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A LIST OF PLANTS REPORTED TO CONTAIN ROTENONE OR ROTENOIDS

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In 1933 Roark (39) listed those plants in which rotenone and related compounds had been found. Since that time many additional plant species have been investigated, and a new list is of interest. In some cases the actual isolation of rotenone or compounds related to it has been reported. In many investigations, however, a characteristic color test has been applied which indicates the presence either of rotenone or of compounds of the rotenone type, collectively termed rotenoids by Roark (42). The color test usually used in this type of work has been that of Durham (24, 51), but the test of Gross and Smith (12, 15) has also been applied.

In table 1 are listed those plants of the family Leguminosae that have been definitely reported to contain rotenone or rotenoids. The part of the plant on which the findings were made is given. By noting the heading under which reference to the literature is made it may be ascertained whether the plant has been reported to contain rotenone, or compounds related to it, or gave a positive color test for rotenone and rotenoids. In most cases reference has been made only to the first work in which the findings were reported. The table lists 68 leguminous plants that have been reported to contain rotenone or rotenoids. The genera, all of the subfamily Papilionatae, have been classified according to tribes, and it will be noted that the tribes Galegeae and Dalbergieae are represented by the largest number of genera. Of the more important genera, 21 species of Tephrosia are listed, 12 species of Derris, 12 of Lonchocarpus, 10 of Millettia, and 2 of Mundulea.

Table 1.--List of leguminous plants reported to contain rotenone or rotenoids

Tribe	Genus and species	Part of plant	Reference to presence of rotenone or rotenoids: Rotenone	Compounds related to rotenone	Color test
Galegeae	Amorpha fruticosa L.	roots,stems,seeds			(54)
	Millettia dura Dunn.	roots,stems,seeds			(59)
	Millettia ferruginea Hochst.	stems, petioles, leaves	(3)		
	Millettia ichtyochtona Bureau & Franch.	seeds	(16)		
	Millettia laurentii de Wild	roots,stems,leaves	(2)		
	Millettia mannii Baker	roots,stems,leaves	(2)		
	Millettia pachycarpa Benth.	roots	(11)		
	Do.	seeds		(19)	(19)
	Millettia reticulata Benth.	roots			(19)
	Millettia taiwaniana Hayata (Derris taiwaniana Matsum.)	roots	(27)		
	Millettia usaramensis Taub.	seeds			(59)
	Millettia versicolor Welw.	roots,stems,leaves	(2)		
	Mundulea pauciflora Baker	roots	(17)		
	Do.	stems (bark)	(6)		
	Mundulea sericea (Willd.) Chevalier (M. suberosa Benth.)	stems,seeds,pods	(14)*		
	Do.	stems (bark)	(57)	(58)	
	Do.	roots, stems, peduncles, ovaries,stamens, seeds			(59)
	Tephrosia ambigua (M. A. Curtis)	roots,whole seed pods			(23)
	Tephrosia candida (Roxb.) A. DC.	seeds	(2,29)		(52,53)
	Do.	roots (bark)	(29)		
	Do.	stems (bark)	(7)		
	Do.	roots, pods	(2)		
	Do.	leaves			(29)
	Do.	roots,stems,ovules, seeds			(59)

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Table 1. (Continued)

Tribe	Genus and species	Part of plant	Reference to presence of rotenone or rotenoids: Rotenone	Compounds related to rotenone	Color test
Dalbergieae	Derris sp.	roots,stems			(55)
	Lonchocarpus chrysophyllus Kleinh.	stems	(50)		
	Do.	roots	(48,30)	(48)	
	Lonchocarpus martynii A.C. Smith	stems	(50)		
	Do.	roots	(50,30)		
	Lonchocarpus nicou (Aubl.) DC.	stems,leaves	(9)		
	Lonchocarpus rariflorus Mart.	roots	(30)		
	Lonchocarpus sericeus H.B.K.	roots,leaves	(2)		
	Lonchocarpus urucu Killip & Smith	roots,stems, leaves	(30)		
	Lonchocarpus utilis A.C.Smith	roots	(4,30)	(4)	
	Do.	stems	(22,30)		
	Do.	leaves	(30)		
	Lonchocarpus velutinus Benth.	roots	(22)		
	Lonchocarpus sp. (L. hondurensis Benth.? "Bejuco de Gusano")	roots	(52)		
	Lonchocarpus sp. (L. guatemalensis Benth.? or L. atropurpureus Benth.?)	roots	(52)		
	Lonchocarpus sp. ("Timbo branco")	roots,stems	(30)		
	Lonchocarpus sp. ("Timbo pao", "Red Haiari")	roots	(32,30)		
	Piscidia piscipula (L.) Sarg.	roots,stems (inner bark)			(55)
Adenanthereae	Entada africana Guill. & Perr.	leaves			(8)

*Greshoff isolated from these species a material that he called "derrid." This is now known to have been an impure substance that contained a large proportion of rotenone.

From the standpoint of actual use as insecticides, the most important species are Derris elliptica, D. malaccensis, Lonchocarpus urucu, and L. utilis. The roots of these plants are at present the chief commercial source of rotenone-containing insecticides. Derris roots are cultivated on a large scale in Malaya and the Dutch East Indies. Lonchocarpus roots are obtained from Brazil and Peru. The material from Brazil is largely L. urucu, generally called "timbo"; that from Peru is mostly L. utilis, generally called "cube". The latter was formerly classified as L. nicou, but this name has been retained for a species found in the Guianas. For a full discussion of the common names used in referring to Lonchocarpus species reference is made to Roark (41). Roots of Derris elliptica and the two species of Lonchocarpus are generally high in rotenone, while those of D. malaccensis, though of only moderate rotenone content, usually have a high content of other toxic principles. In general the content of active principles in other plants is lower than in these commercially used species.

Amorpha fruticosa is indigenous to the Mississippi Valley. This plant is at present under study in this Division. A sample of root from Louisiana was found to give no color test for rotenone or rotenoids.

Some of the Millettia species, particularly M. pachycarpa, appear to have some local use in China as insecticides. A sample of M. pachycarpa from Assam (India) was found to have over 1 percent rotenone but low total extractives (11). The specimens of M. dura, M. laurentii, M. mannii, M. usaramensis, and M. versicolor tested for rotenone were from East Africa and the Congo. The content of rotenone and rotenoids in these and other species of Millettia is in general low.

Mundulea sericea, widely distributed in tropical Africa, has been extensively studied by Worsley (58). Although the bark has low rotenone and total extract contents, Worsley has found that some samples are as toxic to insects as derris root of a moderately high rotenone content.

The genus Tephrosia is widely distributed, and many species have been used as fish poisons. Roark (40) has made a comprehensive review of the use of species of Tephrosia as insecticides. Of the species listed in table 1, T. ambigua, T. chrysophylla, T. gracillima, T. hispidula, T. latidens, T. lindheimeri, T. onobrychoides, T. smallii, T. spicata, and T. virginiana are domestic plants. Of these only T. latidens and T. virginiana have been found to contain sufficient rotenone or rotenoids to be of interest. The latter has been studied extensively (45) and has commercial possibilities. The roots of T. macropoda and the leaves of T. vogelii, tropical African species, have been used locally as insecticides. The leaves of T. vogelii, extensively studied from the chemical standpoint (4, 18, 56), appear to contain little or no rotenone, but contain deguelin and tephrosin. T. toxicaria is distributed throughout tropical America. The rotenone content of the roots of this species and of T. macropoda is comparatively low. The other tropical species of Tephrosia have only very small contents of rotenone and rotenoids.

The species of Derris listed are found in tropical Asia, with the exceptions of D. amazonica and D. grandifolia, which are tropical American species. Except for D. elliptica and D. malaccensis, it is doubtful if any of these species has a sufficiently high content of active principles to be of commercial importance as insecticides. D. polyantha, from Malaya, and D. ferruginea, an Indian species, have moderate rotenone contents and may find local use.

With the exception of the sample of L. sericeus, which was from the Congo, all the species of Lonchocarpus listed are of tropical American origin. L. chrysophyllus is the "Black Haiari" and "Nekoe", and L. martynii the "White Haiari" of the Guianas. They have been the subject of both chemical and toxicological investigations (30, 48, 50), and both have a moderate rotenone content. Aside from L. urucu and L. utilis, the roots of most of the species of Lonchocarpus tested have only moderate or low rotenone contents. An exception to this is "Timbo branco," which according to Krukoff and Smith (30) averages 7 percent rotenone, but no large quantities of the plant exist in the Amazon region.

In general it appears that of the plants thus far examined a greater number of species of Lonchocarpus than of Derris have been found to contain moderate or high percentages of rotenone. The highest rotenone content yet reported has been that of 20.6 percent in a specimen of L. nicou (L. utilis?) grown in Puerto Rico (55).

In addition to the plants listed in table 1, there are references to other species of legumes in which the presence of rotenone may be considered probable. Such references are not accompanied by experimental evidence. These species are listed in table 2.

Table 2.--List of leguminous plants that may contain rotenone or rotenoids

Tribe	Genus and species	Reference to possible presence of rotenone or rotenoids
Galegeae	*Cracca caribea Benth.	(44)
	*Cracca mollis Benth.	(44)
	*Cracca ochroleuca Benth.	(44)
	Tephrosia brevipes Benth.	(32)
	Tephrosia decumbens Benth.	(44)
	Tephrosia heydeana (Rydb.) Standl.	(44)
	Tephrosia nicaraguensis Oerst.	(44)
	Tephrosia nitens Benth.	(32)
	Tephrosia talpo Watson	(44)
Dalbergieae	Lonchocarpus floribundus Benth. (L. nitidulus Benth.)	(30)
	Lonchocarpus madagascariensis (Boivin) R. Viguier	(6)

*Cracca = Benthamantha.

Greshoff in 1890 (13) isolated from the seed of Pachyrhizus angulatus Rich. a substance which he called pachyrhizid. This substance was stated by Greshoff and by Van Sillevoldt (46) to be similar to derrid, isolated from Derris elliptica by Greshoff and now known to have been very impure rotenone. Hanriot (18) stated that pachyrhizid and derrid were similar but not identical. Kariyone and Atsumi (26) compared the properties of pachyrhizid with those of rotenone. However, none of these investigators stated that the substances were identical, and hence it cannot be definitely concluded that P. angulatus contains rotenone. In view of the recent finding of rotenoids in a related species, P. erosus (19a), it is possible that Greshoff's plant material did contain rotenone.

In table 3 are listed plants, of which the common names only are available, reported to contain rotenone or rotenoids. The first three are definitely legumes. "Timbo vermelho" is the Leguminosae sp. of Krukoff and Smith (30). They state that this plant is not a Lonchocarpus, Derris, Tephrosia, or Ormocarpum. No statement can be made as to the "Sopilote" or "Lai-Tung." In the case of the former only chips of wood were available. In the latter case the only literature source available gives no clue as to the identity of the plant. It is realized that there may be some duplication between the plants in table 3 and those in the two previous tables.

Table 3.--List of plants, of which only common names are available, reported to contain rotenone or rotenoids

Name	Source	Part of plant	Reference to presence of rotenone or rotenoids: Rotenone	Compounds related to rotenone	Color test
"Timbo vermelho" "Timbo melancia"	Brazil	roots	(30)		
"Berberra" (Millettia ferruginea Hochst.?)	Ethiopia	(seeds (roots	(52)		(52)
"La Meh"	Southern China	seeds	(52)		
"Lai-Tung"	China	?	(31)	(31)	
"Sopilote"	Honduras	chips of wood			(52)

All the plants listed in tables 1 and 2 and the first three in table 3 are definitely of the family Leguminosae. In the literature there appear references to the presence of rotenone or rotenoids in three plant specimens reported to be of other plant families. However, an examination of these cases shows that these statements may be doubted. Pfaff (38) reported the presence of timboin in Brazilian timbo. Timboin was probably similar to the derrid of Greshoff (13), an impure substance that contained a large proportion of rotenone. Pfaff thought the plant material might be Paullinia pinnata L. (Sapindaceae), but in view of our present knowledge of timbo it is very likely that the plant was a species of Lonchocarpus, possibly L. urucu. Subsequent references to Paullinia pinnata as a rotenone-containing plant have been based either on Pfaff's work or on the confusion in the identification of Brazilian timbo root. Roark (39) stated that rotenone or related compounds had been found in Polygonum (?) sp. According to the records of this Division (52), the identity of this sample, of which only the roots were available, was very doubtful, and it cannot be considered definitely of the family Polygonaceae. Recently Scarone (44) stated that "of numerous plants of the family Bromeliaceae in particular Tillandria usnoides L. [Tillandsia usneoides L.] contains rotenone." The statement is not accompanied by experimental evidence, and no other reference to the rotenone content of this plant has been found. In view of these facts the presence of rotenone or rotenoids in these three species of plants may well be questioned unless substantiated by further work on authentic specimens.

Although it cannot be stated categorically that rotenone and rotenoids occur only in plants of the family Leguminosae, the preponderance of evidence at the present time indicates that this may be the case.

SUMMARY

Rotenone or rotenoids have definitely been reported in 67 species of leguminous plants. Most of these belong to the tribes Galegeae and Dalbergieae. The genera Millettia, Tephrosia, Derris, and Lonchocarpus are represented by the largest numbers of species.

From the evidence now at hand it appears possible that rotenone and rotenoids are present only in plants of the family Leguminosae, and may be confined to the subfamily Papilionatae.

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