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REVIEW

A Brief Resume on the Genus *Lagerstroemia*

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In this review, the different chemical compounds have been isolated from different plants of the genus *Lagerstroemia* (Family Lythraceae) are listed (till 1997 in chemical abstract and from some papers). This genus is characterised by different class of compounds, *viz.*, alkaloids, steroids, terpenoids, anthocyanins, tannins, elagic acids, fatty acids, amino acids, proteins, etc. There are 64 references.

Lagerstroemia (*Crape myrtle*) is an important member of Lythraceae[1], which comprises of 23 genera. This genus contains 18 species which are trees or shrubs. Although they are distributed from South-East Asia to Australia but their centre of origin is Burma[2]. Of all these species, some yield valuable timber and small portions are ornamental[3]. In warmer lands, it achieves economical importance due to its ornamental value[1]. Generally manganese and iron deficiencies are found in *Crape myrtle*[4] and the different species of this genus have also tanning properties[5]. Five species, *viz.*, *L. indica, L. parviflora, L. speciosa, L. lanceolata* and *L. hypoleuca* occur in India.

Although five species of this genus are available in India *L. speciosa* is most abundantly observed among all of them. Besides its economical importance as a member of ornamental value, *L. speciosa* also possesses some commercial use because its wood is hard, strong, durable and fairly heavy. It is resistant to white ant but being liable to other insect attack limits its use in aesthetic work. But due to its resistive property against marine borers it is used in ship-building.

Literature survey reveals the use of different species of this genus as folklore medicine[6, 7].

L. speciosa Pers. syn. L. flos-reginae Retz.: Leaves are purgative, diuretic and deobstruent. Decoction of dried fruits as well as of leaves, bark and roots are used in diabetes[8]. Water extract of its bark is used in abdominal pain, diarrhoea and stimulant. Seeds are narcotic.

L. indica Linn.: Bark of this plant is stimulant and febrifuge. Bark, leaves and flowers are purgative and hydragogue. Roots are astringent. Seeds are narcotic. The candy prepared from calcium and its leaves is useful for controlling hyperglycemia[9].

L. parviflora Roxb.: The plant yields edible gums. The average concentration of nutrients of *L. parviflora* is in the order K > Ca > Na > N > P.[10]

Literature survey also reveals that chemists are in continuous search for active principles which may be responsible for such medicinal properties. As a result, several classes of compounds, *viz.*, alkaloids, terpenoids, sterols, anthocyanins, tannins, etc. were isolated and characterised. The tests were also done for flavonoids[11] and other classes of compounds.

The present account records the entire picture of upto date informations on chemical constituents of *Lagerstroemia* till 1997 (from *Chem. Abstr.*).

Early works on *L. flos-reginae* indicate the absence of alkaloids and sterols[12]. But extensive research on other species of this genus established the presence of alkaloids, sterols and other important compounds.

From early seventies, several alkaloids have been isolated and they are classified into following two groups (A and B) based on their structure[13].

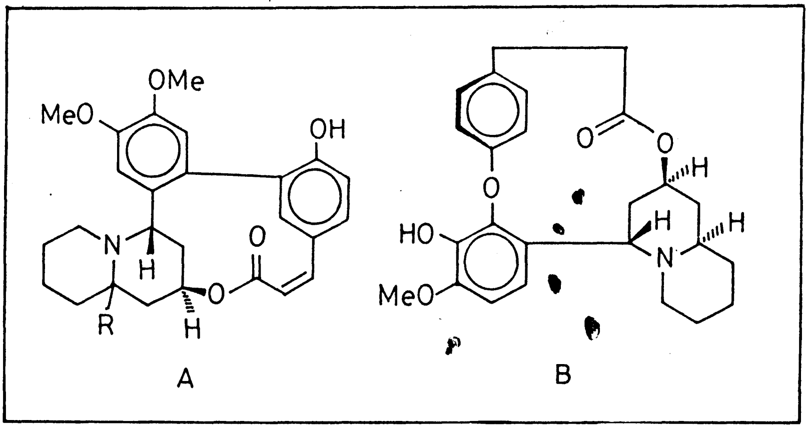


Fig. 1 Skeleton structures of alkaloids A and B

Lythrine and cryogenine are the two alkaloids which are isolated from the leaves of *L. fauriei* and *L. subcostata* and they belong to the structural group (A) whereas lagerine isolated from the seeds of *L. indica* posseses the structural group (B).

Structural type	Name of the compound, m.p. (°C)	m.f.	Substituent R
A	Lythrine[13], 240–242	$C_{26}H_{29}NO_5$	β-H
A	Cryogenine[13, 14], 251–253	$C_{26}H_{29}NO_5$	α-H
B	Lagerine[13, 15, 16, 17], 210	$C_{25}H_{29}NO_5$	—

Barring these two basic structures, leaves of *L. fauriei* contain an alkaloid, lythridine[13], m.f. $C_{26}H_{31}NO_6$, m.p. 210–5°C.

Besides these, a handsome number of alkaloids were also isolated which were not related either with structure (A) or structure (B). Comprehensive investigation on the seeds of *L. indica* reveals the presence of four other alkaloids whose basic skeleton is as follows:

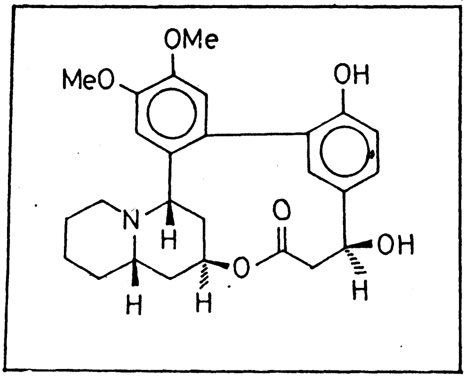


Fig. 2 Structure of lythridine

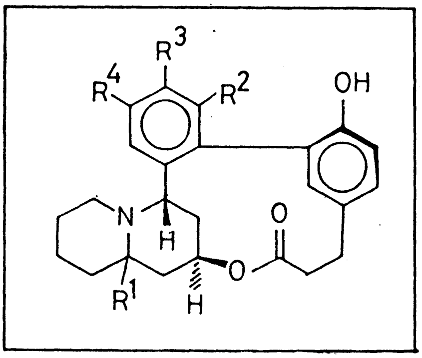


Fig. 3 Basic skeleton structure of four alkaloids

Name of the compound, m.p. (°C)	m.f.	Substituents			
		R^1	R^2	R^3	R^4
Decinine[13, 15], 222–224	$C_{26}H_{31}NO_5$	β-H	—H	—OMe	—OMe
Lagerstroemine[15, 18], 240	$C_{26}H_{31}NO_5$	α-H	—OMe	—OMe	—H
Decamine[15], 221	$C_{26}H_{31}NO_5$	α-H	—H	—OMe	—OMe
Decodine[15, 19–21], 193–197	$C_{25}H_{29}NO_5$	β-H	—OH	—OMe	—H

Moreover, seeds of *L. indica* also contain another alkaloid, dihydroverticillatine[15, 19, 20] of molecular formula $C_{25}H_{29}NO_5$ and melting point 258–259°C, structure of which is given below (Fig. 4):

Four other alkaloids, *viz.*, lasubine-I, lasubine-II (structural type C) and subcosine-I, subcosine-II (structural type D) were also isolated from the leaves of *L. subcostata*[13]. Of these four alkaloids only lasubine-II was present in the leaves of *L. speciosa*[22]. Except lasubine-I, all are oily[13].

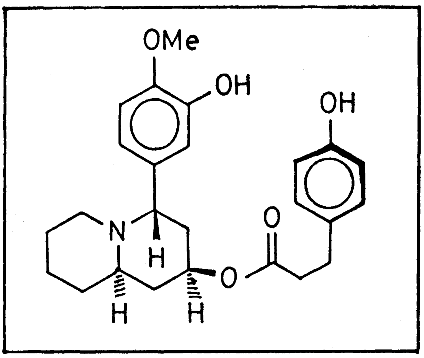


Fig. 4 Structure of dihydroverticillatine

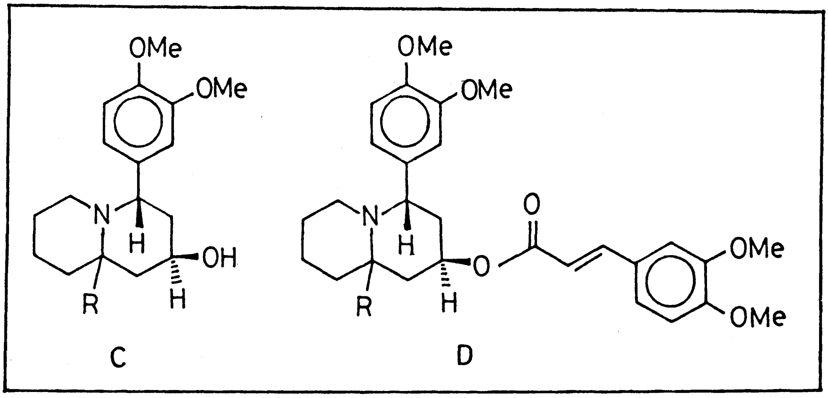


Fig. 5 Structural type of alkaloids C and D

Structural type	Name of the compound, m.p. (°C)	m.f.	Substituent R	Specific rotation $[\alpha]_D^{23}$
C	Lasubine-I, 120.5–122	$C_{17}H_{25}NO_3$	α-H	+68.0° (*c*. 0.20, MeOH)
C	Lasubine-II, Oily	$C_{17}H_{25}NO_3$	β-H	–34.7° (*c*. 0.32, MeOH)
D	Subcosine-I, Oily	$C_{28}H_{35}NO_6$	α-H	+68.0° (*c*. 0.20, MeOH)
D	Subcosine-II, Oily	$C_{28}H_{35}NO_6$	β-H	+85.3° (*c*. 0.64, MeOH)

In addition to Lasubine-II, leaves of *L. speciosa* contain another alkaloid[22] (structure of which is not yet established) having base peak at m/z 149 and other MS fragmentation peaks at m/z 223, 248, 248 and 278.

From early nineties, researchers were able to isolate another important class of compound terpenoids from this genus. All such compounds which have so far been isolated are triterpenoids except one which is a diterpenoid. During the course of isolation of terpenoids, *L. lancasteri* has drawn major attention.

From leaves and twigs of *L. lancasteri*, seven terpenoids were isolated of which only one, *i.e.*, Lagerstronolide[23] is a labdane diterpenoid. Lagernyl acetate[24] and lagernol[24] are the two triterpenoids isolated from *L. lancasteri* have the same basic skeleton (E), whereas jacoumaric acid[24] (isolated as monoacetyl-methyl carboxylate) and 2-α-hydroxy ursolic acid (isolated as its diacetate) have skeleton (F).

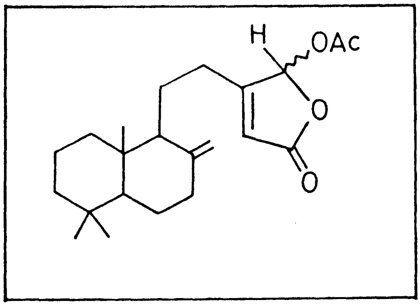


Fig. 6 Structure of lagerstronolide ($C_{22}H_{32}O_4$, m.p. 162°C)

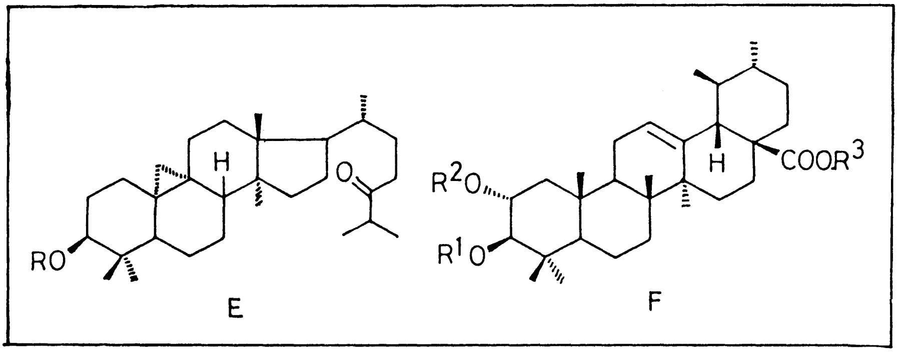
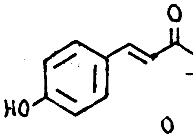
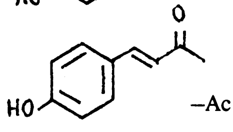


Fig. 7 Skeleton structures of terpenoids E and F

Structural type	Name of the compound m.p. (°C)	m.f.	Substituent R
E	Lagerenyl acetate[24], 122–123	$C_{32}H_{52}O_3$	—Ac
E	Lagerenol[24], 92	$C_{30}H_{50}O_2$	—H

Structural type	Name of the compound, m.p. (°C)	m.f.	Substituents		
			R^1	R^2	R^3
F	Jacoumaric acid[24]	$C_{39}H_{54}O_5$		-H	—H
	(isolated as monoacetyl methyl carboxylate), 281	$C_{42}H_{58}O_7$		-Ac	—CH_3
F	2-α-hydroxy ursolic acid[24] 213	$C_{30}H_{48}O_4$	—H	—H	—H
	(isolated as diacetate), 227	$C_{34}H_{52}O_6$	—Ac	—Ac	—H

Other triterpenoids isolated are friedelin[24], germanicyl acetate[24] and 'β-amyrin[25]. Structures of all these compounds are depicted below:

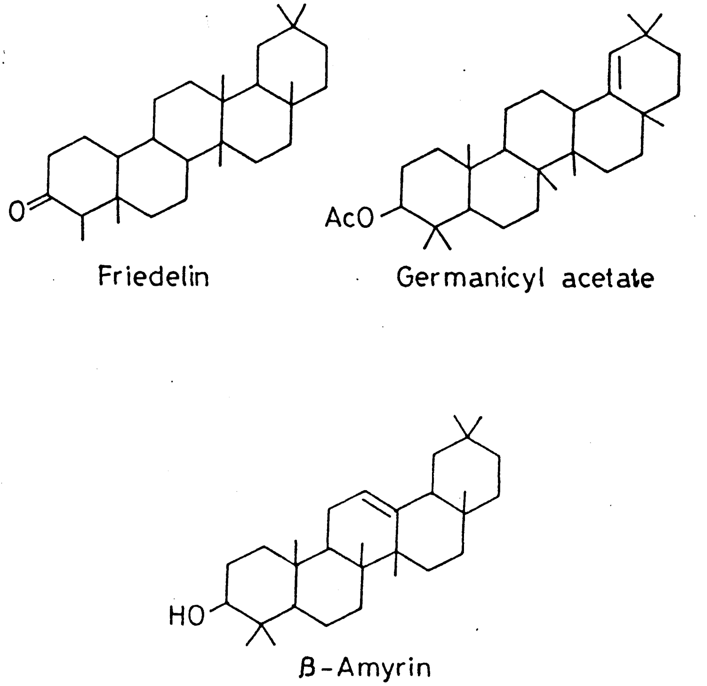


Fig. 8. Structures of friedelin ($C_{30}H_{50}O$, m.p. 255°C), germanicyl acetate ($C_{32}H_{52}O_2$, m.p. 268°C) and β-amyrin ($C_{30}H_{50}O$, m.p. 197°C)

Other species of *Lagerstroemia* from which terpenoids were isolated are *L. parviflora* and *L. indica*. Aerial part (except flower) of *L. indica* contains β-amyrin[25] (structure of which was already depicted) and the whole plant of *L. parviflora* is the source of another triterpenoid, Lageflorin[26] of molecular formula $C_{30}H_{46}O_2$ (m.p. 346–348°C). Structure of Lageflorin is given below:

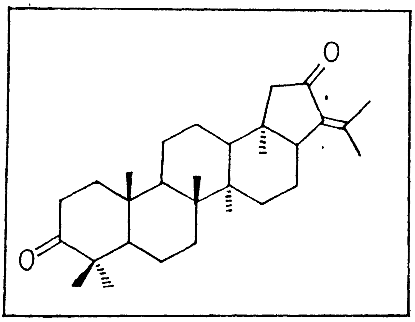


Fig. 9 Structure of lageflorin

Like all other plants, genus *Lagerstroemia*, also contain several sterols which are either Δ^5 or Δ^7. Δ^5-sterols are obtained from the leaves of different species of this genus, *viz.*, *L. indica, L. speciosa, L. subcostata* and *L. fauriei* but Δ^7-sterols are only obtained from the leaves of *L. indica*. Skeleton structure of Δ^5-sterol is as follows:

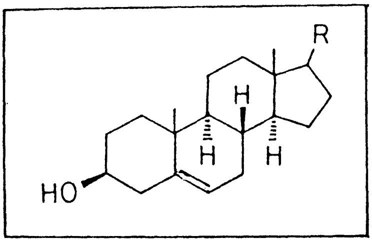


Fig. 10 Skeleton structure of Δ^5-sterol

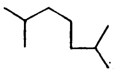
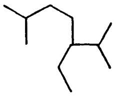
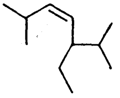
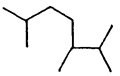
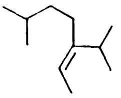
Name of the compound, m.p. (°C)	m.f.	Substituent R
Cholesterol[27], 148.5	$C_{27}H_{46}O$	
β-sitosterol[24, 28–33], 138	$C_{29}H_{50}O$	
Stigmasterol[28, 30, 31], 170	$C_{29}H_{48}O$	
Campesterol[27, 28, 30, 31], 157	$C_{28}H_{48}O$	
24-ethylcholesta-5, 24(28) dien-3-β-ol[27]	$C_{29}H_{48}O$	

Fig. 11. Different substituents of —R of Δ^5-sterol

Until now, only two Δ^7-sterols have been isolated and the structures are as follows:

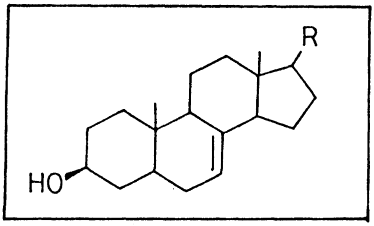


Fig. 12 Skeleton structure of Δ^7-sterol

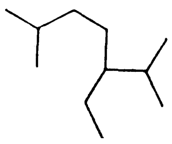
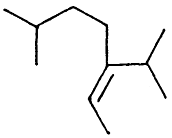
Name of the compound	m.f.	Substituent, R
24-ethylcholest-7-en-3β-ol[27]	$C_{29}H_{50}O$	
24-ethylcholesta-7,24(28)-dien-3β-ol[27]	$C_{29}H_{48}O$	

Fig. 13 Different substituents of —R of Δ^7-sterol

Though *L. lancasteri* is devoid of all these sterols but leaves and twigs of this species contain another sterol, *viz.*, stigmast-4-*en*-3β,6α-diol[23] which has not so far been isolated from any other species of this genus.

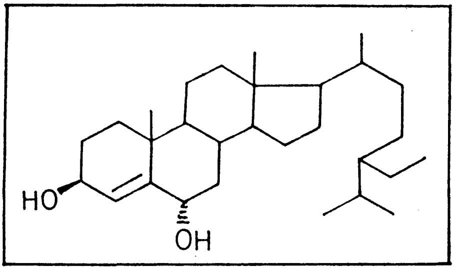


Fig. 14 Structure of stigmast-4-en-3-β,6α-diol ($C_{29}H_{50}O_2$, m.p. 220°C)

It is worth to mention here that different species of this genus not only contain the compounds which were already discussed but also other classes of compounds, *viz.*, polyphenols, anthocyanins, tannins, etc.

Ellagic acid and its O-methyl derivatives were isolated from the leaves of *L. indica, L. subcostata, L. speciosa* and *L. fauriei*. Though the polyphenols were isolated mainly from leaves but 3,4,3′-tri-O-methyl derivative of ellagic acid was isolated from the roots of *L. indica*. Moreover, *L. fauriei*, of American origin, is the only species from which di-O-methyl derivative of ellagic acid was isolated. The skeleton structure of polyphenols is as follows:

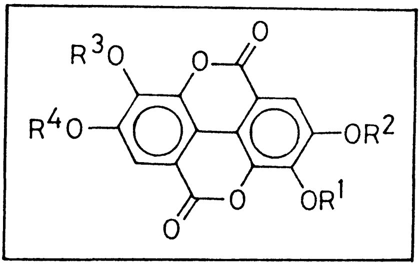


Fig. 15 Skeleton structure of polyphenols

Name of the compound, (m.p., °C)	m.f.	Substituents			
		R^1	R^2	R^3	R^4
Ellagic acid[29, 31, 34–37], > 360°C	$C_{14}H_{16}O_8$	—H	—H	—H	—H
3,4,3′-tri-O-methylellagic acid[29–31, 38], 294–295°C	$C_{17}H_{12}O_2$	—CH_3	—CH_3	—CH_3	—H
3,4-di-O-methylellagic acid[40]	$C_{16}H_{10}O_2$	—CH_3	—CH_3	—H	—H
3-O-methylellagic acid[30]	$C_{15}H_{18}O_8$	—CH_3	—H	—H	—H

These polyphenolic compounds cause difficulties in the pulping of wood during paper-making[38]. The ellagic acid derivatives, detected in the purple flowers are assumed to be the main agents for the blueing of the flowers in *Crape*, *myrtle*[39]. In addition, ellagic acid is a potent antagonist of the mutagenicity of bay-region diol expoxides of several aromatic hydrocarbons. Inhibition of the mutagenicity of the ultimate carcinogenic metabolite of benzo[α]pyrene[41] makes ellagic acid to be considered as a prototype of a new class of cancer-preventing drugs[42].

It has already been stated that anthocyanin, a class of plant pigment, was isolated from this genus. Although initially it was considered that anthocyanidins were present[43], but further investigations revealed the isolation of intact molecules as anthocyanin[39, 44]. Till now, three anthocyanins were isolated from flowers of *L. indica*. They are delphinidin-3-arabinoside[39, 44], petunidin-3-arabinoside[39, 44] and malvidin-3-arabinoside[39, 44] Structures of all those anthocyanins are as follows:

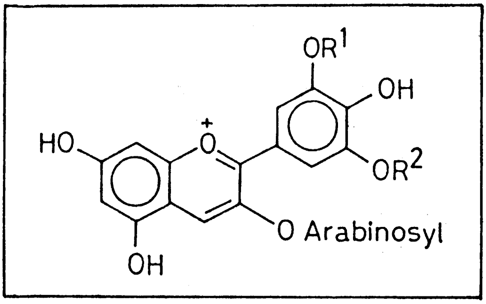


Fig. 16 Structures of three anthocyanins: delphinidin-3-arabinoside (R^1R^2 = —OH), petunidin-3-arabinoside (R^1 = —OMe; R^2 = —OH) and malvidin-3-arabinoside ($R^1 = R^2$ = —OMe)

Although the leaves of *L. subcostata* contain 15% tannin on dry basis[35, 36], isolation of tannin from this genus was far from encouraging. Only one tannin was isolated but its structure was not yet established. The information so far obtained by analysis and acid hydrolysis that it was a diglucoside of luteoic acid[35, 36]. The recent studies for the isolation of tannins from this genus brought a dramatic change in this scenario. Not less than eight ellagitannins[18, 45], *viz.*, flosin A and B; reginin A, B, C and D; pterocarinin A and 5-desgalloyl petrocarinin A together with a hydrolysable tannin, lagerstroemin, were isolated from the leaves of *L. flos-reginae*. Of these tannins, flosin B is monomeric ellagitannin which possesses valoneic acid moiety[45] like flosin A and reginin A and B[18] whereas reginin C and D were characterized as dimeric ellagitannin with pedunculagin moiety connected with pterocarinin A and casuarinin (C_1 epimer of stachyurin) respectively[45]. Another group of scientists further characterised three more ellagitannins[28, 46], *viz.*, lagerstannin A, B, and C having gluconic acid core and were isolated from fruits and leaves of *L. speciosa*. Lagertannin[28] is another new ellagitannin isolated from the leaves of *L. speciosa* and it is responsible for its fungitoxic property[47]. However, several known hydrolyzable tannins were also reported in the course of isolation and characterization of above mentioned new ellagitannins from the leaves of *L. speciosa*.

In addition to all these tannins, presence of pyrogallol tannin in the leaves of

L. speciosa was also reported[48]. But the information regarding structure of this class of tannin so far obtained is inadequate.

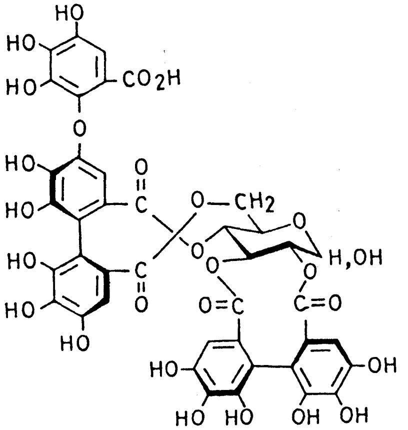
The following two tables enumerate the structures of new tannins (Table-1) and tannins of known structures (Table-2).

TABLE-1
STRUCTURES OF NEW TANNINS

Name of the compound	m.f.	Nature	Structure
Flosin A[18] (monomeric ellagitanin)	$C_{41}H_{28}O_{27}$	An off white amorphous powder	1
Flosin B[45] (monomeric ellagitannin)	$C_{55}H_{32}O_{34}$	An off white amorphous powder	IIa
Lagerstannin A[46] (ellagitannin)	$C_{34}H_{24}O_{23}\cdot\frac{1}{2}H_2O$	A tan amorphous powder	IIIa
Legerstannin B[46] (ellagitannin)	$C_{41}H_{26}O_{27}\cdot H_2O$	A tan amorphous powder	IV
Lagerstannin C[46] (ellagitannin)	$C_{27}H_{22}O_{19}$	A white amorphous powder	IIIb
Lagerstroemin[18, 46]	$C_{55}H_{32}O_{34}\cdot 7H_2O$	m.p. 230°C	IIb
Lagertannin[28] (ellagitannin)	$C_{22}H_{20}O_{13}$	m.p. 360°C	V
Reginin A[18] (dimeric ellagitannin)	$C_{75}H_{50}O_{48}$	An off white amorphous powder	VIa
Reginin B[18] (dimeric ellagitannin)	$C_{75}H_{50}O_{48}\cdot 3H_2O$	An off white amorphous powder	VIb
Reginin C[45] (dimeric ellagitannin)	$C_{80}H_{58}O_{52}\cdot H_2O$	An off white amorphous powder	VIc
Reginin D[45] (dimeric ellagitannin)	$C_{75}H_{50}O_{48}\cdot 3H_2O$	An off white amorphous powder	VII

TABLE-2
NAME OF THE TANNINS OF KNOWN STRUCTURE

Brevifolin carboxylic acid[18]
3-O-caffeoylaquinic acid[18]
Castalagin[18, 46]
Casuarin[18]
Casuarinin[18]
5-desgalloyl-pterocarinin A[45]
5-desgalloyl stachyurin[18]
Gemin D[46]
Gentisic acid-5-O-β-D-glucopyranoside[18]
Gentisic acid 5-O-β-D-(6′-*o*-galloyl)-glucopyranoside[18]
Grandinin[46]
4,6-O-(S)-hexahydroxy-diphenoylagluconic acid[46]
4,6-(S)-HHDP-D-glucose[18]
2,3-(S)-HHDP-D-glucose[18]
Hippophaenin A[46]
Pedunculagin[18]
Pterocarinin A[45]
Punicacortein A[18]
Stachyurin[18]
Vescalagin[18, 46]



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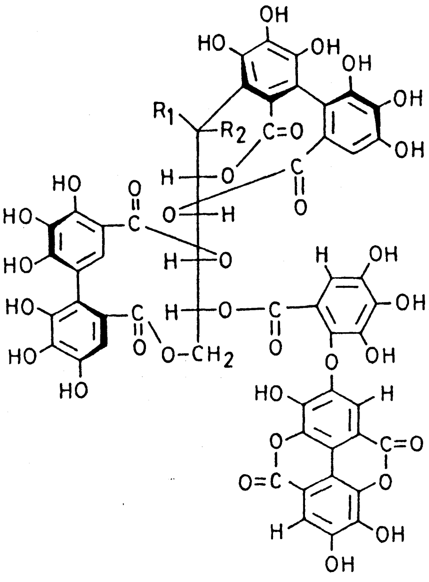
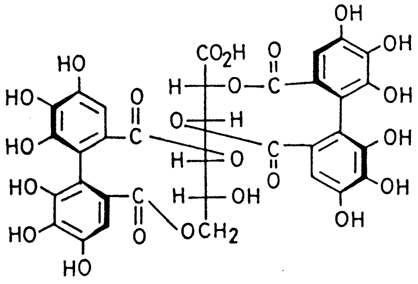


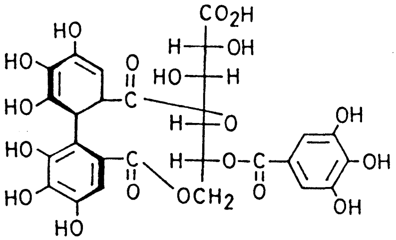
IIa : $R_1 = H, R_2 = OH$

IIb : $R_1 = OH, R_2 = H$

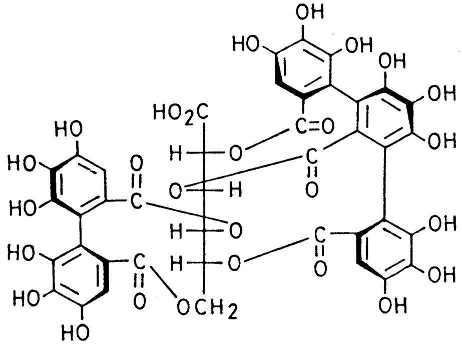
Fig. 17 Structures of new tannins I, IIa and IIb



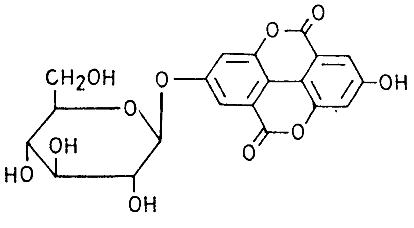
IIIa



IIIb

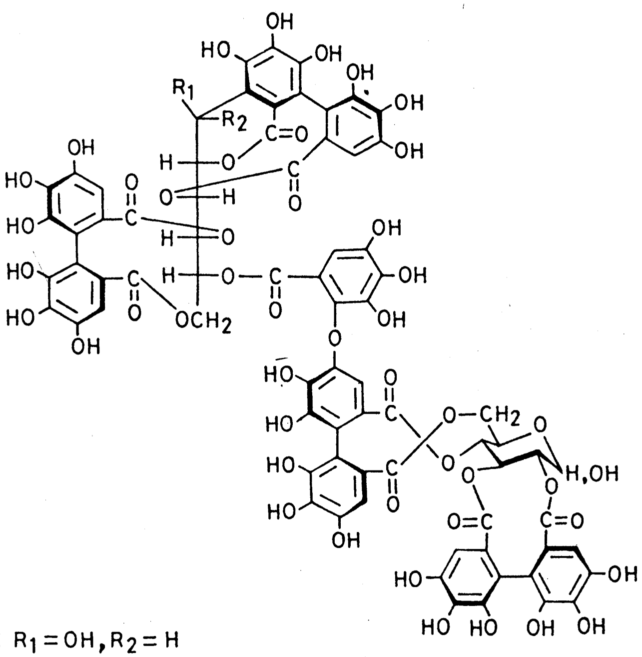


IV



V

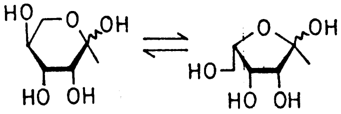
Fig. 18 Structures of new tannins IIIa, IIIb, IV, V

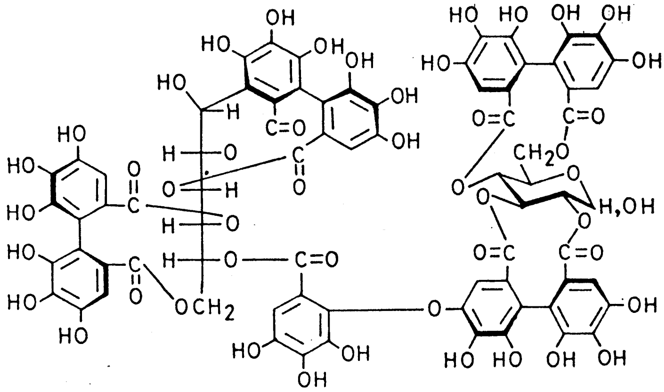


VIa : $R_1 = OH, R_2 = H$

VIb : $R_1 = H, R_2 = OH$

VIc : $R_1 = H, R_2 =$





VII

Fig. 19 Structures of new tannins VIa, VIb, VIc, VII

Besides these, several other compounds were isolated from different species of this genus. Lageracetal[34,39,50], an open chain compound, was isolated from the leaves of *L. speciosa* and *L. subcostata*:

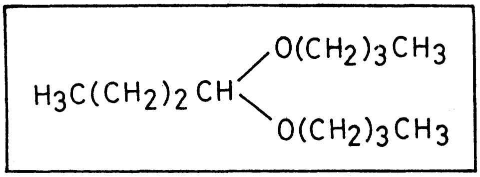


Fig. 20 Structure of lageracetal ($C_{12}H_{26}O_2$, b.p. 203.2°C)

A cyclic alcohol (m.p. 135–144°C) was also isolated from the roots of *L. indica*[51], structure of which is:

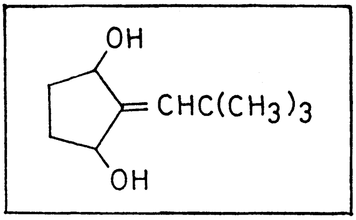
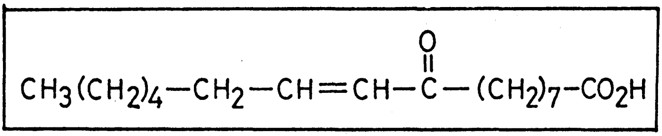


Fig. 21 Structure of cyclic alcohol

Recent investigation on ground part of cultivated *L. indica* (except white flower and root) reveals the presence of a monohydric alcohol 3,6,11,15-tetramethyl-2-hexadecen-1-ol, ellagic acid and its -O-methyl derivative[52].

Moreover, leaves of certain species, *viz.*, *L. speciosa, L. indica* and *L. fauriei* contain *n*-amyl alcohol[34] [an aliphatic straight chain alcohol of boiling point 53°C]. *L. indica* (aerial part except flower) and *L. speciosa* (leaves) not only contain straight chain alcohol[22, 28] but also contain ethyl palmitate[25], hydrocarbon of formula 2,6,10,15,19,23-hexamethyl-2,6,10,14,18,22-tetracosahexene[25], nonacosane[22], *n*-hentriacontane[22], tritria-contane[22], ethyl esters of palmitic[22], daturic[22], stearic[22], arachinic[22], behenic acid[22] and olefins[28] of general formula C_nH_{2n} where n = 24, 26, 28, 30, 32 and 34.

During the recent past, oil chemists are in constant search for new oilseed crops and the genus *Lagerstroemia* is also no exception in this respect. On investigation, seeds of different species of this genus revealed some interesting findings. Analytical data of *L. indica* seed oil showed the presence of unusual fatty acids[53], *e.g.*, eicosenoic acid, octadecatetraenoic acid, eicosentrienoic acid, epoxy, allenic and trienoic acid. But seed oils of other species of this genus contain palmitic acid, stearic acid, oleic acid and linoleic acid[54]. But further investigation showed the presence of appreciable amount of keto acid (21.1%) in *L. speciosa* seed oil. The keto acid which is present in *L. speciosa* seed oil was characterized as 9-keto-octadeca-*cis*-11-enoic acid[55] (m.f. $C_{19}H_{34}O_3$; oily), structure of which is given below:



$$CH_3(CH_2)_4-CH_2-CH=CH-\overset{\overset{O}{\|}}{C}-(CH_2)_7-CO_2H$$

Fig. 22 Structure of 9-keto-octadec-*cis*-11-enoic acid

Generally long chain hydroxy fatty acids are widely distributed in plants but the presence of keto fatty acid is rare[56, 57]. However, the seed oil of this genus contains a high percentage of C_{18} unsaturated fatty acids (77.3–92%). So the seeds of different species of this genus (except *L. indica* and *L. speciosa* because of the presence of unusual fatty acid and keto fatty acid respectively) may be considered as an oilseed crop similar to palm oil[58].

Until now, only three amino acids, isoleucine, methionine and alanine, were isolated from the leaves of *L. flos-reginae*[12] but on the other hand 16 amino acids (all are identified) were isolated from the leaves of *L. sepciosa* and these amino acids constitute the insulin like principle responsible for hypoglycemic activity of this species[48].

From the literature survey it was revealed that scanty work[59] was done on the seed protein of this genus. Preliminary biological and toxicological studies of leaves of *L. speciosa* gave an impression that tannin-free leaf extract is safer than tannin-containing material[60]. Isolation of amino acids from the leaves of *L. speciosa* draws attention of chemists to isolate protein from leaves and seeds of this species. Although no attempt was carried out to isolate protein from leaves but protein was isolated from seeds of this species which contain 17 amino acids. This protein is a mixture of the four fractions as evident from gel electrophoresis and gel filtration. The molecular weights of these fractions were found to be 120, 250; 87, 100; 75, 300 and 17, 400[61, 62]. The presence of abundant lower molecular weight fraction indicates that the protein may be used as a potential alternative source of conventional protein provided it survives toxicological studies.

The never-ending need for the exploration of the potentials of our rich medical armamentarium, with which nature has endowed us, stimulated the impetus to undertake in-depth studies of low molecular weight extractives from *L. speciosa* seeds, a well known medicine known for centuries, for antimicrobial screening. The petroleum ether extract of the seed was found to be much more active than ethanol extract against some test microorganisms[63] (*viz.*, *E. coli.*, *Salmonella* sp., *B. subtilis* and *B. megaterium*). The MIC of the most active acidic fraction was found in between 300–400 μg/mL and the subsequent capillary GC-MS analysis on the methyl ester revealed the presence of nonanedioic acid (28.30%), 12-acetyloxy-9-octadecenoic acid (59.42%) and 16-methyl heptadecanoic acid (14.26%)[64].

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