

# PLANTS OF OKLAHOMA AND TEXAS CAPABLE OF PRODUCING CYANOGENIC COMPOUNDS

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We have surveyed the distribution of cyanogenic compounds in plants from Oklahoma and Texas. Approximately 135 species of plants from 46 families are known to contain compounds capable of liberating hydrogen cyanide upon hydrolysis. These are primarily found in the Gramineae, Rosaceae, Leguminosae, Polypodiaceae, and Euphorbiaceae. The chemical structures of the cyanogens have been studied in only a small number of the species included and investigation of the biology and chemistry of these plants should prove profitable.

## INTRODUCTION

A study of the distribution of cyanogenic plants of Oklahoma and Texas was begun for several reasons. Our principal interest in this study arose because we felt these compounds could be useful as taxonomic characters for the study of plant groups found in North America. The literature of cyanogenic plants from the northeastern United States has previously been surveyed (1). Several reports in the literature point to the utility of these compounds for this purpose (2-16). Although their chemotaxonomic value is considerable, perusal of the literature reveals that structures of specific compounds responsible for this activity are known in but a small percentage of the plants listed (see Table 1). Thus, at the present time we do not have adequate data to utilize these chemical characters for taxonomic study except in a few cases.

A second reason for making this investigation may be even more important to the average reader — these compounds and plants which contain them are poisonous to both humans and livestock. Kingsbury (17) has discussed the toxic nature of cyanogenic glycosides. Generally, plants which contain more than 20 mg HCN/100 grams of fresh plant material may be considered potentially dangerous, but several factors determine whether poisoning will actually take place (17).

Plants which are capable of producing cyanogenic compounds are distributed widely in the plant kingdom and are known from at least 1000 species in 90 families. The known chemical types have recently been reviewed (18). Although plants containing these compounds are widespread, the structures of only about 30 compounds have appeared in the literature and specific compounds have been isolated from fewer than 100 species. Most literature accounts are based on the color test using paper impregnated with sodium picrate solution, suspended in a vial over plant material to which a  $\beta$ -glucosidase has been added. A change from yellow to a brick-red color constitutes a positive test (19).

In this study I have considered only the states of Oklahoma and Texas, which because of their large and diverse flora will add a major section to the contemplated goal of preparing a listing of cyanogenic plants of the entire United States. For information concerning the distribution of certain plant species, I have consulted Correll and Johnston (20), Waterfall (21), Vines (22), Bailey (23), and Warnock (24). Of the records of cyanogenic nature included, many are doubtful and should be verified. Among these are: *Nerium oleander*, *Impatiens balsamina*, *Borago officinalis*, *Heliotropium indicum*, *Campanula rotundifolia*, *Cleome hassleriana*, *Carica papaya*, *Beta vulgaris*, *Ipomoea* spp., members of the Cruciferae, *Ricinus communis*, *Zea mays*, *Cinnamomum camphorum*, *Pisum sativum*, *Medicago sativa*, *Cassia alata*, *Cicer arietinum*, *Glycine max*, *Arachis hypogaea*, *Dolichos lablab*, *Lagerstroemia speciosa*, *Melia azedarach*, *Psidium guajava*, *Oenothera biennis*, *Guara biennis*, *Oxalis corniculatus*, *Dryopteris filix-max*, *Reseda alba*, *Rhamnus frangula*, *Solanum melongena*, and *Lycium halmifolium*.

Considerable changes in cyanogenic properties occur with diurnal, seasonal, and ecological variations. Many plants appear

TABLE 1. *Plants of Oklahoma and Texas known to be capable of producing cyanogenic compounds.*

Family and species	Compound	Reference
Apocynaceae		
<i>Nerium oleander</i> L. <sup>a,b</sup>	unknown	16
Araceae		
<i>Colocasia esculenta</i> Schott. <sup>a,b</sup>	unknown	25
Araliaceae		
<i>Aralia spinosa</i> L.	unknown	1
Balsaminaceae		
<i>Impatiens balsamina</i> L. <sup>a</sup>	unknown	16
Berberidaceae		
<i>Nandina domestica</i> Thunb. <sup>a,b</sup>	<i>p</i> (glucosyloxy) mandelonitrile	26, 27
Boraginaceae		
<i>Borago officinalis</i> L. <sup>a</sup>	unknown	3, 4
<i>Heliotropium indicum</i> L. <sup>b</sup>	unknown	16
Calycanthaceae		
<i>Calycanthus floridus</i> L. <sup>a</sup>	unknown	3, 4
Campanulaceae		
<i>Campanula rotundifolia</i> L.	unknown	16
Capparidaceae		
<i>Cleome hassleriana</i> Chod. <sup>a,b</sup>	unknown	16
Caricaceae		
<i>Carica papaya</i> L. <sup>a</sup>	unknown	16
Chenopodiaceae		
<i>Atriplex semibaccata</i> R.Br. <sup>a,b</sup>	unknown	6
<i>Beta vulgaris</i> L. <sup>a,b</sup>	unknown	16
<i>Chenopodium album</i> L. <sup>b</sup>	unknown	16
<i>Suckleya suckleyana</i> (Torr.) Rydb.	unknown	6
Convolvulaceae		
<i>Ipomoea batatas</i> (L.) Lam. <sup>a,b</sup>	unknown	16
<i>Ipomoea cairica</i> (L.) Sweet <sup>a,b</sup>	unknown	16
<i>Ipomoea quamoclit</i> L. <sup>a</sup>	unknown	16
<i>Ipomoea sinuata</i> Ort.	unknown	26
Compositae		
<i>Achillea millefolium</i> L. <sup>b</sup>	unknown	3, 4
<i>Centaurea americana</i> Nutt.	unknown	28
<i>Dimorphotheca ecklonis</i> D.C. <sup>a</sup>	linamarin and lotaustralin	29
<i>Dimorphotheca pluvialis</i> Moench. <sup>a</sup>	linamarin and lotaustralin	29
Cruciferae		
<i>Armoracia lapathifolia</i> Gilib. <sup>a,b</sup>	unknown	30
<i>Brassica oleracea</i> L.	unknown	16
<i>Eruca sativa</i> Mill. <sup>b</sup>	unknown	30
<i>Nasturtium officinale</i> R.Br. <sup>b</sup>	unknown	16
<i>Thlaspi arvense</i> L. <sup>b</sup>	unknown	30
<i>Stanleya pinnata</i> (Pursh.) Britt.?	unknown	16
Cycadaceae		
<i>Cycas revoluta</i> Thunb. <sup>a</sup>	The pseudocyanogenic compounds, cycasin and neocycasin A	31, 32
Droseraceae		
<i>Drosera intermedia</i> Hayne.	unknown	29
Euphorbiaceae		
<i>Cnidocolus texanus</i> (Muell. Arg.) Small	linamarin	16, 33
<i>Codiaeum variegatum</i> Blume <sup>a</sup>	unknown	16
<i>Euphorbia hirta</i> L.	unknown	16
<i>Manihot walkerae</i> Croizat.	unknown	20, 34 this study
<i>Phyllanthus niruri</i> L.	unknown	16
<i>Ricinus communis</i> L. <sup>a,b</sup>	unknown	26
<i>Sapium sebiferum</i> (L.) Roxb. <sup>a,b</sup>	unknown	this study
<i>Stillingia texana</i> I.M. Johnst. (or <i>S. dentata</i> )	unknown	28
Garryaceae		
<i>Garrya wrightii</i> Torr.	unknown	16
Gramineae		
<i>Agrostis stolonifera</i> L. <sup>b</sup>	unknown	35
<i>Bambusa arundinacea</i> Willd. <sup>a</sup>	unknown	36
<i>Bothriochloa intermedia</i> (R.Br.) <sup>a,b</sup> A. Camus	unknown	37
<i>Bothriochloa ischaemum</i> (L.) Keng. <sup>a,b</sup>	unknown	37
<i>Bouteloua gracilis</i> (HBK.) Griffiths	unknown	37

<i>Briza minor</i> L. <sup>b</sup>	unknown	37
<i>Cortaderia argentea</i> Stapf. <sup>a</sup>	unknown	37
<i>Dactyloctenium aegypticum</i> (L.) Beauv. <sup>b</sup>	unknown	37
<i>Eleusine indica</i> (L.) Gaertn. <sup>b</sup>	unknown	37
<i>Festuca elatior</i> L.	unknown	35
<i>Glyceria septentrionalis</i> Hitch.	unknown	28
<i>Holcus lanatus</i> L.	unknown	37
<i>Leptochloa dubia</i> (HBK.) Nees	unknown	37
<i>Lolium perenne</i> L. <sup>b</sup>	unknown	37
<i>Panicum maximum</i> Jacq. <sup>b</sup> ?	unknown	37
<i>Poa pratensis</i> L.	unknown	51
<i>Sorghum alnum</i> Parodi. <sup>a,b</sup>	unknown	17
<i>Sorghum bicolor</i> (L.) Moench. <sup>a,b,c</sup>	dhurrin	37, 38
<i>Sorghum halepense</i> (L.) Pers. <sup>a</sup>	dhurrin	17, 38, 39
<i>Tridens flavus</i> (L.) Hitch.	unknown	37
<i>Zea mays</i> L. <sup>a</sup>	unknown	40

*Avena*, *Hordeum*, *Triticum*, *Oryza*, *Saccharum* and *Secale* have also been reported as cyanogenic (43). The cyanogenic principles are all unknown.

Grossulariaceae		
<i>Ribes odoratum</i> Wendl.	unknown	41
Haloragaceae		
<i>Myriophyllum brasiliense</i> Camb. <sup>b</sup>	unknown	3, 4
Hydrocharitaceae		
<i>Vallisneria americana</i> Michx.	unknown	16
Hydrophyllaceae		
<i>Phacelia congesta</i> Hood	unknown	16, this study
Iteaceae		
<i>Itea virginica</i> L.	unknown	42
Lauraceae		
<i>Cinnamomum camphora</i> Nees & Eberm. <sup>a,b</sup>	unknown	16
Leguminosae		
<i>Acacia berlandieri</i> Benth.	unknown	this study
<i>Acacia constricta</i> Gray	acacipetalin	44
<i>Acacia farnesiana</i> (L.) Willd.	linamarin and lotaustralin (?)	45
<i>Acacia greggii</i> Gray	unknown	17
<i>Acacia roemeriana</i> Scheele	unknown	this study
<i>Arachis hypogaea</i> L.	unknown	16
<i>Cassia alata</i> L.	unknown	16
<i>Cicer arietinum</i> L.	unknown	6
<i>Dolichos lablab</i> L. <sup>a</sup>	unknown	6, 26
<i>Glycine max</i> Merr.	unknown	16
<i>Lotus corniculatus</i> L. <sup>a,b</sup>	linamarin and lotaustralin	46
<i>Lupinus texensis</i> Hook.	unknown	this study
<i>Medicago sativa</i> L. <sup>a,b</sup>	unknown	6
<i>Phaseolus lunatus</i> L. <sup>a</sup>	linamarin and lotaustralin	25
<i>Phaseolus vulgaris</i> L.	linamarin and lotaustralin ?	50
<i>Pisum sativum</i> L. <sup>a</sup>	unknown	16
<i>Prosopis glandulosa</i> Torr. (juliflora)	unknown	3, 4, 6
<i>Trifolium repens</i> L. <sup>a,b</sup>	linamarin and lotaustralin	47, 48
<i>Trifolium pratense</i> L.	unknown	35
<i>Vicia angustifolia</i> L. <sup>b</sup>	vicianin	49
<i>Vicia sativa</i> L. <sup>b</sup>	unknown	26
Linaceae		
<i>Linum lewisii</i> Pursh.	unknown	28
<i>Linum usitatissimum</i>	linamarin and lotaustralin	46, 52
Lythraceae		
<i>Lagerstroemia speciosa</i> Pers. <sup>a</sup>	unknown	16
Magnoliaceae		
<i>Liriodendron tulipifera</i> L.	unknown	3, 29
Meliaceae		
<i>Melia azedarach</i> L. <sup>b</sup>	unknown	16
Menispermaceae		
<i>Menispermum canadense</i> L.	unknown	16
Myrtaceae		
<i>Psidium guajava</i> L. <sup>a</sup>	unknown	16
Onagraceae		
<i>Guara biennis</i> L.	unknown	16
<i>Oenothera biennis</i> L.	unknown	4, 5

Oxalidaceae		
<i>Oxalis corniculata</i> L. <sup>b</sup>	unknown	16
Papaveraceae		
<i>Eschscholtzia californica</i> Cham. <sup>a</sup>	unknown	4, 5, 30
<i>Eschscholtzia mexicana</i> Greene	unknown	this study
<i>Papaver nudicaule</i> L. <sup>a</sup>	linamarin and lotaustralin	53
Passifloraceae		
<i>Passiflora foetida</i> L.	unknown	16
<i>Passiflora incarnata</i> L.	unknown	16
<i>Passiflora lutea</i> L.	unknown	54
<i>Passiflora suberosa</i> L.	unknown	55
Platanaceae		
<i>Platanus acerifolia</i> Willd. <sup>a,b</sup>	unknown	29
<i>Platanus occidentalis</i> L.	unknown	29
Polypodiaceae		
<i>Asplenium septentrionale</i> (L.) Hoffm.	unknown	38
<i>Cheilanthes aemula</i> Maxon.	unknown	this study
<i>Cheilanthes alabamensis</i> (Buckl.) Kunze	unknown	1
<i>Cheilanthes lanosa</i> (Michx.) D.C. Eat.	unknown	1
<i>Cystopteris bulbifera</i> (L.) Bernh.	unknown	1
<i>Cystopteris fragilis</i> (L.) Bernh.	prunasin	1, 29, 56
<i>Davallia braziliensis</i> Hook. <sup>a</sup>	unknown	26
<i>Davallia fijeensis</i> Hook. <sup>a</sup>	vicianin	56
<i>Dryopteris filix-max</i> (L.) Schott.	unknown	4, 5
<i>Pteridium aquilinum</i> (L.) Kuhn	prunasin	57, 58
Ranunculaceae		
<i>Aquilegia canadensis</i> L.	unknown	1
<i>Aquilegia vulgaris</i> L. <sup>a</sup>	unknown	26
<i>Isopyrum biternatum</i> (Raf.) T. & G.	unknown	1
<i>Myosurus minimus</i> L.	unknown	16
<i>Ranunculus repens</i> L.	unknown	4, 5
<i>Thalictrum aquilegifolium</i> L. <sup>a</sup>	proteacin, triglochinin methyl ester, <i>p</i> -(glucosyloxy) mandelonitrile	26, 59, 60
<i>Thalictrum dasycarpum</i> Fisch. and All.	unknown	16
Resedaceae		
<i>Reseda alba</i> L. <sup>a</sup>	unknown	16
Rhamnaceae		
<i>Rhamnus frangula</i> L. <sup>a</sup>	unknown	16, 26
Rosaceae		
<i>Amelanchier arborea</i> (Michx. F.) Fern.	unknown	6
<i>Aronia arbutifolia</i> (L.) Ell.	unknown	16
<i>Cotoneaster</i> spp. <sup>a</sup>	prunasin and amygdalin	61
<i>Eriobotrya japonica</i> Lindl. <sup>a</sup>	amygdalin	16, 26
<i>Malus angustifolia</i> (Ait.) Michx.	unknown	16
<i>Photinia serrulata</i> Lindl. <sup>a</sup>	unknown	16
<i>Photinia villosa</i> D.C. <sup>a</sup>	unknown	16
<i>Prunus armeniaca</i> L. <sup>a</sup>	prunasin and amygdalin	17
<i>Prunus caroliniana</i> (Mill.) Ait.	unknown	16
<i>Prunus cerasus</i> L.	prunasin and amygdalin	16
<i>Prunus laurocerasus</i> Lindl. <sup>a,b</sup>	prunasin and amygdalin	62, 63
<i>Prunus persica</i> (L.) Batsch. <sup>a</sup>	prunasin and amygdalin	62
<i>Prunus serotina</i> Ehrh.	prunasin	64
<i>Prunus virginiana</i> L.	unknown	1, 17
<i>Pyracantha coccinea</i> Roem. <sup>a,b</sup>	unknown	16
<i>Sorbus aucuparia</i> L.	prunasin and amygdalin	1, 9
<i>Spiraea prunifolia</i> Sieb. & Zucc. <sup>a,b</sup>	unknown	16
<i>Spiraea japonica</i> L.f. <sup>a,b</sup>	unknown	16
Sapindaceae		
<i>Cardiospermum halicacabum</i> L.	cyanolipids and an unknown glycoside	65, 66
<i>Koeleruteria paniculata</i> Laxm. <sup>a</sup>	cyanolipids	68
<i>Sapindus drummondii</i> H. & A.	cyanolipids	66, 67
<i>Ungnadia speciosa</i> Endl.	cyanolipids and two unknown glycosides	5, 6, 69
<i>Urvillea ulmacea</i> HBK.	cyanolipids	70
Solanaceae		
<i>Datura stramonium</i> L.	unknown	16
<i>Lycium halimifolium</i> Mill. <sup>a,b</sup>	unknown	6
<i>Solanum nigrum</i> L. <sup>b</sup>	unknown	16
<i>Solanum melongena</i> <sup>a</sup>	unknown	72

Taxaceae		
<i>Taxus cuspidata</i> Sieb. & Zucc. <sup>a</sup>	taxiphyllin	6, 71
Turneraceae		
<i>Turnera diffusa</i> Willd.	unknown	55, this study
Typhaceae		
<i>Typha angustifolia</i> L.	unknown	16

<sup>a</sup>=cultivated

<sup>b</sup>=introduced

<sup>c</sup>=*Sorghum vulgare* and *Sorghum sudanense* are considered conspecific with or synonymous to *Sorghum bicolor*.

to respond to stress conditions by increased synthesis of these compounds; *Sorghum halepense* is known to be especially poisonous to livestock after a light frost or during drought (17). Often some plant parts are cyanogenic whereas others may be completely devoid of any cyanogens. Because of these variations, it is clear that positive records are more important than negative reports. Most workers, with the exception of Gibbs (16) and Seigler (1, 18), have examined materials from continents other than North America and the occurrence of cyanide-producing materials should be confirmed in material from this continent. A tabulation of plants which have been reported as cyanogenic or have been found so in our laboratory (as indicated by the sodium picrate method) is given below (Table 1). This is not a complete list and, no doubt, additions will be made. Several species, as suggested above, should probably be deleted if the presence of cyanide cannot be confirmed. In most cases, the reference cited represents the most complete chemical work on characterized compounds. It usually represents the first record in plants with uncharacterized cyanogens.

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