Pongamia glabra: Constituents & Uses*

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PONGAMIA GLABRA Vent. (Leguminosae, Papilionaceae), a medium sized glabrous tree, popularly known as *karanja*, is an important shade tree of India. Considered to be a native of Western Ghats, it is capable of growing under a wide range of agroclimatic conditions and is a common sight around coastal areas, river banks, tidal forests and roadsides. The isolates from the various parts of this tree have been used as a folk remedy since ancient times. The bark and roots are hot, acrid, bitter anthelmintic and alexipharmic and find application in curing diseases of eye, vagina and skin. They also form a useful remedy for tumours, piles, wounds, ulcers, itching troubles, urinary discharges and a number of other diseases. Seeds find use as external application in skin diseases[1] and the juice of leaves is prescribed in flatulence, dyspepsia, diarrhoea, cough, leprosy and gonorrhoea[2], in addition to the traditional use of leaves as a preservative for books and stored grains. The wood of this tree can also be used as timber, but it is susceptible to attack by insect pests and is not durable.

These uses have generated a lot of scientific interest and karanja is, at present, one of the most extensively chemically investigated plants. A large number of biogenetically related compounds have been isolated and characterized and the industrial uses of some of them established. The present review gives a brief account of the chemistry and uses of these chemical constituents.

Karanjin, the principal furanoflavonoid constituent (approximately 1·25%, oil basis) of the plant, was the first crystalline compound reported as early as 1925 (ref. 3). It was isolated from the seed oil[4] and roots[5] and its structure, constitution and synthesis were thoroughly investigated[6-8] by several groups of workers. It was followed by the discovery of pongamol[9], another minor component (0·85%, oil basis), whose structure remained elusive for a long time. It was finally established[10] to be a novel diketone, by both degradative and synthetic methods[11].

With the advent of new physical methods for the structural elucidation of natural products, the other minor chemical constituents of the oil as well as of various other parts of the tree began to be discovered in early 60's. The structures of the various important products isolated so far are shown in Chart 1, while Table 1 lists the sources and the common and generic names of the compounds.

It is obvious from Chart 1 that the various furano and chromeno derivatives of *P. glabra* possess angular orientation of the furan or the chromene ring. Further, most of these are derivatives of resorcinol in so far as ring A is concerned. The methoxylated derivatives as observed in the chromeno chalkones, viz. glabrachromene I and II, and pongachalkone, have been discovered only recently.

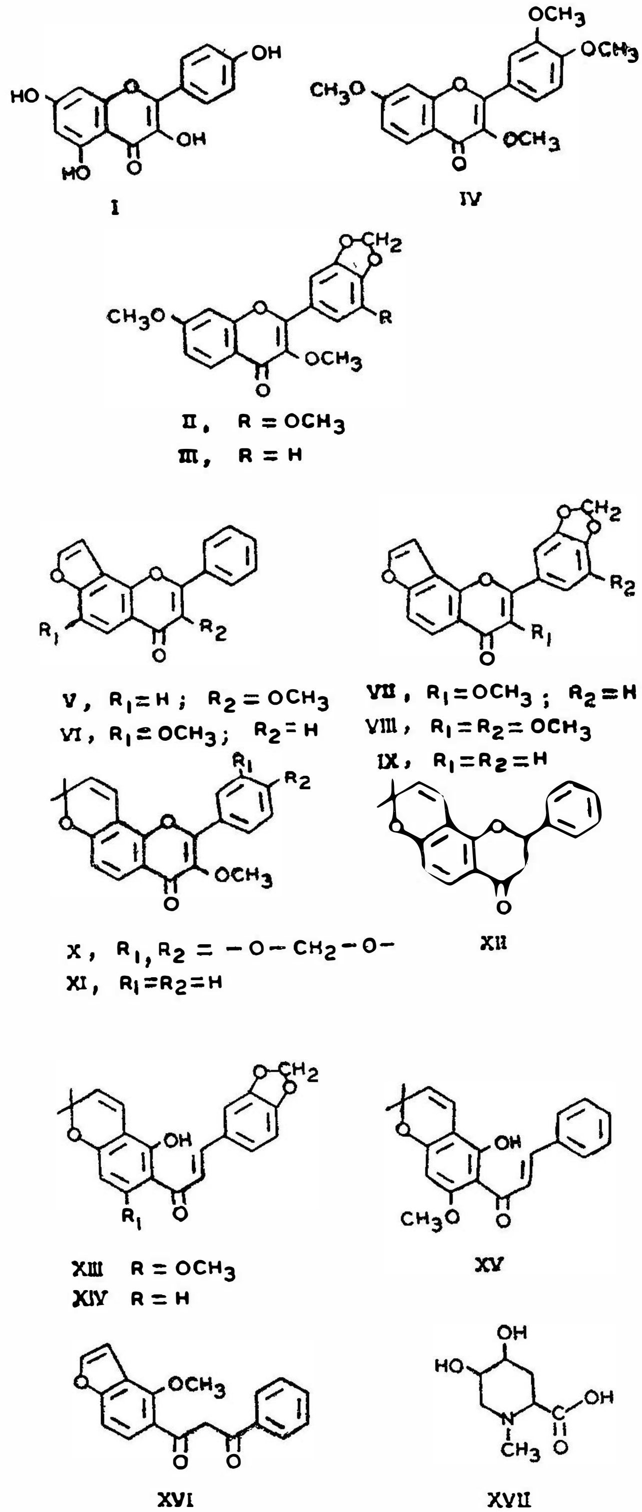

CHART 1

*Contribution No. 113 from the Division of Agricultural Chemicals, IARI, New Delhi 110012.

TABLE 1 — CONSTITUENTS OF *Pongamia glabra*

Sl No.	Common name	Chemical name	Source	Reference
		FLAVONOIDS		
1	Kaempferol	3,5,7,4′-Tetrahydroxyflavone (I)	Flowers	12, 13
2	Kanugin	3,7,5′-Trimethoxy-3′,4′-methylenedioxyflavone (II)	Root, stem	14
3	Desmethoxykanugin	3,7-Dimethoxy-3′,4′-methylenedioxyflavone (III)	Root, stem, seed	15
4	Tetra-*o*-methyl fisetin	3,7,3′,4′-tetramethoxyflavone (IV)	Stem	16
		FURANO FLAVONOIDS		
5	Karanjin	3-Methoxyfurano-(2″,3″: 7,8)-flavone (V)	Seeds	3-8
6	Kanjone	6-Methoxyfurano-(2″,3″: 7,8)-flavone (VI)	do	17
7	Pongapin	3-Methoxy-3′,4′-methylenedioxyfurano-(2″,3″: 7,8)-flavone (VII)	do	18
8	3′-Methoxy-pongapin	3,5′-Dimethoxy-3′,4′-methylenedioxyfurano-(2″,3″: 7,8)-flavone (VIII)	Leaves	19
9	Pongaglabrone	3′,4′-Methylenedioxy furano-(2″,3″: 7,8)-flavone (IX)	Seed	20
		CHROMENOFLAVONES		
10	Pongachromene	3-Methoxy-3′-4′-methylenedioxy-2″,2″-dimethylchromeno-(6″,5″: 7,8)-flavone (X)	Stem	21
11	Karanja chromene	3-Methoxy-2″,2″-dimethylchromeno-(6″,5″: 7,8)-flavone (XI)	Seeds	22
12	(—)I-solonchocarpin	2″,2″-Dimethylchromeno-(6″,5″ : 7,8)-flavanone (XII)	do	23
		CHROMENOCHALKONES		
13	Glabrachromene-I	2′-Hydroxy-6′-methoxy-3,4-methylenedioxy-2″,2″-dimethylchromeno-(5″,6″ : 3′,4′)-chalkone (XIII)	Leaves	24
14	Glabrachromene-II	2′-Hydroxy-3,4-methylenedioxy-2″,2″-dimethylchromeno-(5″,6″: 3′,4′)-chalkone (XIV)	do	25
15	Pongachalkone	2′-Hydroxy-6′-methoxy-2″,2″-dimethylchromeno-(5″,6″: 3′,4′)-chalkone (XV)	Heartwood	26
		FURANO-DIKETONE		
16	Pongamol	4-Methoxy-5-(ω-benzoyl acetyl)-coumarone (XVI)	Seeds	9
		MISCELLANEOUS		
17	Glabrin	4,5-Dihydroxy-N-methyl pipecolic acid (XVII)	do	27, 28
18	γ-Sitosterol	—	Flowers	12
19	β-Sitosterol	—	Wood	29

The biogenetic relation between the chromene ring and the furan ring in flavonoids is well known[30].

Isolation and identification of the various constituents of *P. glabra* led to attempts to find out their remunerative outlets. Some of the results available on the various aspects of its biological spectrum are enunciated here.

As a Source of Pesticidal and Allied Chemicals

Biocidal activity — Karanja and its isolates have been tested for their piscidal, insecticidal, nematicidal, bactericidal and antitubercular activity by several workers. Rangaswami and Seshadri[31] were the first to report the piscidal activity.

Against the cockroach (*Periplaneta americana* Linn.) both the oil and karanjin have been found active[32,33] and against the housefly (*Musca domestica* Linn.), the dorsal application of the oil dissolved in white oil was more effective than that of the oil dissolved in acetone[32]. Karanjin, however, does not possess any contact insecticidal activity against the red flour beetle, *Tribolium castaneum* Herbst.[32].

Singh[34] reported the biological activity of some of the components of karanja seed cake against the mustard aphid (*Lipaphis erysimi* Kalt.). His results (Table 2) indicated that although the alcohol extract as well as some of the purer furanoflavonoids possessed aphicidal activity, karanjin seems to be primarily responsible for it and could be used for this purpose, with advantage.

The nematicidal activity of the water extract of karanja cake has been investigated against second stage larvae of root-knot nematode, *Meloidogyne incognita* and it has been found inferior to neem and mahua cakes[35]. Karanja cake has been reported to be more effective at low levels of nematization[36],

TABLE 2 — ACTIVITIES OF VARIOUS ISOLATES FROM KARANJA AGAINST *Lipaphis erysimi* KALT.

Test fraction	LC_{50} %
Cold ethanol extract of deoiled cake	0·06
Hot ethanol extract of deoiled cake	0·07
Cold ethanol extract of defatted seeds	0·07
Hot ethanol extract of defatted seeds	0·06
Karanjin (crude)	0·07
Karanjin (pure)	0·06
Pongaglabrone	0·10
Pongamol	0·16

but Singh[37] observed that in larger dose, the cake completely controlled the root-knot of tomato.

The antibacterial activity of karanja oil seems to be governed by the test technique[38]; the cup-plate method[39] indicates the oil to be active against both gram-positive and gram-negative organisms. Osmani and Naidu[32]; however, failed to observe any antibacterial activity against *Bacillus chinensis* of both oil and karanjin. Similarly, the soap prepared from the oil has been found to be devoid of any antibacterial activity[40]. Ramaswamy and Sirsi[41a] reported that karanjin possesses antitubercular activity at 10^{-5} dilution.

Synergistic activity — Karanja oil has been reported to synergize endrin against houseflies[41b]. Parmar *et al.*[42,43] investigated this property of the oil with pyrethrins as well as chlorinated insecticides. It was found that the oil synergized the knock-down capability of pyrethrins against the housefly, *M. domestica* Linn. With chlorinated insecticides, this oil synergized the action of lindane, endrin, heptachlor and thiodan, but antagonized BHC and toxaphene against *Tribolium castaneum* Herbst. Aldrin and dieldrin were antagonized at lower levels, and at higher levels, this antagonism was masked. Parmar[44] also studied mixtures of karanja oil and piperonyl butoxide as pyrethrum synergists against *M. domestica* Linn. and found that the use of the mixture was more economical than that of piperonyl butoxide when used alone.

Parmar and Gulati[33] compared the synergistic potential of karanjin with piperonyl butoxide and found it to be a significantly inferior pyrethrum synergist against *M. domestica* Linn. and *Periplaneta americana* Linn. Attri *et al.*[45] observed that both karanja oil and karanjin antagonized pyrethrins against *Tribolium castaneum*, but pongapin (a methylenedioxy analogue of karanjin) was mildly synergistic.

As a Source of Slow Release Plant Nutrients

Non-edible oilseed cakes, in general, and karanja and neem (*Azadirachta indica*), in particular, have since long been used in Indian agriculture as sources of slow release nutrients. Various aspects relating to the manurial value of these cakes under different conditions have been investigated[46-49]. The chemical compositions of different oil cakes have been reported by Prakash *et al.*[50]. The results of these workers coupled with the earlier observations recorded with these oil cakes led to the hypothesis that the non-fatty minor constituents of the oilseeds may be responsible for their slow release characteristics. This aspect has been investigated in detail recently.

Singh[34], while investigating the ability of various karanja extractives in influencing the efficiency of ammoniacal fertilizers, observed that the addition of crude extractives to ammonium sulphate caused accumulation of ammonia in incubated soils. He also observed stabilization of soil structure by the addition of these extractives. Sahrawat *et al.*[51] compared the extractives from bark, leaves and seeds of karanja and found the seed extract to be most active in inhibiting nitrification. Bark extract and leaves ranked next in order. The major furanoflavonoid from seeds, viz. karanjin, was therefore investigated extensively[52]. It gives a matching performance to N-serve, a well-established nitrification inhibitor, in both laboratory incubations and greenhouse experiments with rice crop.

As a Source of Non-edible Industrial Oil

India has a potential to produce over one lakh tonnes of karanja seed and 30,000 tonnes of oil; of this hardly one-fourth is presently utilized[53]. Seed is mainly valued for the oil which can be put to a number of industrial (leather dressing, soap making, lubrication, illumination, etc.) and medicinal uses[1,2]. The IS: 3492 specifications[54] for pongam oil are summarized in Table 3.

Karanja oil resembles groundnut oil in composition and its fatty acid composition is: palmitic, 3·7-7·9; stearic, 2·4-8·9; arachidic, 2·2-4·7; behenic, 4·2-5·3; lignoceric, 1·1-3·5; oleic, 44·5-71·3; linolenic, 10·8-18·3; and eicosenoic, 9·5-12·4%[2]. The presence of furanoflavonoids caused difficulties in the industrial use (soap making) of this oil. Recently, techniques have been evolved for the removal of these toxic constituents and at present purified karanj oil is extensively used in the manufacture of cheaper quality soap.

As a Source of Cheap Cattle Feed

Singh[34] assessed the protein quality of processed seed and cake meals and reported the presence of 16 amino acids, including the 10 essential amino acids (Table 4).

Feeding trials on albino rats conducted by the same author established the acceptability of this material to the test animals.

TABLE 3 — SPECIFICATIONS FOR PONGAM OIL

Characteristics	Requirement
Moisture and insoluble impurities	≯0·25%
Colour (Lovibond scale, Y+5 R)	≯40
$d^{30°}$	0·925-0·940
n_D^{40}	1·4734-1·4790
Acid val.	≯20
Sap. val.	185-195
Iodine val. (Wij's)	80-90
Unsaponifiable matter	≯3·0%
Titre	≯31°
Filtered sample kept at 30° for 24 hr	No turbidity

TABLE 4 — AMINO ACID COMPOSITION OF PROCESSED KARANJA SEED AND CAKE MEAL

[Values in parentheses indicate amino acid (g) per 100 g protein or per 16 g of nitrogen]

Amino acid	Amino acid (%) in	
	Seed meal	Cake meal
Leucine	2·70 (8·99)	2 85 (9 49)
Lysine	2 65 (8·82)	2·81 (9 36)
Methionine	2·02 (6·73)	2 05 (6 83)
Arginine	1·90 (6·33)	1 87 (6 23)
Valine	1·85 (6·17)	1·14 (3·78)
Tryptophan	1 67 (5 57)	— —
Histidine	1·52 (5 06)	1·74 (5 79)
Isoleucine	1 03 (3·43)	1·50 (5 00)
Threonine	0 98 (3 27)	1·00 (3 33)
Phenyl alanine	0 70 (2 33)	0 76 (2 53)
Aspartic acid	2·75 (9·16)	3·18 (10·59)
Serine	1 72 (5·73)	2·05 (6 83)
Glutamic acid	4 45 (14 80)	4 62 (15·38)
Glycine	1·50 (5·00)	1 66 (5 53)
Alanine	1 40 (4 70)	1 22 (4·06)
Tyrosine	1·75 (5·83)	1 82 (6 06)

Summary

The literature on karanja is evaluated critically. As with any other material, there is still a vast area of research remaining uncovered but the present information does point out areas where seeds and oil available in a large amount in the country can be utilized. To mention some of the uses, the use of karanjin as a nitrification inhibitor and karanja oil as a synergist-cum-solvent for chlorinated insecticides might consume considerable amounts of these materials. Similarly, karanja cake meal can be processed and used as a cheap cattle feed. The oil is already finding considerable use in soap making. Besides, it is a potential source of fatty acids.

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