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

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

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

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

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

Taxaceae		
Taxus cuspidata Sieb. & Zucc.[a]	taxiphyllin	6, 71
Turneraceae		
Turnera diffusa Willd.	unknown	55, this study
Typhaceae		
Typha angustifolia L.	unknown	16

[a]=cultivated
[b]=introduced
[c]=*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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