , 1989
C-Alkaloid E	<i>S. froesii</i>	Aimi <i>et al.</i> , 1989
	<i>S. solimoesana</i>	Aimi <i>et al.</i> , 1989
	<i>S. tomentosa</i>	Aimi <i>et al.</i> , 1989
Strychnobiline	<i>S. variabilis</i>	Tits and Tavernier, 1978.
12'-Hydroxystrychnobiline	<i>S. variabilis</i>	Tits and Tavernier, 1978.
Isostrychnobiline	<i>S. variabilis</i>	Tits and Tavernier, 1978.
12'-Hydroxyisostrychnobiline	<i>S. variabilis</i>	Tits, Angenot and Tavernier, 1983
16,17-Dehydroisostrychnobiline	<i>S. kasengaensis</i>	Thepenier <i>et al.</i> , 1984

(continued)
53

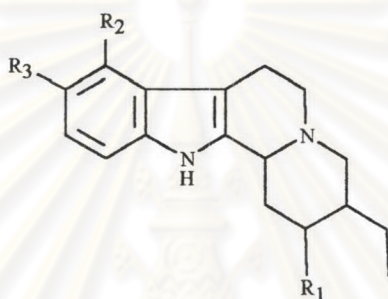
Alkaloid	Strychnos species	References
3.2 Diaboline-Diaboline group		
Caracurine II	<i>S. toxifera</i>	Aimi <i>et al.</i> , 1989
Caracurine II dimethosalt	<i>S. toxifera</i>	Aimi <i>et al.</i> , 1989
Caracurine V	<i>S. afzelii</i>	Massiot and Delaude, 1988
	<i>S. angolensis</i>	Massiot and Delaude, 1988
	<i>S. chrysohylla</i>	Massiot and Delaude, 1988
	<i>S. dolichothyrsa</i>	Verpoorte and Baerheim-Svendsen, 1978
	<i>S. malacoclados</i>	Massiot and Delaude, 1988
	<i>S. toxifera</i>	Aimi <i>et al.</i> , 1989
Caracurine V mono- <i>N</i> -oxide	<i>S. urceolata</i>	Verpoorte <i>et al.</i> , 1980
	<i>S. afzelii</i>	Massiot and Delaude, 1988
	<i>S. dolichothyrsa</i>	Verpoorte and Baerheim-Svendsen, 1978
Caracurine V di- <i>N</i> -oxide	<i>S. dolichothyrsa</i>	Verpoorte and Baerheim-Svendsen, 1978

Alkaloid	Strychnos species	References
3.3 Isostrychnine-Isostrychnine group		
Sangucine	<i>S. icaja</i>	Kambu <i>et al.</i> , 1979
18-Hydroxyisosangucine	<i>S. icaja</i>	Frederich <i>et al.</i> , 2001
Isosangucine	<i>S. icaja</i>	Frederich <i>et al.</i> , 2001
18-Hydroxyisosangucine	<i>S. icaja</i>	Frederich <i>et al.</i> , 2001
3.4 Diaboline-isostrychnine group		
Strychnogucine A	<i>S. icaja</i>	Frederich <i>et al.</i> , 2001
Strychnogucine B	<i>S. icaja</i>	Frederich <i>et al.</i> , 2001
4. Miscellaneous		
Janussine A	<i>S. johnsonii</i>	Massiot <i>et al.</i> , 1987
Janussine B	<i>S. johnsonii</i>	Massiot <i>et al.</i> , 1987
Strellidimine	<i>S. dinklagei</i>	Massiot and Delaude, 1988

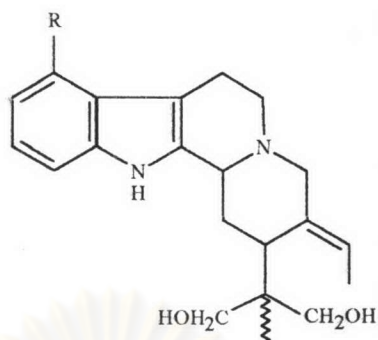
Monomeric alkaloids

1. Corynanthean type

1.1 Corynantheine group

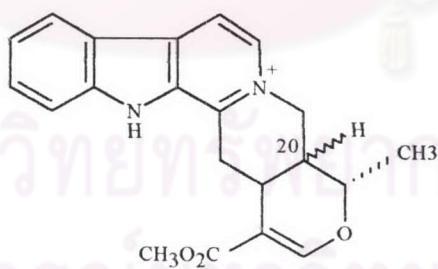


	R ₁	R ₂	R ₃	
10-Hydroxy- <i>N</i> _b -methyl-corynantheol	CH ₂ -CH ₂ OH	H	OH	<i>N</i> _b -Me
2,7-Dihydroapogeissochizine	C(CO ₂ CH ₃) = CHO	H	H	Δ 19,20; 2,7-dihydro
9-Methoxy- <i>N</i> _b -methyl-geissochizol	CH ₂ -CH ₂ OH	OMe	H	Δ 19,20; <i>N</i> _b -Me
9-Methoxygeissochizol	CH ₂ -CH ₂ OH	OMe	H	Δ 19,20
De-carbomethoxygeissochizine	CH=CHO	H	H	Δ 19,20
Dihydrocorynantheol	CH ₂ -CH ₂ OH	H	H	
Geissochizal	CH ₂ -CHO	H	H	Δ 19,20
Geissochizine	C(CO ₂ CH ₃) = CHO	H	H	Δ 19,20
Geissochizol	CH ₂ -CH ₂ OH	H	H	Δ 19,20
Melinonine B	CH ₂ -CH ₂ OH	H	H	Δ 18,19; <i>N</i> _b -Me
Normelinonine B	CH ₂ -CH ₂ OH	H	H	Δ 18,19



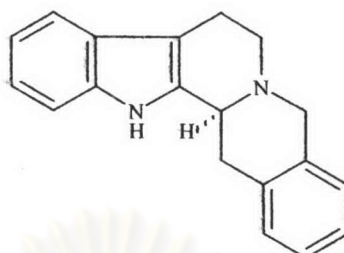
(16R)-Isositsirikine	R = H
16 - Epidiplocerine	R = H
Diplocerine	$N_b - \alpha\text{Me}$
Strychnorubigine	R = H
(9-Methoxyisositirikine)	$N_b - \alpha\text{Me}$
	R = OMe

1.2 Ajmalicine group



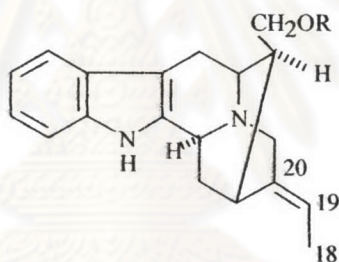
Alstonine	H -20 = α
Serpentine	H -20 = β

1.3 Yohimbine group

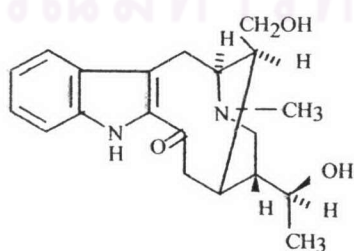


Decarbomethoxydihydrogambirtannine

1.4 Sarpagine group

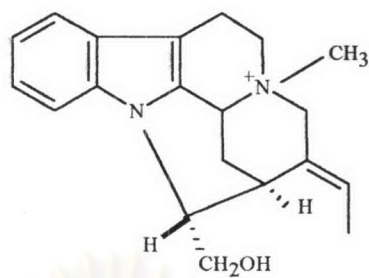


Macusine B	$N_{b^+}\text{-}\alpha \text{ Me, R = H}$
O-Methyldihyromacusine B	$N_{b^+}\text{-Me, R=Me, 19,20-dihydro}$
O-Methylmacusine B	$N_{b^+}\text{-Me, R=Me}$
Normacusine B	R = H
3-Hydroxy-19(Z)-normacusine B	R = H, 3-OH

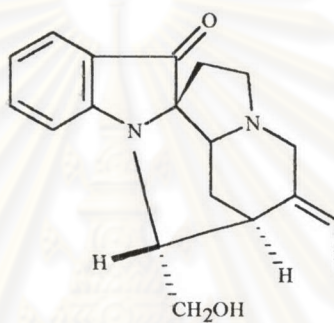


Erichsonine

1.5 Mavacurine group

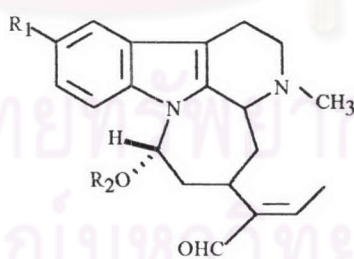


C-mavacurine (Mavacurine)

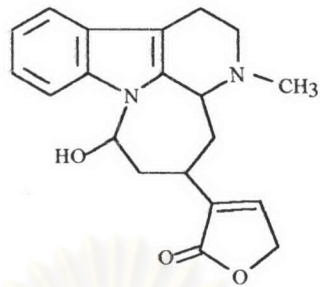


C-fluorocurine (Fluorocurine)

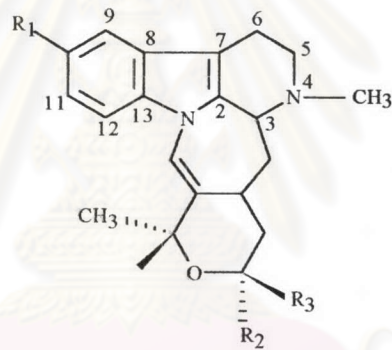
1.6 Akagerine group



Akagerine	R ₁	R ₂
10-Hydroxyakagerine	H	H
10-Hydroxy-17-O-methyakagerine	OH	H
17-O-Methylakagerine	H	Me
17-O-Ethylakagerine	H	Et



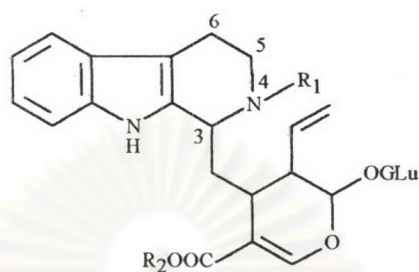
Akagerine lactone



	R ₁	R ₂	R ₃
Kribine	H	H	OH
21- <i>O</i> -Methylkribine	H	H	OMe
21-Epi- <i>O</i> -methylkribine	H	OMe	H
10-Hydroxy-21- <i>O</i> -methylkribine	OH	H	OMe
10-Hydroxy-21-epi- <i>O</i> -methylkribine	OH	OMe	H

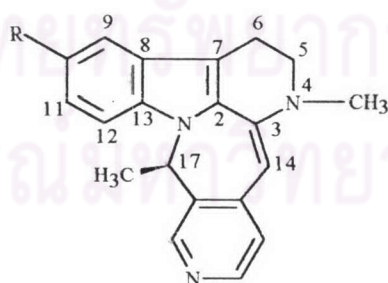
2. Vincosan type

2.1 Strictosidine group

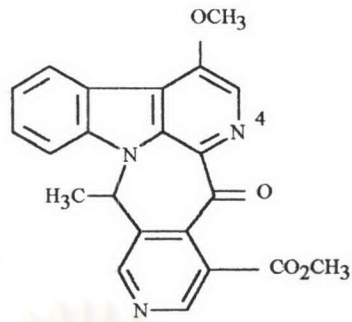


	R ₁	R ₂	
Desoxycordifoline	H	H	Δ^3, Δ^5
Dolichantoside	CH ₃	CH ₃	C ₃ - α H
3,4,5,6-Tetrahydrodolichantoside	CH ₃	CH ₃	C ₃ - α H Δ^3, Δ^5
Isodolichantoside	CH ₃	CH ₃	C ₃ - β H
Palicoside	CH ₃	H	C ₃ - α H
3,4,5,6-Tetrahydropalicoside	CH ₃	H	C ₃ - α H Δ^3, Δ^5
Strictosidine	H	CH ₃	C ₃ - α H

2.2 Decussine group



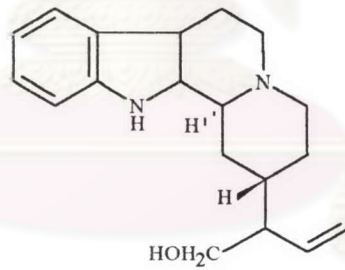
Decussine	R = H
3,14-Dihydrodecussine	R = H, 3,14-dihydro
10-Hydro-3,14-dihydrodecussine	R = OH, 3,14-dihydro



Camptoneurine

3. Vallesiachotaman type

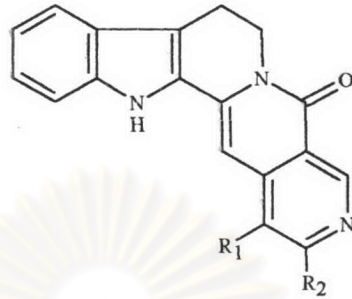
3.1 Antirhine group



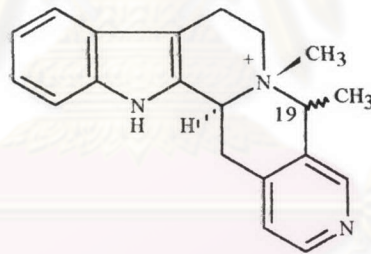
Antirhine

*N*_b-Methylantirhine*N*_b-Me

3.2 Angustine group



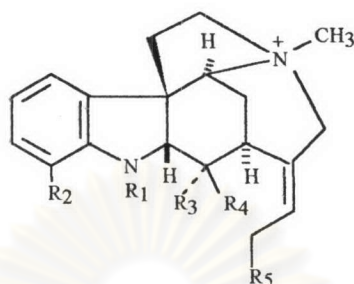
	R ₁	R ₂
Angustine	-CH=CH ₂	H
Angustidine	H	Me
Angustoline	-CH(OH)-CH ₃	H



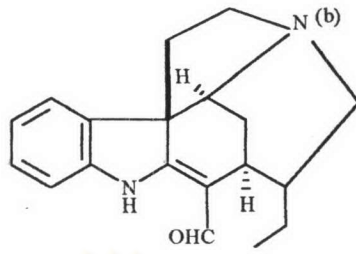
Malindine	H -19 = α
Isomalindine	H -19 = β

4. Strychnan type

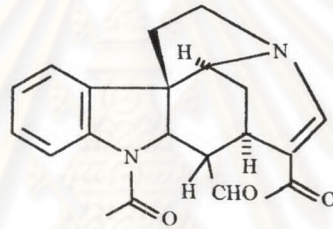
4.1 Akuammicine group



	R ₁	R ₂	R ₃	R ₄	R ₅
Retuline	Ac	H	CH ₂ OH	H	H
11-Methoxyretuline	Ac 11-OMe	H	CH ₂ OH	H	H
O-Acetylretuline	Ac	H	CH ₂ OAc	H	H
N _a -Deacetylretuline	H	H	CH ₂ OH	H	H
N-Oxyretuline	Ac	H	CH ₂ OH	H	H
Retulinal	Ac	H	CHO	H	H
12-Hydroxyretulinal	Ac	OH	CHO	H	H
Isoretuline	Ac	H	H	CH ₂ OH	H
18-Hydroxyisoretuline	Ac	H	H	CH ₂ OH	OH
11-Methoxyisoretuline	Ac 11-OMe	H	H	CH ₂ OH	H
O-Acetylisoretuline	Ac	H	H	CH ₂ OAc	H
N _a -Deacetylisoretuline	H	H	H	CH ₂ OH	H
N _a -Deacety-18-hydroxyisoretuline	H	H	H	CH ₂ OH	OH
N _a -Deacety-17-O-acetyl-18-hydroxyisoretuline	H	H	H	CH ₂ OAc	OH
N _a -Deacety-18-acetoxyisoretuline	H	H	H	CH ₂ OH	OAc
Isoretulinal	Ac	H	H	CH ₂ OH	H
12-Hydroxyretulinal	Ac	OH	CHO		H
16-Hydroxyisoretulinal	Ac		OH	CHO	H
Tsilanimbine	H 10-OMe	H	H	CH ₂ OH	H
18-Deoxy Wieland – Gumlich aldehyde (Nordihydrofluorocurarine)	H	H	H	CHO	H
Strychnopivotine	Ac	H	= O		H

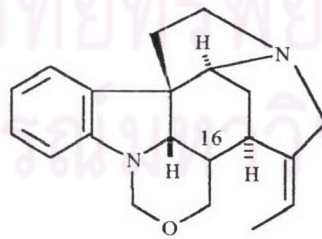


Fluorocurarine	N_b -Me
Nor-C-fluorocurarine	



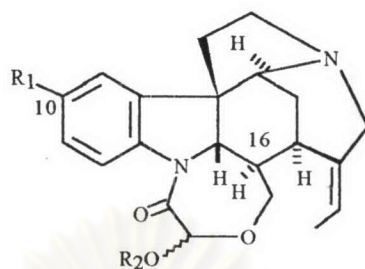
Strychnozairine

4.2 Rosibiline group



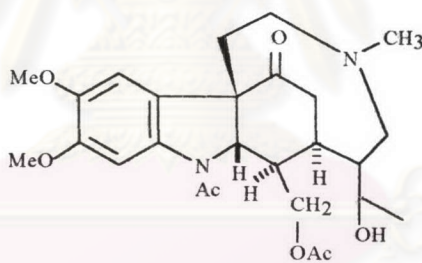
Rosibiline	H-16 β
Isorosibiline	H-16 α

4.4 Tsilanine group

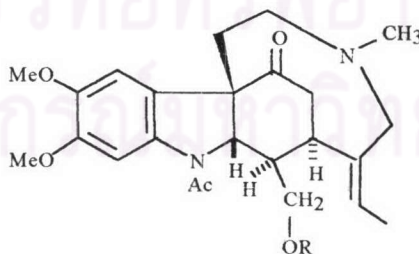


	R ₁	R ₂
Tsilanine	H	Me
<i>O</i> -Demethyltsilanine	H	H
10-Methoxytsilanine	OMe	Me
10-Methoxy- <i>O</i> -demethyltsilanine	OMe	H

4.5 Strychnosilidine group

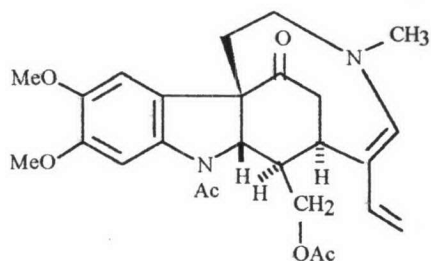


Alvimine



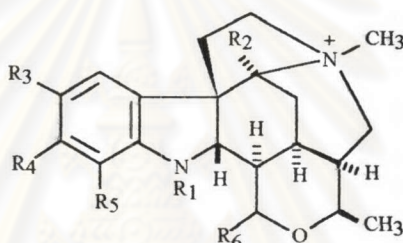
Strychnosilidine R = Ac

Tabascanine R = H

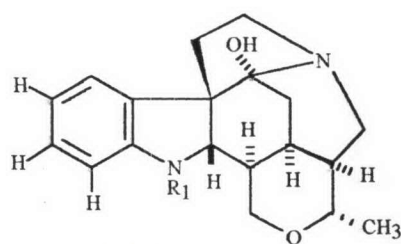


Strychnosiline

4.6 Spermotryhnine group

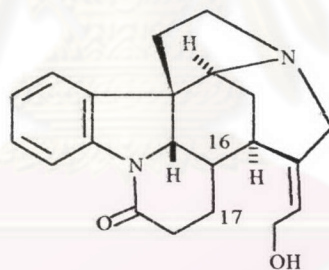


	R ₁	R ₂	R ₃	R ₄	R ₅	R ₆
Spermotryhnine	Ac	H	H	H	H	H
12-Hydroxy-11-methoxyspermotrychnine	Ac	H	H	OMe	OH	H
23-Hydroxyspermotrychnine	COCH ₂ OH	H	H	H	H	H
23-Hydroxyspermotrychnine- <i>N</i> -oxide	COCH ₂ OH <i>N</i> _{b+} -O	H	H	H	H	H
19-Epi-23-hydroxyspermotrychnine	COCH ₂ OH H-19 = β	H	H	H	H	H
17, 23-Hydroxyspermotrychnine	COCH ₂ OH	H	H	H	H	OH
Strychnospermine	Ac	H	H	OMe	H	H
Strychnosplendine	H	OH	H	H	H	H
<i>N</i> _a - Acetylstrychnosplendine	Ac	OH	H	H	H	H
<i>N</i> _a - Acetyl-12-hydroxy-11-methoxysterylstrychnosplendine	Ac	OH	H	OMe	H	H
<i>O</i> -Methy- <i>N</i> _a -acetylstrychnosplendine	Ac	OMe	H	H	H	H
Splendoline	COCH ₂ OH	OH	H	H	H	H
<i>N</i> _a -Acetyl-13-deoxy-isostrychnosplendine	Ac	H	H	H	H	H



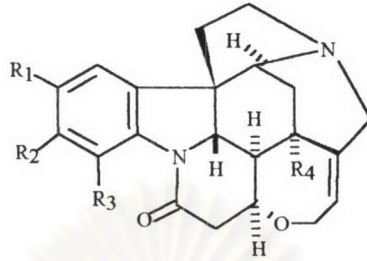
	R ₁
Isostrychnosplendine	H
N _α - Acetyl-isostrychnosplendine	Ac
Isosplendoline	COCH ₂ OH

4.7 Isostrychnine group

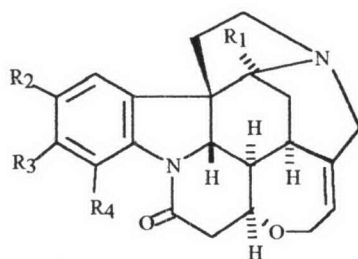


Isostrychnine	
19, 20-Dihydroisostrychnine	19, 20-Dihydro
Protostrychnine	H-16 = α , OH-17 = α

4.8 Strychnine group

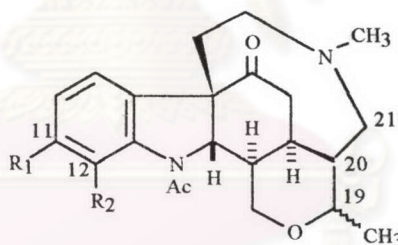


	R ₁	R ₂	R ₃	R ₄
Strychnine	H	H	H	H
Strychnine- <i>N</i> -oxide	H	H <i>N</i> ^b -O	H	H
10-Hydroxystrychnine	OH	H	H	H
12-Hydroxystrychnine (4-Hydroxystrychnine)	H	H <i>N</i> ^b -O	OH	H
12-Hydroxystrychnine- <i>N</i> -oxide	H	H <i>N</i> ^b -O	OH	H
15-Hydroxystrychnine	H	H	H	OH
<i>N</i> _b -Methylstrychnine	H	H <i>N</i> ^{b+} -Me	H	H
10-Hydroxy-11-methoxystrychnine	OH	OMe	H	H
12-Hydroxy-11-methoxystrychnine	H	OMe	OH	H
12-Hydroxy-11-methoxystrychnine- <i>N</i> -oxide	H	OMe <i>N</i> ^b -O	OH	H
Brucine	OMe	OMe	H	H
Bucine- <i>N</i> -oxide	OMe	OMe <i>N</i> ^b -O	H	H
α-Colubrine	H	OMe	H	H
β-Colubrine	OMe	H	H	H



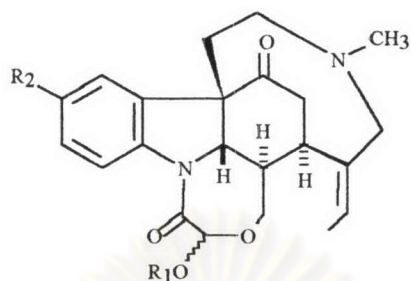
	R ₁	R ₂	R ₃	R ₄
Pseudostrychnine	OH	H	H	H
Pseudobrucine (3-hydroxybrucine)	OH	OMe	OMe	H
3-Hydroxy- α colubrine	OH	OMe	H	H
3-Hydroxy- β colubrine	OH	H	OMe	H
3-Ethoxystrychnine	OEt	H	H	H
3-Methoxystrychnine	OMe	H	H	H

4.9 Strychnobrasiline group



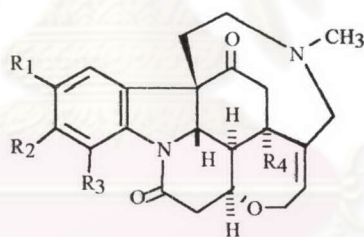
	R ₁	R ₂	19-Me	20-H
Isosplendine	H	H	α	α
Strychnofendlerine	H	H	β	α
11-Methoxystrychnofendlerine	OMe	H	β	α
12-Hydroxy-11-methoxystrychnofendlerine	OMe	H	β	α
N _a -Deacetylstrychnofendlerine	H N _a -Deacetyl	H	β	α
Strychnobrasiline	H	H	β	$\Delta^{20,21}$
10-Methoxystrychnobrasiline	H	OMe (C-11)	β	$\Delta^{20,21}$
10,11-Dimethoxystrychnobrasiline	OMe (C-10)	OMe (C-11)	β	$\Delta^{20,21}$
12-Hydroxy-11-methoxystrychnobrasiline	OMe	OH	β	$\Delta^{20,21}$

4.10 Holstiine group

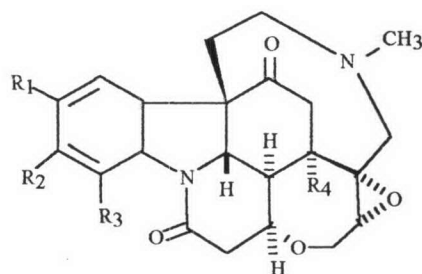


	R ₁	R ₂
Holstiine	H	H
Holstiline	Me	H
Rindline	Me	OMe

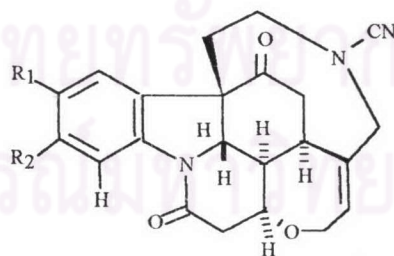
4.11 Icajine group



	R ₁	R ₂	R ₃	R ₄
Icajine	H	H	H	H
Icajine- <i>N</i> -oxide	H	H <i>N_b-O</i>	H	H
14-Hydroxy-11- methoxy- <i>N</i> -methyl- <i>sec</i> -pseudstrychnine (14-hydroxyicajine)	H	H	H	OH
11-Methoxyicajine	H	OMe	H	H
12-Hydroxy-11- methoxyicajine	H	OMe	OH	H
Vomicine	H	H	OH	H
Novacine	OMe	OMe	H	H
14-Hydroxynovacine	OMe	OMe	H	OH
<i>N</i> -Methyl- <i>sec</i> - pseudo- β -colubrine	OMe	H	H	H

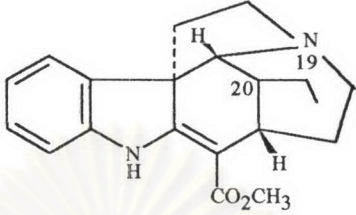


	R ₁	R ₂	R ₃	R ₄
19,20 α -Epoxy-10-methoxyicajine	OMe	H	H	H
19,20 α -Epoxy-12-methoxyicajine	H	H	OMe	H
19,20 α -Epoxy-12-hydroxy-11-methoxyicajine	H	OMe	OH	H
19,20 α -Epoxy-15-methoxy-12-methoxyicajine	H	H	OMe	OMe
19,20 α -Epoxy-10,11-dimethoxyicajine	OMe	OMe	H	H
19,20 α -Epoxy-11,12-dimethoxyicajine	H	OMe	OMe	H
19,20 α -Epoxy-15-hydroxy-10,11-dimethoxyicajine	OMe	OMe	H	OH
19,20 α -Epoxy-12,15-dihydroxy-11-methoxyicajine	H	OMe	OH	OH
19,20 α -Epoxy-15-hydroxyicajine	H	H	H	OH
19,20 α -Epoxyvomicine	OMe	OMe	OH	H
19,20 α -Epoxy-15-hydroxyvomicine	OMe	OMe	OH	OH
19,20 α -Epoxyynovacine	H	H	OH	H
19,20 α -Epoxy-15-hydroxyynovacine	H	H	OH	OH



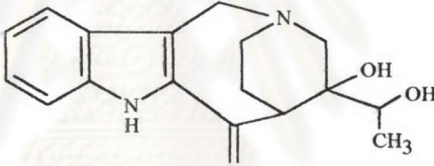
	R ₁	R ₂
<i>N</i> -Cyano- <i>sec</i> -pseudostrychine	H	H
<i>N</i> -Cyano- <i>sec</i> -pseudobrucine	OMe	OMe
<i>N</i> -Cyano- <i>sec</i> -pseudocolubrine	OMe	H

5. Aspidospermatan type

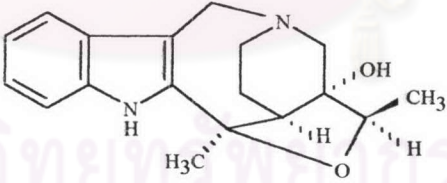


Condyllocarpine	19,20-dehydro
Tubotaiwine	

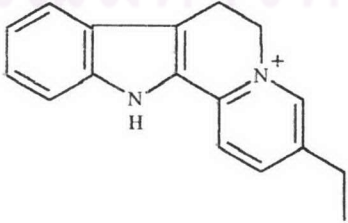
6. Miscellaneous group



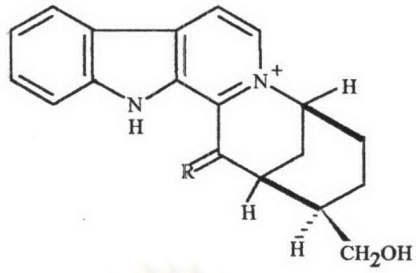
Brafoledine



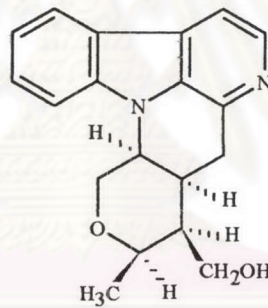
Isobrafoledine



6, 7-Dihydroflavoperirine



	R
Strychnoxanthine	O
Melinonine E	H ₂



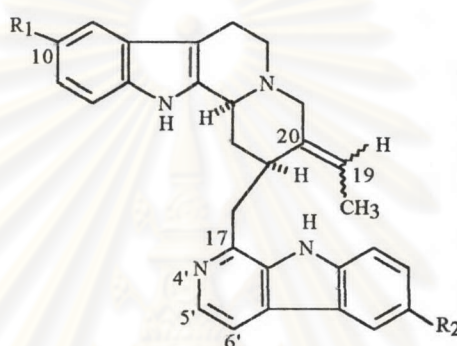
Strychnohirsutine	
Tetrahydrostrychnohirsutine	3,4,5,6-tetrahydro

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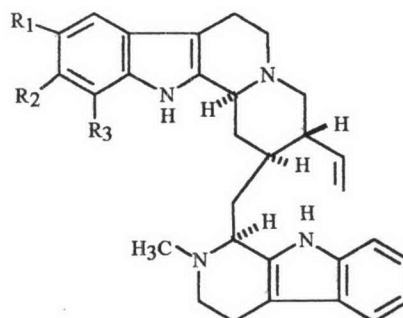
Dimeric alkaloids

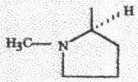
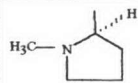
1. Quasi-dimeric alkaloids

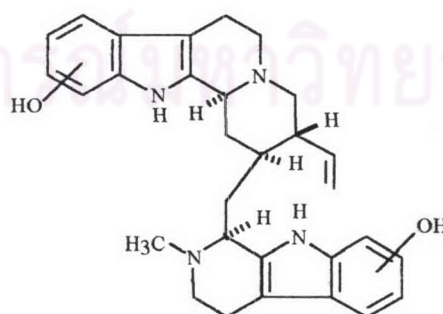
1.1 Usambarensine group



	R ₁	R ₂	
Usambarensine	H	H	
<i>N_b</i> -Methylusambarensine	H	H	<i>N_b</i> ⁺ -Me
Tchibangensine (5', 6'-Dihydrousambarensine)	H	H	5', 6'-dihydro
Tetrahydrousambarensine	H	H	3, 17, 5', 6'-
10'-Hydroxy-tetrahydrousambarensine	H	OH	tetrahydro
10,10'-Dimethoxytetrahydrousambarensine	OMe	OMe	
10,10'-Dihydroxy- <i>N_b</i> -tetrahydrousambarensine	OH <i>N_b</i> ⁺ -Me	OH	
10,10'-Dimethoxy- <i>N_b</i> -methyl-tetrahydrousambarensine	OMe <i>N_b</i> ⁺ -Me	OMe	
10-Hydroxy-10'-methoxy- <i>N_b</i> -methyl-tetrahydrousambarensine	OH <i>N_b</i> ⁺ -Me	OMe	
10'-Hydroxyusambarensine	H	OH	

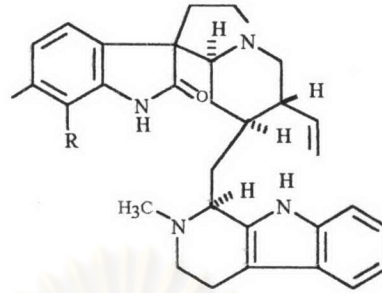


	R ₁	R ₂	R ₃
Usambarine	H	H	H
Usambaridine Vi	OH	H	H
Usambaridine Br	H	OH	H
N ₆ -Methyl-10-hydroxyusambarine	OH	H N _b ⁺ -Me	H
N ₆ -Methyl-11-hydroxyusambarine	H	OH N _b ⁺ -Me	H
Nigritanine (18,19-Dihydrousambarine)	F 18, 19- dihydro	H	H
11-Hydroxynigritanine	H 18, 19- dihydro	OH	H
Strychnopentamine	H	OH	
Isostrychnopentamine	H	OH N _b ⁺ -Me	



Strychnobaridine

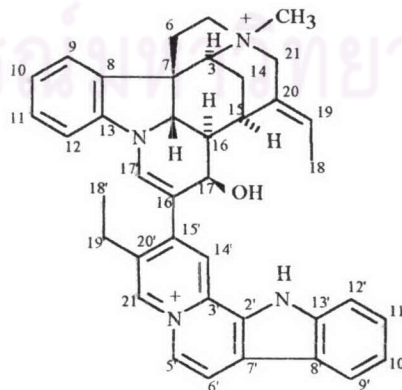
1.2 Strychnofoline group



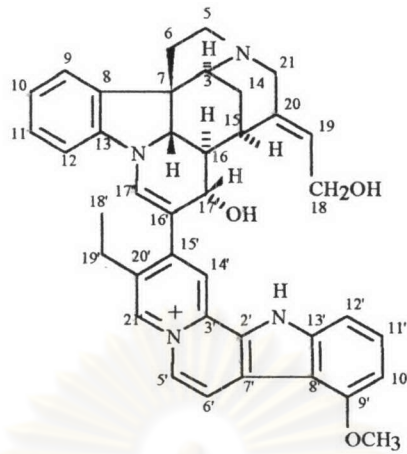
	R
Strychnofoline	H
Strychnophylline	

2. Strychnan-Corynanthean type

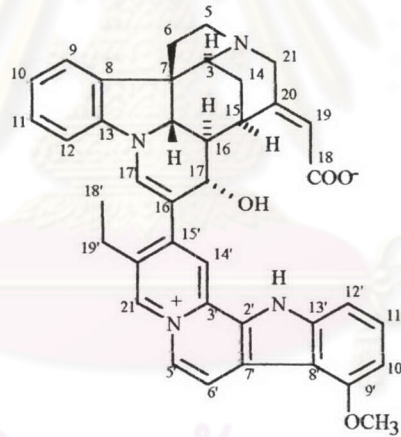
2.1 Retuline-Corynantheine group



Afrocurarine

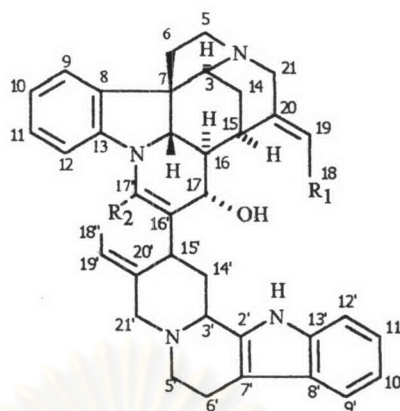


Guaiachrysin	N^+_6 -Me
5', 6'-Dehydroguaiachrysin	N^+_6 -Me 5', 6'-dehydro

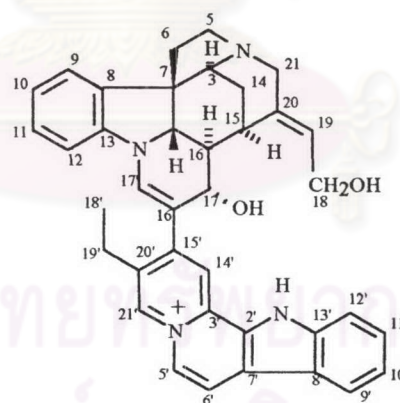


Guianensine

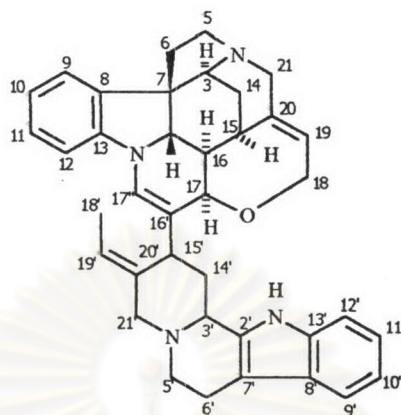
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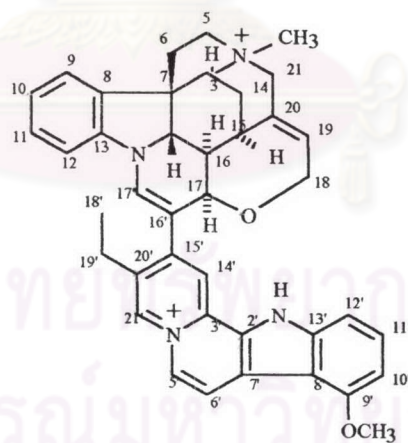
	R ₁	R ₂	
Longicaudatine F (18-Hydroxylongicaudatine Y)	CH ₂ OH	H	
Longicaudatine Y	CH ₃	H	
Dihydrolongicaudatine Y	CH ₃	H	19',20'-dihydro
3',4',5',6'- Tetrahydrolongicaudatine Y	CH ₃	H	3',4',5',6'- tetrahydro
Longicaudatine Z	CH ₃	OH	16',17'-dihydro



Strychnochrysin



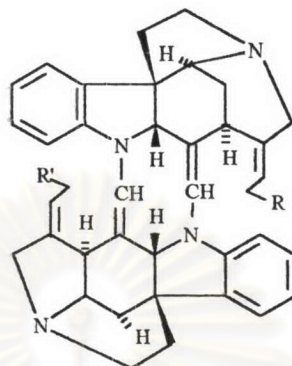
Longicaudatine



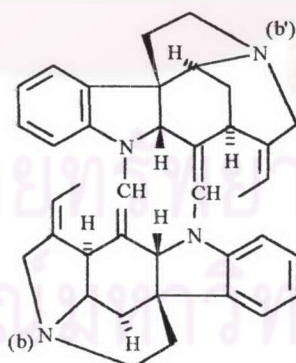
Guiaflavine
5', 6'-Dehydroguiaflavine

3. Strychnan-Strychnan type

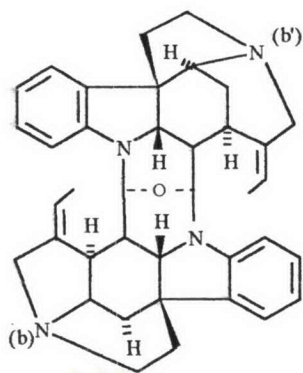
3.1 Retuline-Retuline group



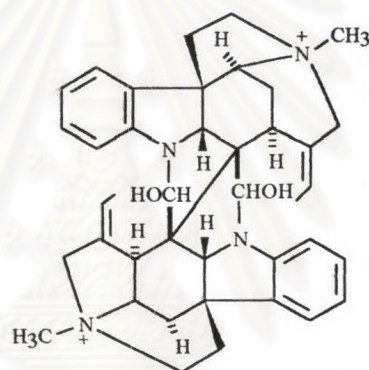
<i>C</i> - Toxiferine (toxiferine V)	R = R' = OH <i>N</i> _b , <i>N</i> _{b'} -dimethyl
<i>C</i> -Alkaloid H	R = H, R' = OH <i>N</i> _b -Me, <i>N</i> _{b'} -Me
Bisnor- <i>C</i> -alkaloid H	R = H, R' = OH
Bisnor- <i>C</i> -alkaloid H mono - <i>N</i> - oxide	R = H, R' = OH <i>N</i> _b -O
Bisnor- <i>C</i> -alkaloid H di- <i>N</i> -oxide	R = H, R' = OH <i>N</i> _b -O, <i>N</i> _{b'} -O



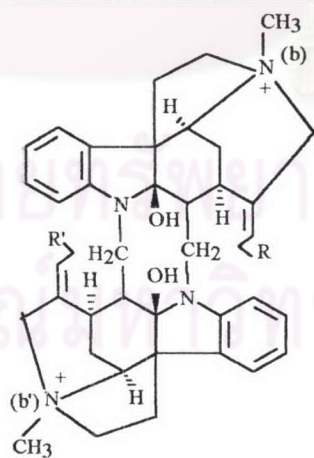
<i>C</i> -Alkaloid K (<i>C</i> -Dihydrotoxiferine)	<i>N</i> _b -Me, <i>N</i> _{b'} -Me
Bisnordihydrotoxiferine	
Bisnordihydrotoxiferine mono- <i>N</i> -oxide	<i>N</i> _b -O



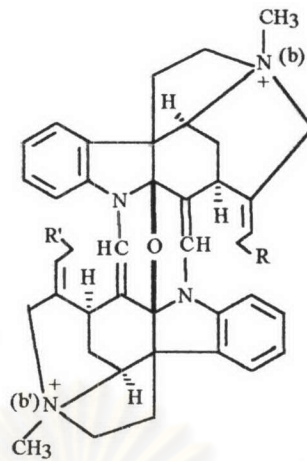
Matopensine	
Matopensine- <i>N</i> -oxide	$N_b\text{-O}$



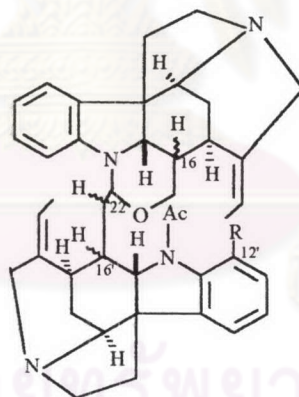
C-alkaloid D



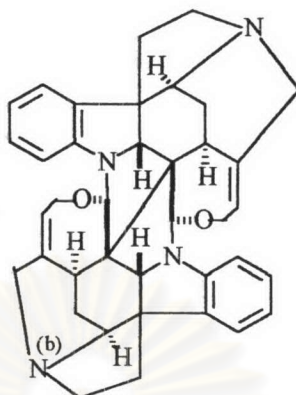
	R	R'
C-Calebassine	H	H
C-Alkaloid F	H	OH
C-Alkaloid A	OH	OH



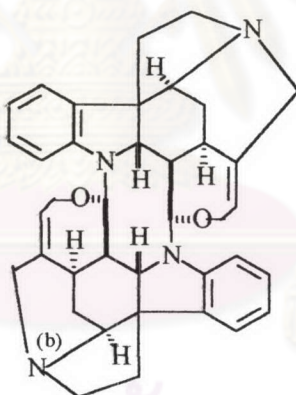
	R	R'
C-Curarine	H	H
C-Alkaloid G	H	OH
C-Alkaloid E	OH	OH



	R	C-16	C-22	C-16'
Strychnobiline	H	Not indicated		
12'-Hydroxystrychnobiline	OH			
Isostrychnobiline	H	β -H	α -H	α -H
12'-Hydroxyisostrychnobiline	OH	β -H	α -H	α -H
16, 17-Dehydroisostrychnobiline	H	16, 17-dehedro	α -H	α -H

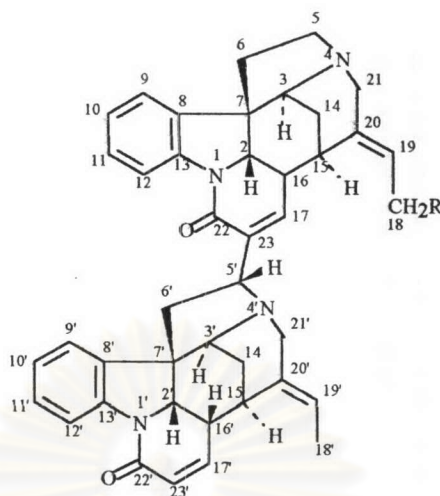


Caracurine II	
Caracurine II dimethosalt	N_a -Me, N_b -Me



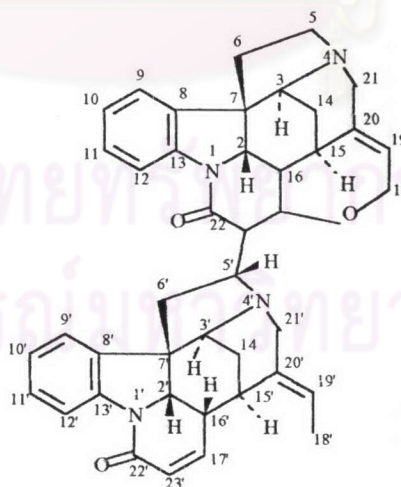
Caracurine V	
Caracurine V mono- <i>N</i> -oxide	N_b -O
Caracurine V di- <i>N</i> -oxide	N_b -O, $N_{b'}$ -O

3.3 Isostrychnine-Isostrychnine group

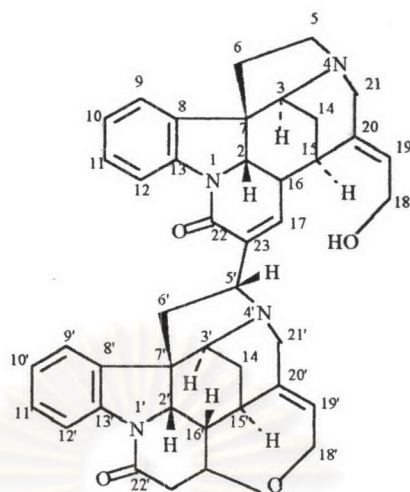


	R
Sungucine	H
18-Hydroxysungucine	$\text{OH}, \Delta 6' 7'$
Isosungucine	H
18-Hydroxyisosungucine	$\text{OH}, \Delta 6' 7'$

3.4 Diaboline-isostrychnine group

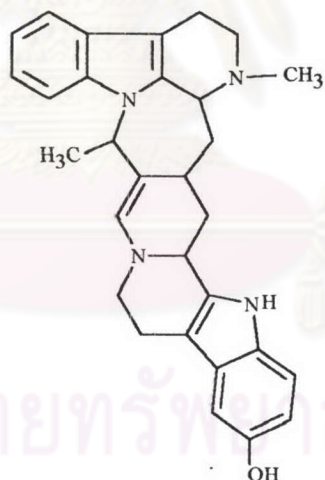


Strychnogucine A

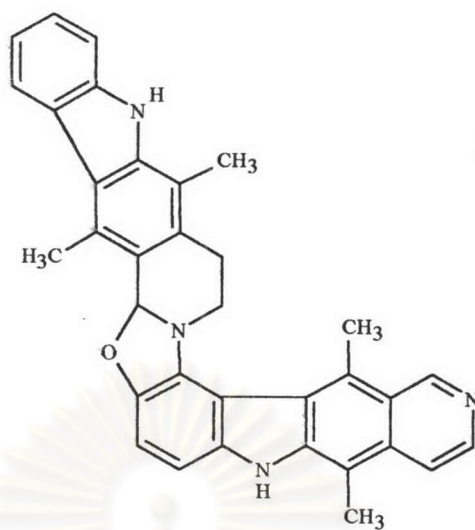


Strychnogucine B

4. Miscellaneous



Janussine A, B



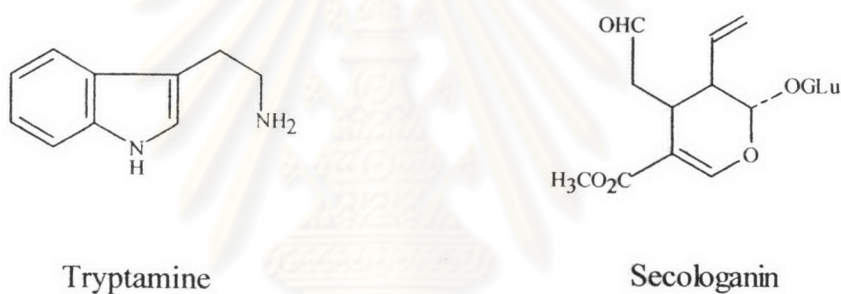
Strellidimine

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Biosynthesis of Indole Alkaloids

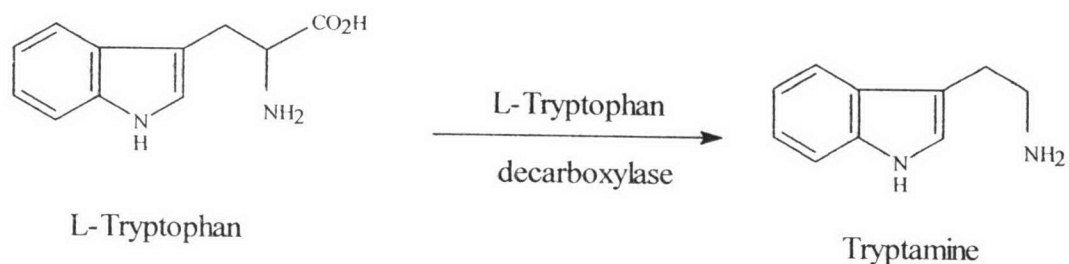
The structures of indole alkaloids were typically derived from the condensation between the nitrogen containing moiety, tryptamine and a C-9 or C-10 monoterpenoid moiety, secologanin or other modified secologanin unit (Kompis, Hesse and Schmidt, 1971).

The biogenesis of indole alkaloids involved two important pathways, one of which lead to the non-terpenoid moiety and the other lead to the terpenoid moiety. In order to gain more informations about the whole process of indole alkaloid biosynthesis, many works have been carried out by using the cell-free system (Scott and Lee 1975; Zenk, 1980).



1) The non-terpenoid Moiety

The non-terpenoid moiety of the indole alkaloids originated from an amino acid, L-tryptophan *via* its decarboxylation product, tryptamine, which is the more direct biogenetic precursor (Battersby, Bernett and Parsons, 1969). The enzyme, L-tryptophan decarboxylase was indicated to involve in the biosynthesis of indole alkaloids (Scott and Lee 1975) (see Scheme 3).

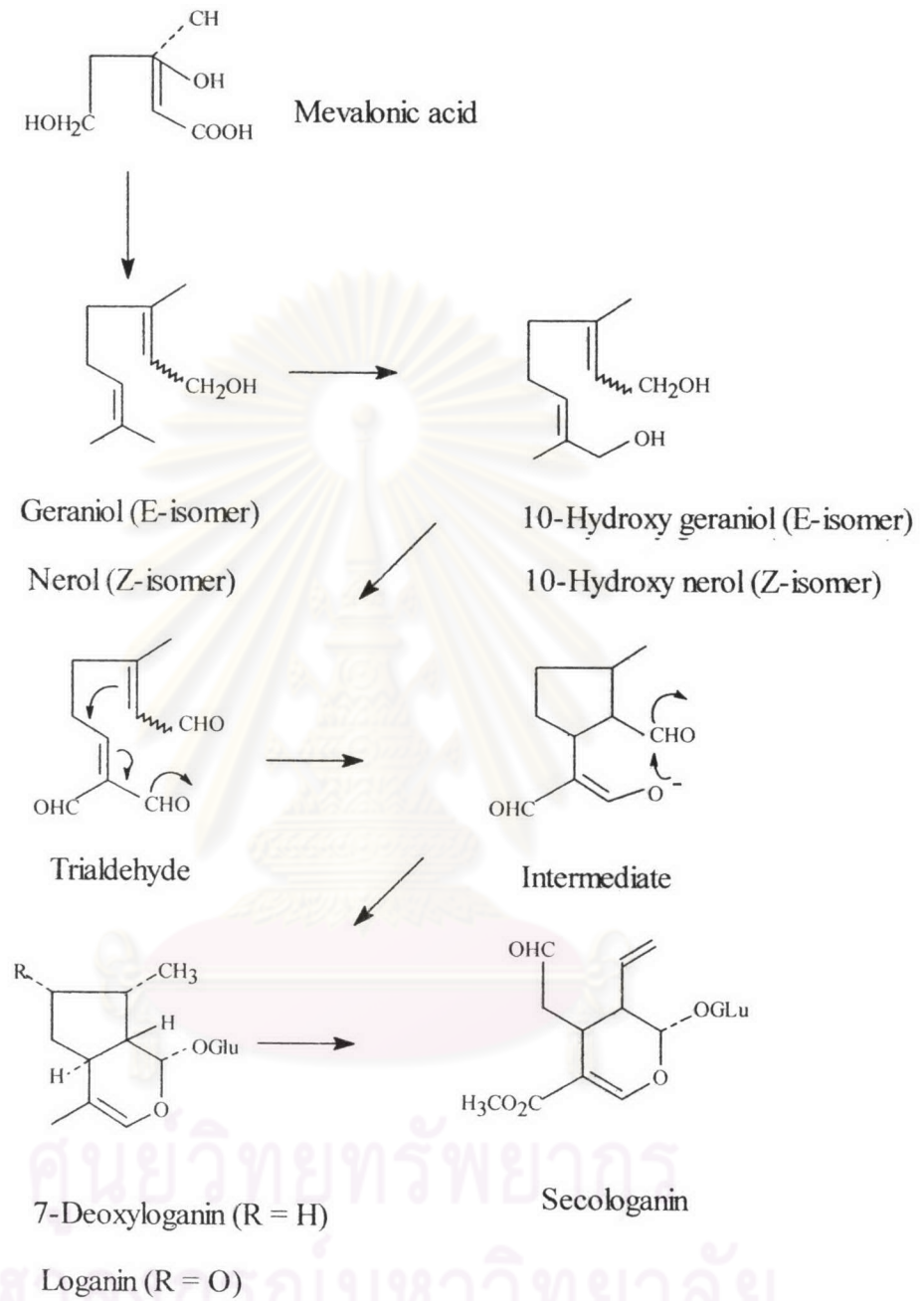


Scheme 3 Formation of tryptamine

2) The terpenoid moiety

The terpenoid moiety of indole alkaloids was proved to be the C-9 or C-10 monoterpene (Kompia *et al.*, 1971). The possible biosynthetic relationship between the monoterpenes and the indole alkaloids was first postulated by Thomas (1961) and Wenkert (Wenkert and Wickberg, 1965). The result demonstrated that secologanin was a sole direct precursor for the monoterpenoid moiety. Loganin was established as a key precursor of secologanin. The studies of the biosynthesis of loganin have proved that its C-10 skeleton derived specifically from geraniol or its *cis*-isomer, nerol (Battersby *et al.*, 1968). Mevalonic acid was available for the formation of geraniol which could be established by using liver and yeast system (Battersby *et al.*, 1968). The conversion of geraniol or nerol into loganin involved unknown sequences including the oxidations of the C-9 and C-10 methyl groups and the oxidation of the C-1 position to the aldehydic state, the saturation of the cyclopentane ring (Battersby, Brown and Payne, 1970).

The hydroxylation at C-10 to form 10-hydroxy geraniol and 10-hydroxy nerol might be the primary step beyond the geraniol stage (Battersby *et al.*, 1970). The following stages are proceeded through the oxidation of the hydroxyl groups at C-1 and C-10 and also the oxidation of C-9 to form a trialdehyde functions which after cyclization gives rise to the possible intermediate and the cyclopentane units, loganin and 7-deoxyloganin (Escher, Loew and Arigoni, 1970). The intermediate of deoxyloganin in the biosynthetic process leading to loganin as well as indole alkaloids is well documented. The final cleavage of the iridoid skeleton of loganin directly gives rise to its corresponding seco-derivatives, secologanin. The overall view of the biosynthetic pathway to secologanin is accommodated in Scheme 4.



Scheme 4 The conversion pathway of geraniol and nerol to loganin and secologanin

3) The Key Role Intermediate "strictosidine"

The condensation of tryptamine with secologanin was demonstrated by Battersby *et al.* (1969) (Scheme 6). The reaction resulted in the formation of two epimeric β -carboline gluco-alkaloids; strictosidine (isovincoside) with 3α -(S) configuration and vincoside with 3β -(R) configuration. Recent works (Stockigt, 1980; Zenk, 1980) have defined strictosidine but not vincoside as being the true precursor of the various types of indole alkaloids (Scheme 5). The crucial enzyme catalysing the condensation was named strictosidine synthase (Stockigt and Zenk, 1977).

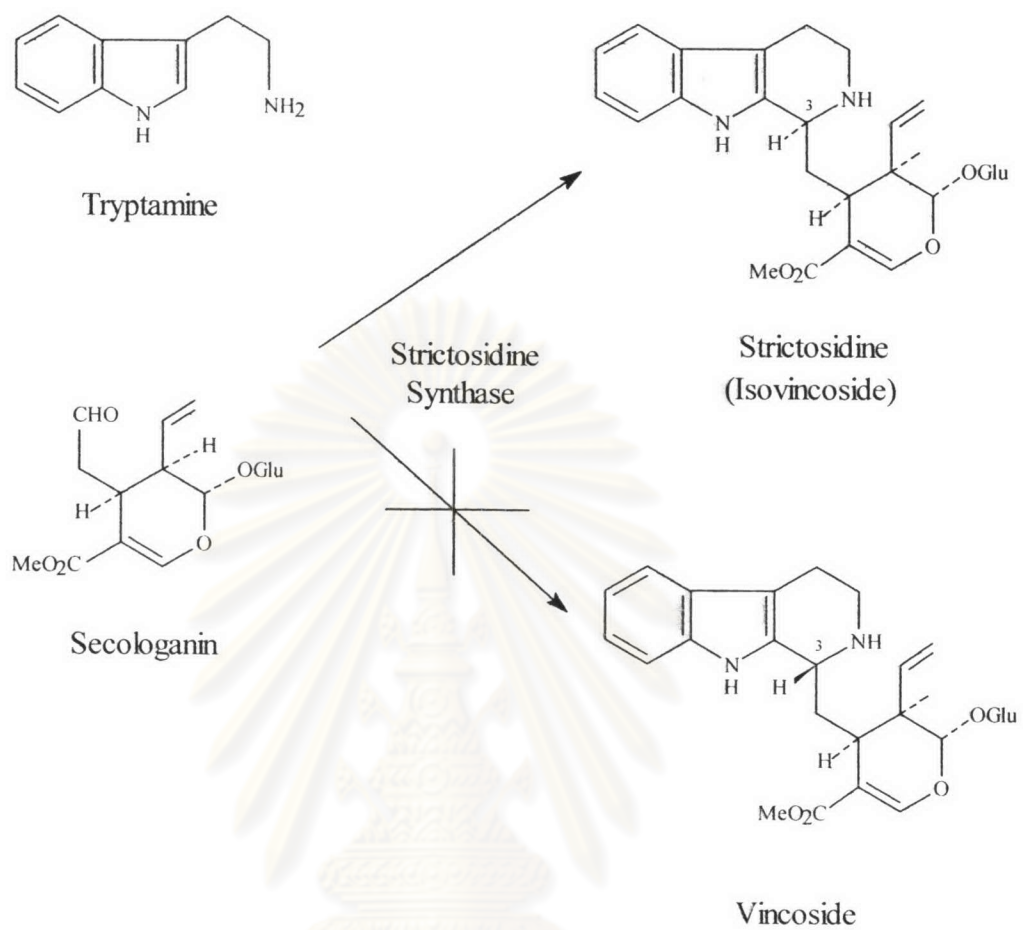
Strictosidine can be regarded as the universal precursor of monoterpenoid indole alkaloids. The various types of monoterpenoid indole alkaloids and their relationships with strictosidine are demonstrated in Scheme 6.

Biosynthesis of *Strychnos* alkaloids

Like other terpenoid indole alkaloids, the biogenetic pathway of *Strychnos* alkaloids is starting from tryptamine and secologanin. The typical route of the alkaloid biosynthesis in this genus has been indicated by Heimberger and Scott (1973). The overall pathway has proceeded *via* strictosidine, geissochizine, dehydro-preakuammicine and Weiland-Gumlich aldehyde (Heimberger and Scott, 1973; Cordell, 1974)

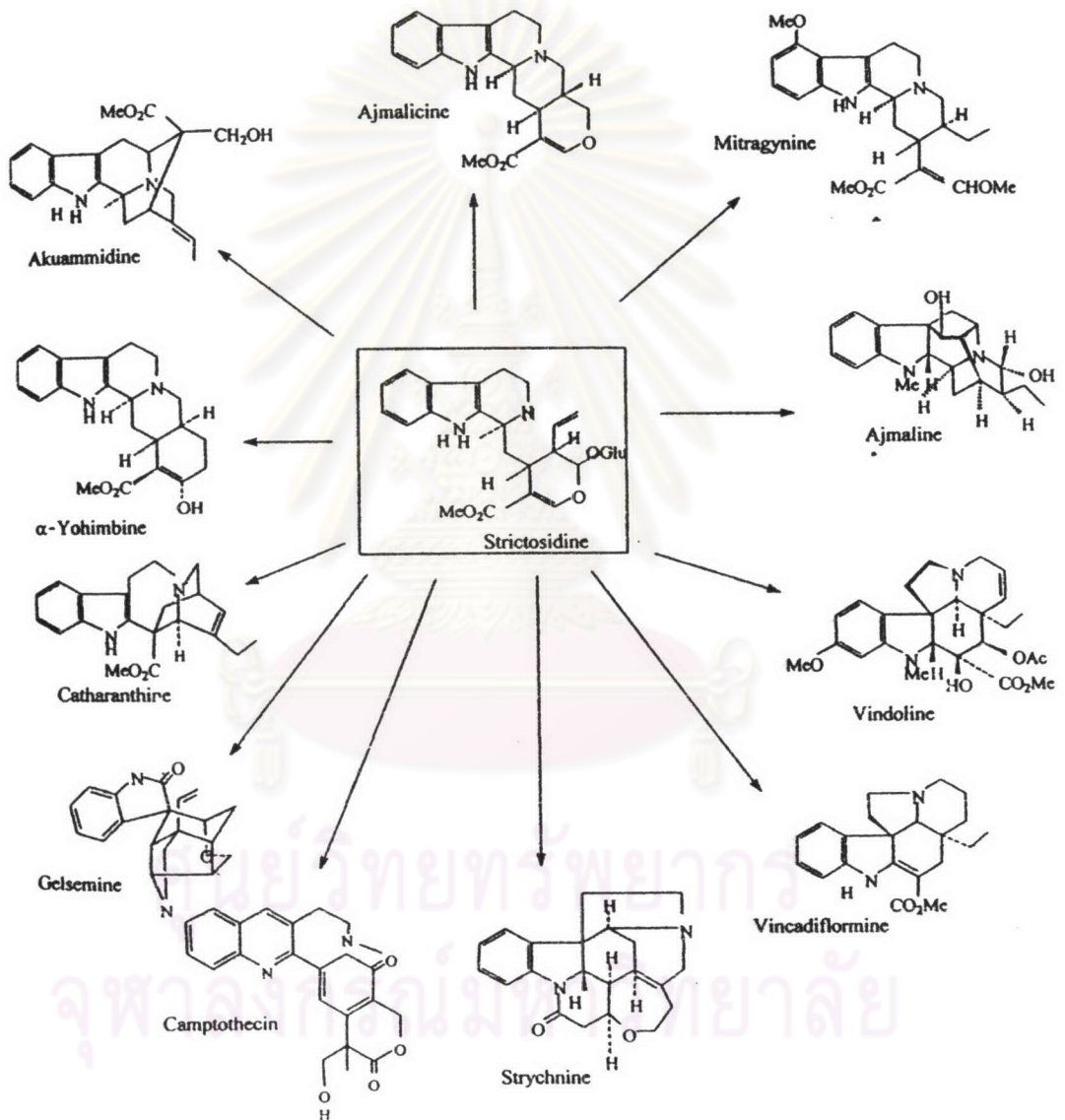
Most of the indole alkaloids found in *Strychnos* species belong to the corynanthean and the strychnan types. As shown in Scheme 7, the bases of the corynanthean types are mainly derived from 4,21 dehydrogeissoschizine. This compound is also considered as the important branch point in the biosynthesis of ibogan-, aspidospermatan- and strychnan-types alkaloids (Scheme 8).

The C-mavacurine-group alkaloid of the corynanthean type are postulated to be derived from 4,21 dehydrogeissoschizine *via* geissoschizine by ring closure between C-16 and N_a (Cordell, 1974) while those of the sarpagine groups are presumed to originate more directly from 4,21 dehydrogeissoschizine (Cordell, 1974). However more information is still required for detail explanation of C₆-C₁₅ bridge formation in the biosynthesis of these sarpagine derivatives (Scheme 8).



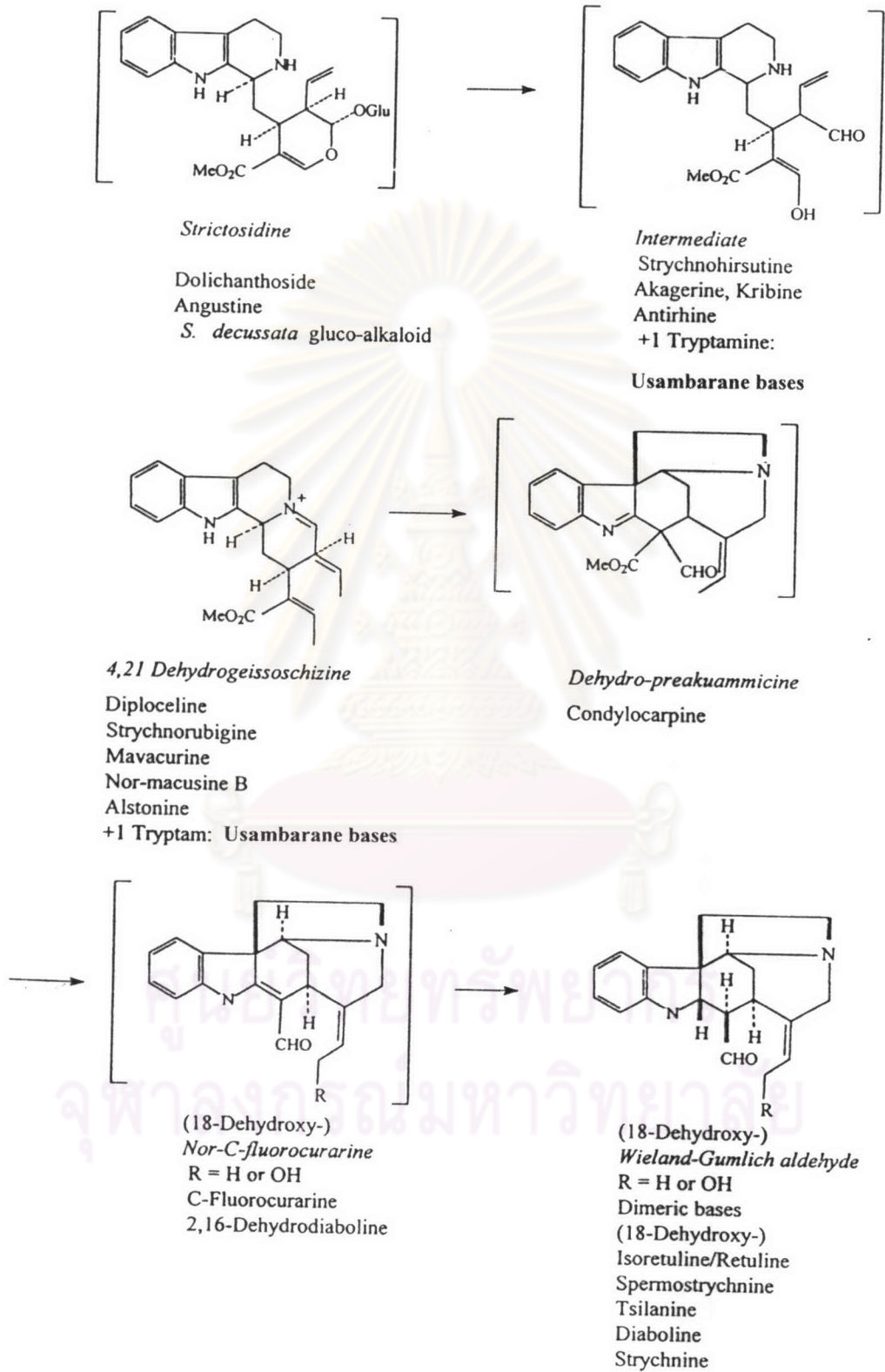
Scheme 5 Formation of strictosidine from tryptamine and secologanin

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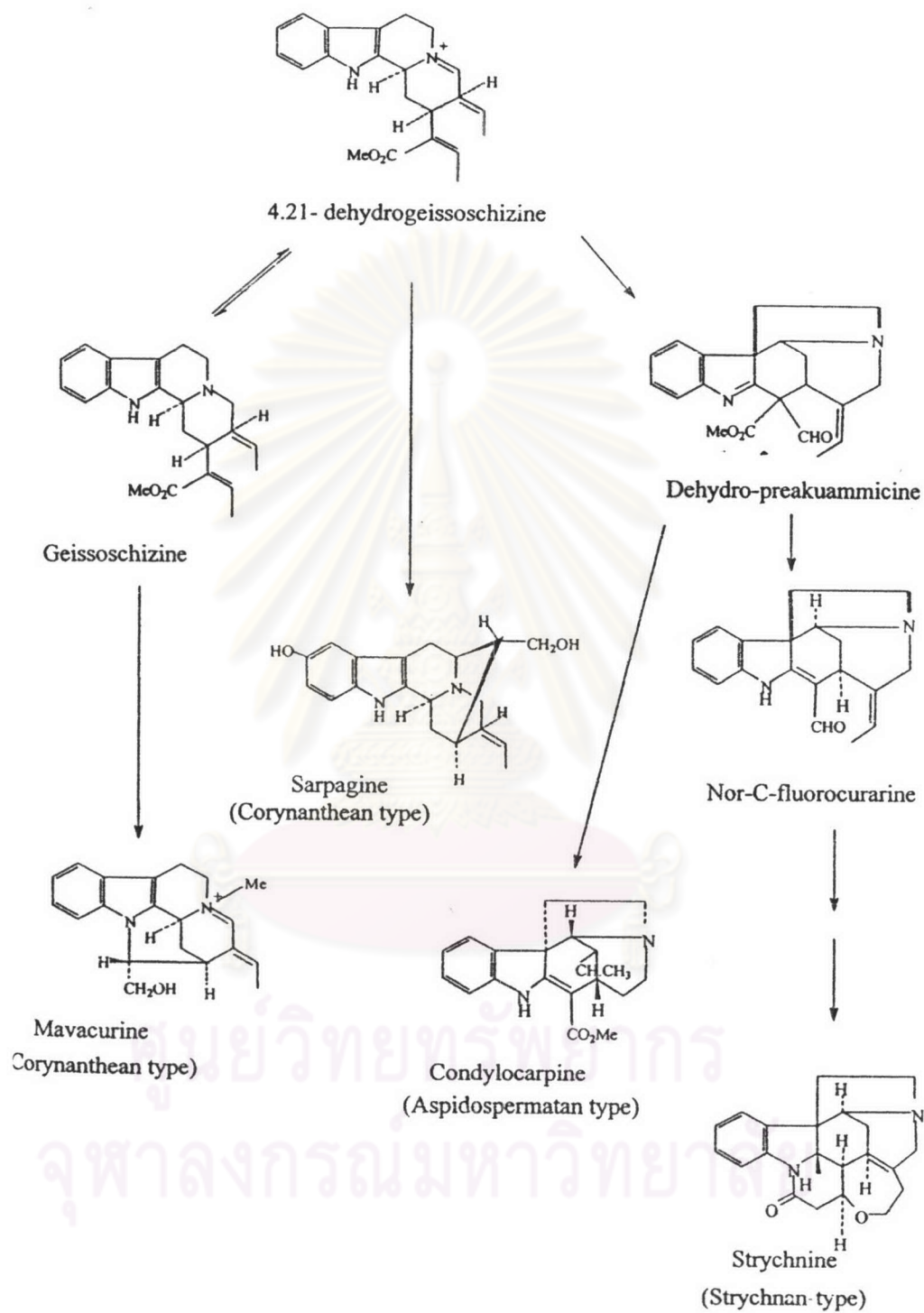


Scheme 6
biosynthesis

Strictosidine as a key role intermediate in indole alkaloids



Scheme 7 Presumed central biosynthetic pathway indole alkaloid in *Strychnos*

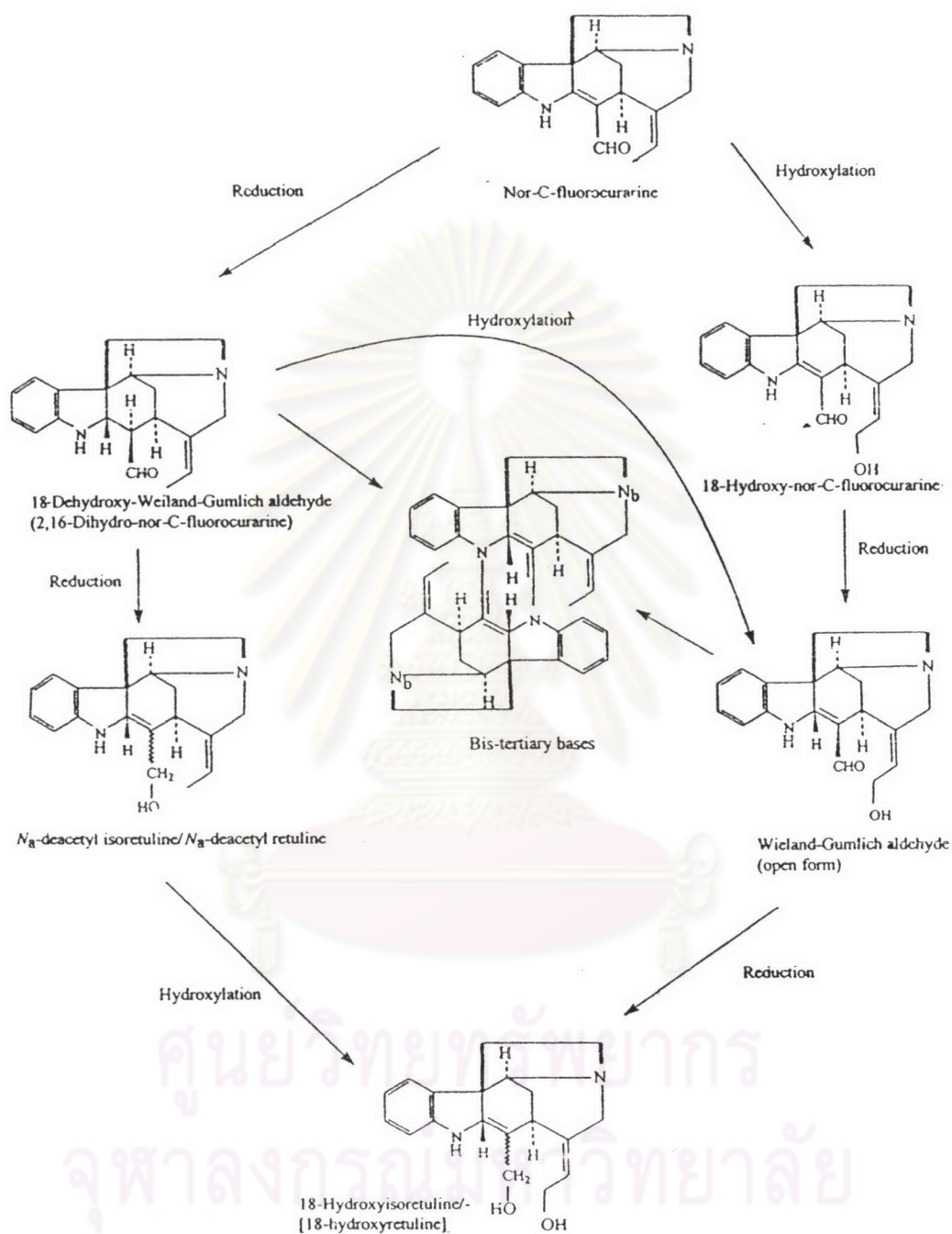


Scheme 8 4,21-Dehydrogeissoschizine as the key intermediate in *Strychnos* alkaloids biosynthesis

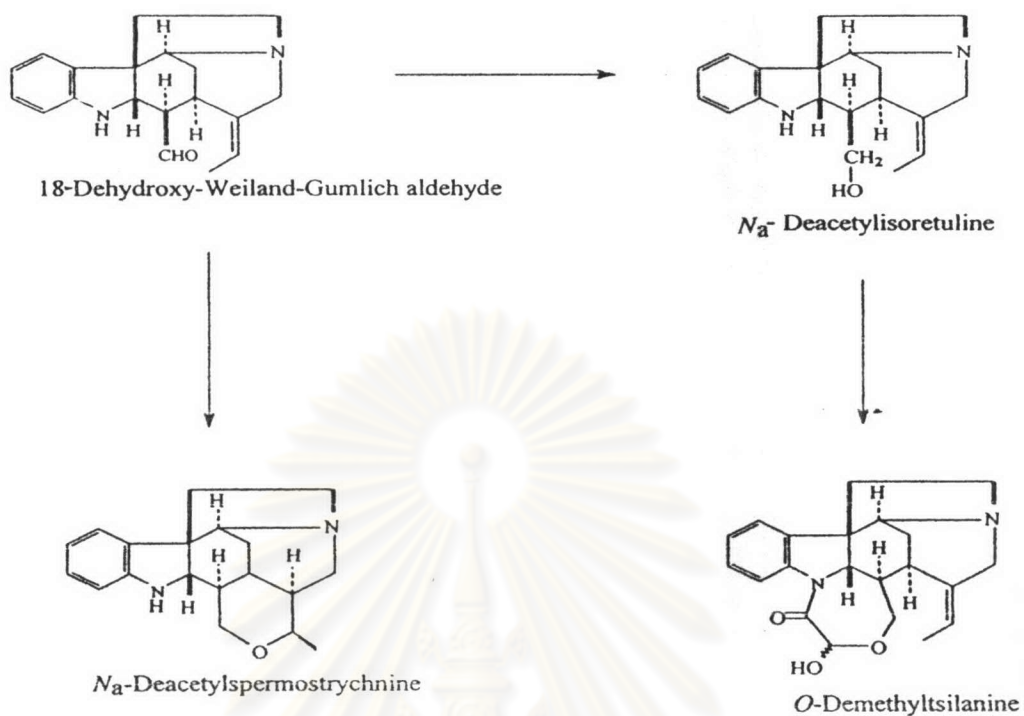
In the biosynthesis of Strychnan type alkaloids, dehydro-preakuammicine is presumed to be the next intermediate after 4,21 dehydrogeissoschizine. Loss of the carbomethoxy group from this base could afford the following intermediate, nor-C-fluorocurarine which can be recognized as the starting point for a rather complicated grid of the strychnan-type biosynthesis. Schemes 9-11 demonstrate the biosynthetic routes through which the alkaloids of the six groups belonging to the strychnan type are formed, Scheme 9 is for those of the retuline group, Scheme 10 for those of the spermostrychnine and the tsilanine groups, and Scheme 11 for derivatives of diaboline, isostrychnine and strychnine (Bisset, 1980).

Several biogenetic studies on the formation of strychnine and its derivatives have been carried out. It is evident that Weiland-Gumlich aldehyde is a precursor of these bases but its N_a -acetyl derivative, diaboline, is not. Heimberger and Scott have proposed the existence of an aldol acid intermediate named prestrychnine which can undergo lactamization and further cyclization to afford strychnine (Heimberger and Scott, 1973). Their hypothesis has been supported by the isolation of protostrychnine, considerable as a partly cyclized prestrychnine (Baser *et al.*, 1979). According to this hypothesis the final stage of the biosynthetic pathway to strychnine could be established as shown in Scheme 12.

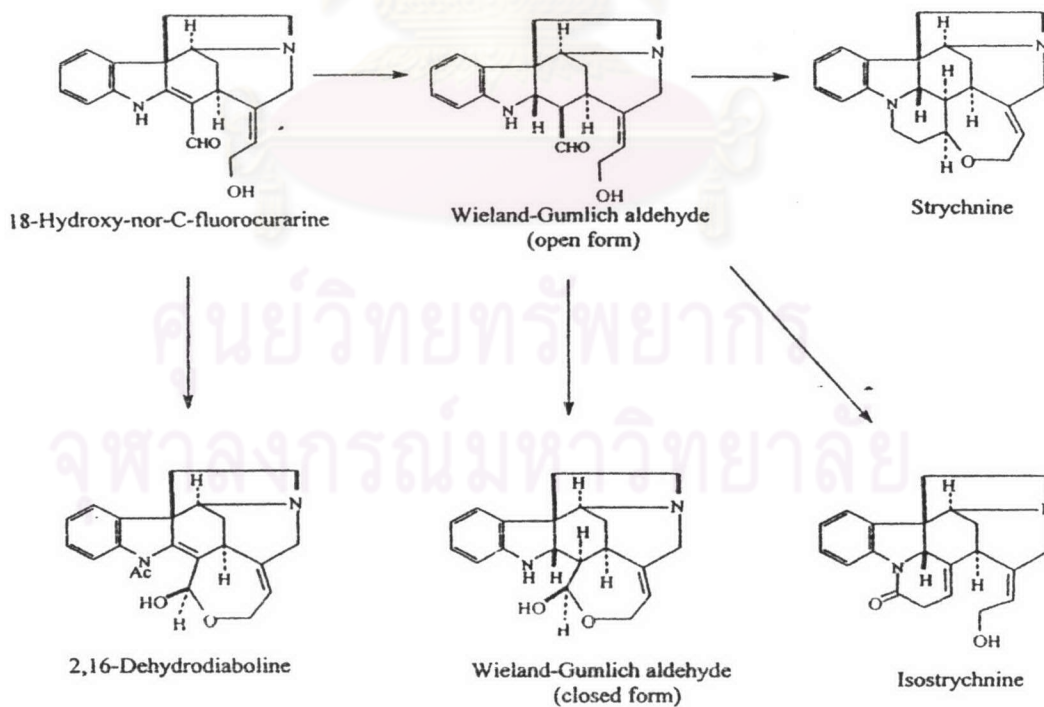
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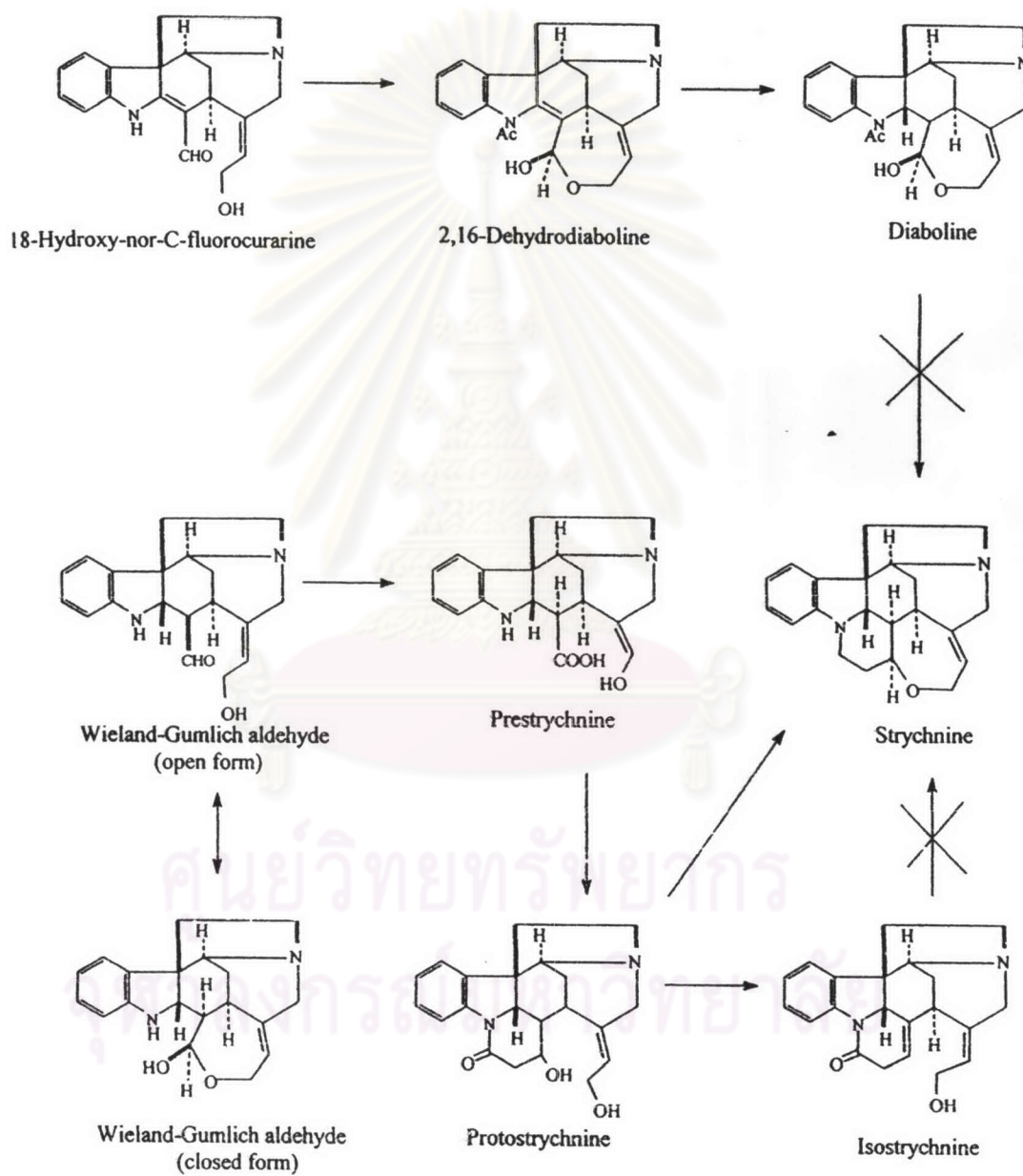
Scheme 9 Alkaloids derived from Nor-C-fluocurarine



Scheme 10 Biogenetic route of spermostrychnine and tsilanine groups



Scheme 11 Biogenetic route of isostrychnine and strychnine groups



Scheme 12 Final stage in the biogenesis of strychnine

Pharmacological activities of *Strychnos* alkaloids

Although convulsant and muscle relaxant activities are the two more thoroughly investigated properties of the *Strychnos* alkaloids, a number of other pharmacological effects such as antimicrobial, antimalarial and cytotoxic activities have been found.

Convulsant effects may produce either clonic or tonic convulsion. Clonic convulsion occurs when there is an alternating contraction and relaxation of the muscle, whereas in tonic convulsion, a sustained rigidity of the muscle is observed. Convulsant activity is due to an antagonistic effect on glycine, an important inhibitory transmitter in the spinal cord. This leads to enhanced reflex responses and, in larger doses, tonic convulsion which may result in death by asphyxia. Generally, alkaloids having the strychnine skeleton possess convulsant properties, while quaternary dimeric nitrogenous compounds, including members of toxiferine, curarine and calebassine groups, have a curarizing action. Curarizing activity is a phenomenological term describing neuro-muscular block of impulse transmission of the motor end plate as a result of inhibition of acetylcholine. The result is complete paralysis of the skeletal or striated muscle apparatus (Ohiri *et al.*, 1983a).

The *Strychnos* alkaloids and their pharmacological activities were shown in Table 4.

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Table 4 Pharmacological activity of *Strychnos* alkaloids

Pharmacological activity	Compound	References
Antimicrobial activity	Bisnor-C-alkaloid H	Verpoorte <i>et al.</i> , 1978b
	Bisnordihydrotoxiferine	Melo <i>et al.</i> , 1987
	Bisnordihydrotoxiferine-di-N-oxide	Verpoorte <i>et al.</i> , 1978b
	Caracurine V	Verpoorte <i>et al.</i> , 1978b
	Caracurine V-di-N-oxide	Verpoorte <i>et al.</i> , 1978b
	Diploceline	Thepenier <i>et al.</i> , 1990a
	Ellipticine	Verpoorte <i>et al.</i> , 1983a
	Tchibangensine	Caron <i>et al.</i> , 1988
	Tetrahydrousambarensine	Caron <i>et al.</i> , 1988
	Usambarensine	Caron <i>et al.</i> , 1988
	10,10'-Dihydroxy- <i>N</i> _b -tetrahydro usambarensine	Caron <i>et al.</i> , 1988
	10,10'-Dimethoxy- <i>N</i> _b -methyl-tetrahydrousambarensine	Caron <i>et al.</i> , 1988
	10,10'-Dimethoxytetrahydro usambarensine	Caron <i>et al.</i> , 1988
	10-Hydroxy-10'-methoxy- <i>N</i> _b -methyl-tetrahydrousambarensine	Caron <i>et al.</i> , 1988
Cytotoxic activity	Akagerine	Leclerq <i>et al.</i> , 1986
	Alstonine	Ohiri <i>et al.</i> , 1983a
	Dolichantoside	Leclerq <i>et al.</i> , 1986
	Ellipticine	Ohiri <i>et al.</i> , 1983a
	Isodolichantoside	Leclerq <i>et al.</i> , 1986
	Methylantirhine	Leclerq <i>et al.</i> , 1986
	<i>N</i> _b -Methyl-10-hydroxyusambarine	Leclerq <i>et al.</i> , 1986
	<i>N</i> _b -Methyl-11-hydroxyusambarine	Leclerq <i>et al.</i> , 1986
	<i>N</i> _b -Methylusambarensine	Leclerq <i>et al.</i> , 1986
	Serpentine	Ohiri <i>et al.</i> , 1983a
	Strychnofoline	Leclerq <i>et al.</i> , 1986
	Strychnopentamine	Leclerq <i>et al.</i> , 1986
	Strychnophylline	Leclerq <i>et al.</i> , 1986
	Tchibangensine	Leclerq <i>et al.</i> , 1986
	Usambarensine	Leclerq <i>et al.</i> , 1986
Usambarine	Leclerq <i>et al.</i> , 1986	

Pharmacological activity	Compound	References
Convulsant activity	Akagerine	Rolfesen <i>et al.</i> , 1978
	Brucine	Ohiri <i>et al.</i> , 1983a
	Icajine	Ohiri <i>et al.</i> , 1983a
	Pseudostrychnine	Ohiri <i>et al.</i> , 1983a
	Strychnine	Ohiri <i>et al.</i> , 1983a
	Strychnine- <i>N</i> -oxide	Ohiri <i>et al.</i> , 1983a
	Vomicine	Ohiri <i>et al.</i> , 1983a
	(+)-Tubotaiwine	Ohiri <i>et al.</i> , 1983a
	β -Colubrine	Ohiri <i>et al.</i> , 1983a
	10-Hydroxy-17- <i>O</i> -methylakagerine	Rolfesen <i>et al.</i> , 1980b
	10-Hydroxy-21- <i>O</i> -methylkribine	Rolfesen <i>et al.</i> , 1980b
	10-Hydroxy-epi-21- <i>O</i> -methylkribine	Rolfesen <i>et al.</i> , 1980b
	12-Hydroxystrychnine	Ohiri <i>et al.</i> , 1983a
	17- <i>O</i> -Methylakagerine	Rolfesen <i>et al.</i> , 1978
	19,20-Dihydrostrychnine	Ohiri <i>et al.</i> , 1983a
Skeletal muscle relaxant	11-Methoxymacucine A	Verpoorte <i>et al.</i> , 1983b
	C-Mavacurine	Ohiri <i>et al.</i> , 1983a
	C-Fluorocurine	Ohiri <i>et al.</i> , 1983a
	Decussine	Rolfesen <i>et al.</i> , 1980c
	3,14-dihydrodecussine	Rolfesen <i>et al.</i> , 1981
	Malindine	Olaniyi <i>et al.</i> , 1980
	Strychnocarpine	Rolfesen <i>et al.</i> , 1980a
	Fluorocurarine	Ohiri <i>et al.</i> , 1983a
	<i>O</i> -Methyl- <i>N</i> _a -acetyl strynospandine	Goodnetilleke <i>et al.</i> , 1980
	Bisnordihydrotoxiferine	Ohiri <i>et al.</i> , 1983a
	Caracurine V	Verpoorte and Baerheim-Svendson, 1978
	Caracurine V- <i>N</i> -oxide	
	Caracurine V-di- <i>N</i> -oxide	
	Toxiferine	Ohiri <i>et al.</i> , 1983a
	C-Dihydrotoxiferine	Ohiri <i>et al.</i> , 1983a
	C-Alkaloid H	Ohiri <i>et al.</i> , 1983a
	C-Curarine	Ohiri <i>et al.</i> , 1983a
	C-Alkaloid E	Ohiri <i>et al.</i> , 1983a
	C-Alkaloid G	Ohiri <i>et al.</i> , 1983a
	C-Alkaloid A	Ohiri <i>et al.</i> , 1983a
	C-Alkaloid F	Ohiri <i>et al.</i> , 1983a
	C-Calebassine	Ohiri <i>et al.</i> , 1983a
	Afrocurarine	Ohiri <i>et al.</i> , 1983a

Pharmacological activity	Compound	References
Antimalarial activity	10'-Hydroxyusambarensine	Frederich <i>et al.</i> , 1999b
	10-Hydroxyusambarine	Frederich <i>et al.</i> , 1999a
	11-Hydroxyusambarine	Frederich <i>et al.</i> , 1999a
	18-Hydroxyisosangucine	Frederich <i>et al.</i> , 2000
	Bisnordihydrotoxiferine	Frederich <i>et al.</i> , 2000
	Dihydrousambarensine	Frederich <i>et al.</i> , 1999a
	Dihydrousambarine	Frederich <i>et al.</i> , 1999a
	Isosangucine	Frederich <i>et al.</i> , 2000
	Isostrychnopentamine	Frederich <i>et al.</i> , 1999a
	Malagashanine	Rasoanaivo <i>et al.</i> , 1994
	Strychnogucine A	Frederich <i>et al.</i> , 2001
	Strychnogucine B	Frederich <i>et al.</i> , 2001
	Strychnopentamine	Frederich <i>et al.</i> , 1999a
	Sungucine	Frederich <i>et al.</i> , 1999a
	Usambarensine	Frederich <i>et al.</i> , 1999a
Usambarine	Frederich <i>et al.</i> , 1999a	
Hypotensive activity	Alstonine	Ohiri <i>et al.</i> , 1983a
	Diaboline	Singh and Kapoor, 1976
	Macusine B	Leonard, 1968
	Normacusine B	Ohiri <i>et al.</i> , 1983a
	Serpentine	Ohiri <i>et al.</i> , 1983a
Anti-inflammatory activity	Isoretuline	Tits <i>et al.</i> , 1991
	Retuline	Tits <i>et al.</i> , 1991

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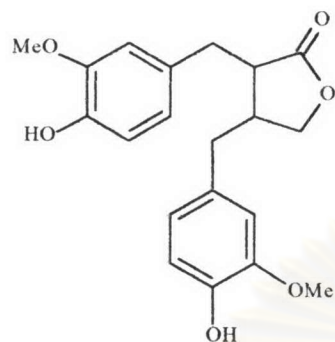
2.2 Lignans

By definition, lignan are dimers of phenylpropanoid (C₆-C₃) units linked by the central carbons of their side chains. It is assumed that lignan biosynthesis involves the combination of two phenylpropanoid units by oxidative coupling. Lignan are widely distributed in the plant kingdom. They have been identified in species belonging to seventy families, many of them used in folk medicine. Lignans have been isolated from all parts of plants. They are important constituents in heartwood of gymnosperms and in angiosperm trees; the bark and resin may be good sources of lignans. Recently, lignans have been detected in mammals, including man and their possible hormonal activity has been suggested, although other authors suggest that they are either of alimentary origin or metabolic products of the microflora of the gut (MacRae and Tower, 1984)

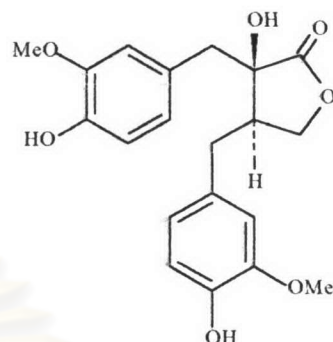
Biological activities of lignans are widely recognized. For examples, podophyllotoxin type lignans show antitumor, antimutagenic, antiviral, cathartic and allergenic activities, as well as cardiovascular effects, toxicity to fishes and mammals and are also capable of acting on nucleic acid metabolism. Other lignans, belonging to debenzylbutyrolactonic and furofuranic types, are active as cAMP-phosphodiesterase inhibitors. The activities of lignans on the human central nervous system, or as agents against hepatotoxins, etc., have also been studied. At the ecological level there is evidence that lignans play a role in plant-plant, plant-fungus and plant-insect interactions (Massanet *et al.*, 1989). Examples of lignans possessing some biological activities are as follows (Macrae and Tower, 1984)

- Antitumor activity : podophyllotoxin derivatives (α -peltatin, β -peltatin, epipodophyllotoxin), nordihydroguaiaretic acid
- Antiviral activity : podophyllotoxin derivatives
- Antimicrobial activity : nor- isoguaiacin, (-)dihydroguaiaretic acid
- Cathartic activity : podophyllotoxin derivatives, 2-hydroxyarctiin
- Allergenicity : plicatic acid
- Piscicidal activity : justicidin A and B, diphyllin
- Antioxidant activity : (-)-matairesinol, (-)-nortrachelogenin (Tiwari, 1999)
: saururin A, machilin D (Ahn, 2001)

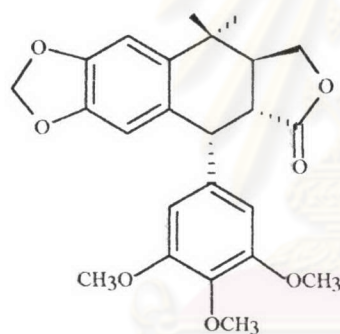
Antifungal activity : oleiferin-G, verrucosin (Sartorelli, Young and Kato, 1998)



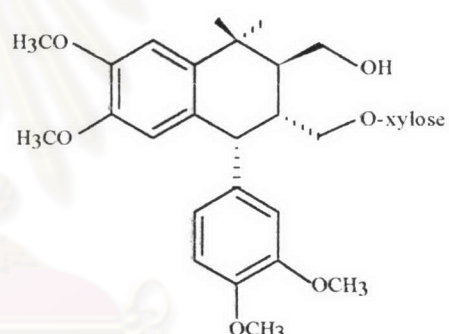
(-)-Matairesinol



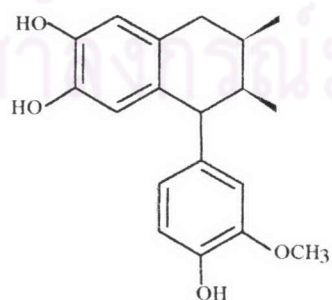
(-)-Nortrachelogenin



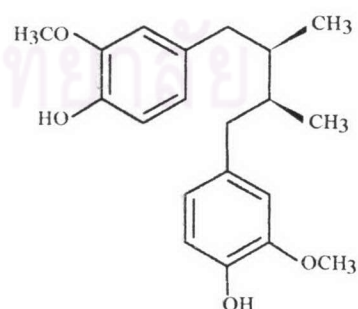
Podophyllotoxin



(+) Dimethylsolaricresinol-9'-xyloside



Nor-isoguaiacin

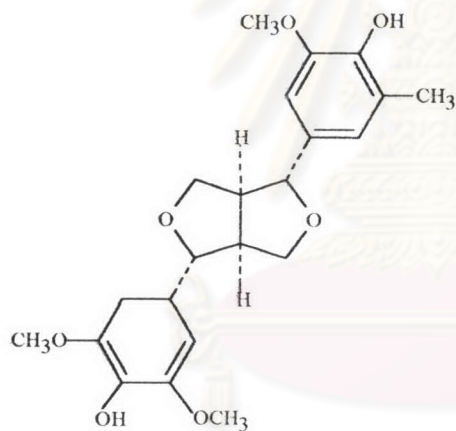


Dihydroguaiaretic acid

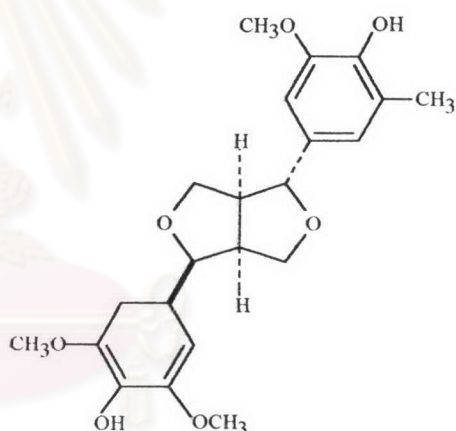
The information obtained from phytochemical studies of *Strychnos* species has suggested the rare occurrence of lignans in the genus. Only three *Strychnos* species have been reported as sources of lignans. The information on lignans of the genus *Strychnos* are summarized in Table 5.

Table 5 Lignans of *Strychnos* species

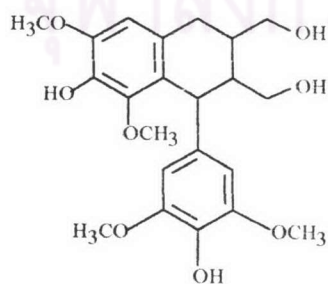
Lignan	<i>Strychnos</i> species	Plant part	References
Lirioresinol A	<i>Strychnos dinklagei</i>	Stem bark	Michel <i>et al.</i> , 1986
Lirioresinol B	<i>S. dinklagei</i>	Stem bark	Michel <i>et al.</i> , 1986
Lyoniresinol	<i>S. thorelii</i>	Stem	Sukhakul, 1994
	<i>S. nitida</i>	Stem	Vejjajiva, 1996
Lyoniresinol 3- <i>O</i> - β -glucopyranoside	<i>S. nitida</i>	Stem	Vejjajiva, 1996



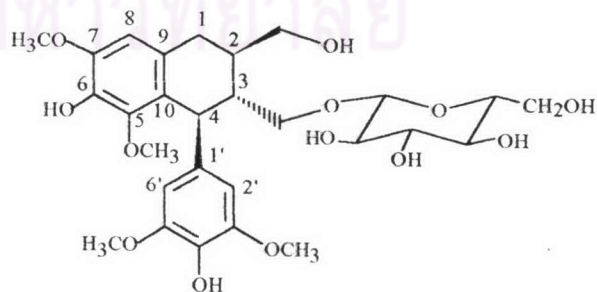
Lirioresinol A



Lirioresinol B



Lyoniresinol



Lyoniresinol 3-*O*- β -glucopyranoside