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Nature of Ergastic Substances in Some Fabaceae Seeds

[1]M. Idu and [2]H.I. Onyibe
[1]Department of Botany, University of Benin, P.M.B. 1154, Benin City, Nigeria
[2]Department of Botany, Ambrose Ali University, P.M.B. 14, Ekpoma, Nigeria

Abstract: The ergastic substances of 93 angiospermous seed samples belonging to the family Fabaceae have been investigated. Forty four and 86 of the samples indicated positive for alkaloid and fats and oil respectively while 34 samples indicated the presence of protein and tannins. The morphological characteristics of starch grains i.e., size, shape, helium striation, percentage of different types and their frequency are given. Of the 93 seed samples 27 are found to contain starch grain. However, the starch grains are restricted mainly to the herbaceous habit. In general arborescent taxa either lack starch grains or such grains are of sparing occurrence.

Key words: Ergastic substances, Fabaceae, seeds

INTRODUCTION

The ergastic substances are secondary products of plant metabolism, which might have been formed at certain stages of metabolic process and are retained when the taxon in question underwent further evolution (Erdtman, 1956).

Since seed is the storage organ of ergastic materials such as alevrone grains and starch grains and these stored materials are of taxonomic value, protein bodies, alkaloids and oil and fat bodies are of limited systematic value. However, the shape, size and percentages of different types of starch grains are of great systematic value as demonstrated by Tatteoka (1955 and 1962) in the family Poaceae. Harz (1880) was the pioneer in the recognition of the taxonomic value of starch grains. Hackel (1896) and Reichert (1913) used the starch grain characteristics in the delimitation of genera and species in the family Poaceae.

A comparative study of the structure of starch grains and the type of striations is of great significance in determining the identity of taxa, especially when starch is used as an adulterant in commercial flour. Attempts have been made by different workers at elucidating the chemical composition of plants belonging to different families (Nwachukwu and Edeoga, 2006) and data from such investigation suggest that thorough survey of different taxonomic groups might give results of taxonomic significance as earlier expressed by Hilditch (1952).

The present research is a part of ongoing project on the nature of ergastic substances in angiospermic seeds. The earlier contributions on this project are Gill and Ayodele (1986), Gill *et al*. (1980, 1984 and 1991), Omoigui and Gill (1988), Gill and Abili (1989), Idu and Gill (1997 and 1998) and Gill and Idu (2001). The results of the survey of 93 Fabaceae seeds for ergastic substances are reported here.

MATERIALS AND METHODS

This study was carried out in 2006. Seeds of 63 species were obtained from the Botanischer Garten and Botanischer Museum, Berlin-Dahlem Königin-Luise Strasse, Germany through seed

Corresponding Author: M. Idu, Department of Botany, University of Benin, P.M.B. 1154, Benin City, Nigeria

exchange programme, while seeds of 30 species were collected from the northern part of Nigeria. Vouchers of the seeds examined are kept in the Botany Department of the University of Benin, Benin City, Nigeria. Chemical tests of various ergastic substances were carried out following methods used by Idu and Gill (1998).

RESULTS AND DISCUSSION

The results of the taxa studied for their ergastic substances according to their life forms (trees, herbs and shrubs) have been summarized in Table 1-3 respectively. The morphological characters of starch grain of 27 species of Fabaceae are summarized in Table 4-6 according to their life forms.

For about four decades now, much attention has been focused on the comparative studies of basic molecules in relation to taxonomic problems. De-Wet and Scott (1965) are of the opinion that essential oil can be used as a taxonomic criterion and according to them, chemical characters are often found to be more reliable than the gross morphology in determining the taxonomic affinities.

Several researchers, Bate-Smith and Metcalfe (1959), Gill *et al*. (1980, 1984 and 1991), Gill and Ayodele (1986) and Idu and Gill (1997 and 1998) have established a relationship between life form and the nature of ergastic substances. From the present survey of 93 seed samples of Fabaceae, 46 taxa were herbaceous and 47 ligneous. Of these, alkaloid was found to be present in 44 taxa; 25 taxa are herbaceous and 19 ligneous. Gill and Abili (1989) reported the occurrence of alkaloids in 121 of the 200 angiospermic seeds they investigated and Gill *et al*. (1991) observed the occurrence of alkaloids in 146 taxa of the 364 seeds sample tested. They also reported the absence of alkaloids in the seeds of members of the family Agavaceae, Caricaceae, Cornaceae and Limnatheceae.

Fats and Oil have been observed in all the presently investigated taxa except the following species *Acacia albida*, *A. scorpiodes*, *C. obtusifolia*, *Crotalaria ochroleuca*, *Daniella oliverii*, *Kennedya rubicunda* and *Tephiosia purpurea*. Out of the 86 taxa reported here to contain Fats and Oil, 44 are

Table 1: Nature of ergastic substances in taxa studied

Taxon	Life form	Alkaloid	Fats and Oil	Inulin	Protein	Starch	Tannin
Acacia albida Del.	T*	-	-	+	+	+	-
Acacia scorpioides L.	T	-	+	+	+	-	+
Afzelia africana SM.	T	+	-	+	+	-	+
Albizia lebbeck (Linn.) Benth.	T	+	+	+	+	+	-
Bauhina refescens Lam.	T	-	+	+	+	-	-
Brachystegia eurycoma Harms.	T	-	+	+	+	-	+
Cassia absus L.	T	-	+	+	+	-	+
Cassia obtusifolia L.	T	-	-	+	+	-	+
Cassia siamea Lam.	T	-	+	-	+	-	-
Cassia sieberiana DC.	T	-	+	+	+	-	+
Daniella oliverii (Rolfe) Hutch and Dalz. Ex.	T	-	-	+	+	-	+
Datarium microcarpum Guill and per	T	+	+	+	+	+	-
Delonix regia (Boj.) Rafin.	T	+	+	+	+	-	-
Dichrostachys cinerea (L.) Wight and AM.	T	-	+	-	+	-	+
Millettia thonningii L.	T	+	+	-	+	-	+
Neptunia oleracea Lour.	T	+	+	-	+	-	-
Parkia clappertoniana Keay.	T	-	+	+	+	-	-
Pentaclethra macrophylla Benth.	T	+	+	+	+	-	+
Pithecellobium latifollum (L.) Benth.	T	-	+	+	+	-	-
Prosopis africanum Guill and perr.	T	-	+	+	+	-	-
Sesbania bispinosa (Jacq.) W. F. Wight.	T	-	+	-	+	-	-
Tamarindus indica L.	T	-	+	+	+	-	-
Tephrosia purpurea L.	T	+	-	+	+	-	+
Tetrapleura tetraptera (Schum and Taub.)	T	-	+	+	+	-	+

* T = Tree; + = Present; - = Absent

Table 2: Nature of ergastic substances in taxa studied

Taxon	Life form	Alkaloid	Fats and oil	Inulin	Protein	Starch	Tannin
Amorpha fruticosa L.	H*	+	+	+	+	-	+
Anthyllis vulneraria L.	H	+	+	+	+	-	+
Arachis hypogeae L.	H	+	+	+	+	+	-
Astragalus cicer L.	H	+	+	+	+	-	+
Astragalus glycyphyllos L.	H	-	+	+	-	-	-
Astragalus hamosus L.	H	-	+	+	+	-	-
Bituminaria bituminosa (L.) Stirton.	H	+	+	+	+	-	-
Cicer arietinum L.	H	+	+	+	+	+	-
Crotalaria ochroleuca G. Don.	H	-	-	+	+	+	+
Dorycnium pentaphyllum Scop.	H	+	+	+	+	-	-
Galega officinalis L.	H	-	+	+	+	-	-
Glycine max (L.) Merr.	H	+	+	+	+	-	-
Hedysarum alpinum L.	H	-	+	+	+	-	+
Hippocrepis emeroides	H	+	+	+	+	-	+
Hippocrepis emeroides (Boiss and Spruner.) Lassen.	H	+	+	+	+	-	+
Hippocrepis emerus (L.) Lassen.	H	+	+	+	+	-	+
Hymenocarpus circinnatus (L.) Savi.	H	-	+	+	+	-	+
Kennedya rubicunda (Schneev.) Vent.	H	-	-	+	+	+	-
Lablab purpureus (L.) Sweet.	H	-	+	+	+	+	+
Lathyrus latifolius L.	H	+	+	+	+	+	+
Lathyrus pratensis L.	H	-	+	+	+	+	+
Lathyrus sylvestris L.	H	-	+	+	+	+	-
Lathyrus venetus (Miller) Wohlf.	H	-	+	+	+	+	-
Lathyrus vernus (L.) Bernh.	H	+	+	+	+	+	-
Melilotus albus Medikus.	H	+	+	+	+	-	+
Melilotus altissimus Thuill.	H	+	+	+	+	-	+
Melilotus indicus (L.) All.	H	-	+	+	+	+	+
Melilotus officinalis (L.) Lam.	H	+	+	+	+	+	-
Onobrychis viciifolia Scop.	H	+	+	+	+	+	-
Ononis spinosa L. subsp. maritima (Dumort) P. Fourn.	H	+	+	+	+	-	-
Petteria ramentacea (Sieber) C. Fresl.	H	+	+	+	+	-	-
Phaseolus lunatus L.	H	+	+	+	+	+	+
Phaseolus vulgaris L.	H	+	+	+	+	+	-
Psoralea onobrychis Nutt.	H	+	+	+	+	-	+
Securigera parviflora (Desv) Lassen.	H	-	+	+	+	-	-
Securigera varia (L.) Lassen.	H	-	+	+	+	-	+
Spartium junceum L.	H	-	+	+	+	-	+
Stizolobium decringianum L.	H	+	+	-	+	+	+
Trifolium arvense L.	H	-	+	+	+	-	-
Trifolium hirtum All.	H	-	+	+	+	-	-
Trifolium infamia-ponertii Greuter.	H	-	+	+	+	-	-
Trifolium pannonicum Jacq.	H	-	+	+	+	-	-
Trifolium pignantii Fauche and Chaub.	H	-	+	+	+	-	-
Trifolium pratense L.	H	-	+	+	+	+	-
Vigna mungo L.	H	+	+	+	+	+	+
Vigna radiata L.	H	+	+	+	+	+	+
Vigna unguiculata (L.) Walp.	H	+	+	+	+	-	-
Voandzeia subterranea (L.) Thou.	H	-	+	+	+	-	-

* H = Herb; + = Present; - = Absent

herbaceous and 42 are ligneous. Gill and Abili (1989) in their survey of ergastic substances of 200 angiospermic seeds reported the occurrence of Fats and Oil in all the taxa except *Pertya sinensis* (Asteraceae).

De-Wet and Scott (1965) are of the opinion that essential oils can be used as a taxonomic criterion and according to the chemical characters are often found to be more reliable than the gross morphology in determining the taxonomic affinities.

Table 3: Nature of ergastic substances in taxa studied

Taxon	Life Form	Alkaloid	Fats and Oil	Inulin	Protein	Starch	Tannin
Cajanus cajan (L.) Mill sp.	S*	+	+	+	+	-	-
Calliandra portoricensis (Jack) Benth.	S	-	+	+	+	-	-
Canavalia ensiformis (L.) DC.	S	-	+	+	+	-	-
Cassia occidentalis Linn.	S	-	+	+	+	-	-
Ceratonia chilensis Molina.	S	+	+	+	+	-	-
Cercis siliquastrum L.	S	-	+	+	-	-	-
Colutea arborescens L. Subsp. arborescens	S	-	+	+	+	-	-
Colutea cilicica Boiss and Bal.	S	+	+	+	+	-	-
Genista microphylla DC.	S	-	+	+	+	-	-
Genista monspessulana (L.) Johnson.	S	-	+	+	+	-	-
Genista tinctoria L.	S	-	+	+	+	-	-
Lotus tetragonolobus L.	S	+	+	+	+	-	-
Lotus glaber Miller.	S	+	+	+	+	+	-
Lupinus polyhyllus Lindley.	S	+	+	+	+	+	-
Medicago carstiensis Wulfen.	S	+	+	+	+	-	-
Medicago intertexta (L.) Miller.	S	+	+	+	+	+	+
Medicago lupulina L.	S	-	+	+	+	-	-
Medicago orbicularis (L.) Bartal.	S	+	+	+	+	-	-
Medicago polymorpha L.	S	+	+	+	+	-	+
Medicago sativa L.	S	-	+	+	+	-	+
Mimosa invisa Mart.	S	-	+	+	+	-	-
Mimosa pigra L.	S	+	+	+	+	+	+
Piliostigma thanningii Schum.	S	-	+	+	+	-	-

* S = Shrub; + = Present; - = Absent

Table 4: The morphological characteristics of starch grain of some species of Fabaceae

Taxon	Life Form	Circular (%)	Irregular (%)	Triangular (%)	Reinform (%)	Oblong (%)	Hilum and Striation	Size (μm)	Type
Acacia albida Del.	T*	100	-	-	-	-	Indistinct	8.36×8.36	Simple
Albizia lebbeck (Linn.) Benth.	T	40	-	-	-	60	Indistinct	20.1×8.71	Simple
Datarium microcarpum Guill and perr.	T	100	-	-	-	-	Indistinct	46.9×26.8	Simple

* T = Tree

Table 5: The morphological characteristics of starch grain of some species of Fabaceae

Taxon	Life Form*	Circular (%)	Irregular (%)	Triangular (%)	Reinform (%)	Oblong (%)	Hilum and Striation	Size (μm)	Type
Arachis hypogeae L.	H*	100	-	-	-	-	Indistinct	6.7×6.7	Simple
Bituminaria bituminosa (L.) Stirton.	H	40	20	20	-	20	Distinct	43.55×16.75	Simple
Cicer arietinum L.	H	40	-	-	-	60	Distinct	25.0×25.0	Simple
Crotalaria ochroleuca	H	50	50	-	-	-	Indistinct	41.9×33.5	Simple and compound
Lathyrus latifolius L.	H	10	50	-	-	40	Distinct	43.55×26.8	Simple
Lathyrus pratensis L.	H	-	50	-	-	50	Distinct	30.15×20.1	Simple
Lathyrus sylvestris L.	H	-	40	-	-	60	Distinct	41.54×20.1	Simple
Lathyrus venetus (Miller) Wohlf.	H	30	20	-	-	50	Distinct	33.5×16.75	Simple
Lathyrus vernus (L.) Bernh.	H	40	-	-	-	60	Indistinct	46.9×20.1	Simple
Melilotus indica (L.) All.	H	30	30	-	-	40	Indistinct	41.53×26.1	Simple
Melilotus officinalis (L.) Lam.	H	40	20	-	-	40	Indistinct	43.55×20.1	Simple
Onobrychis viciifolia Scop.	H	10	30	-	-	60	Distinct	30.15×13.4	Simple
Phaseolus lunatus L.	H	70	-	-	-	30	Distinct	33.5×33.5	Simple
Phaseolus vulgaris L.	H	30	10	-	-	60	Distinct	41.54×27.47	Simple
Stizolobium decringianum L.	H	10	30	-	-	60	Distinct	41.9×16.8	Simple and compound
Trifolium pretense L.	H	30	70	-	-	-	Distinct	22.11×13.4	Simple
Vigna mungo L.	H	20	60	-	-	20	Distinct	41.9×16.75	Simple and compound
Vigna radiata L.	H	10	80	-	-	10	Distinct	33.5×33.5	Simple and compound
Voandzeia subterranea (L.) Thou.	H	20	40	-	-	30	Distinct	80.4×60.3	Simple

* H = Herb

Table 6: The morphological characteristics of starch grain of some species of Fabaceae

Taxon	Life Form	Circular (%)	Irregular (%)	Triangular (%)	Reinform (%)	Oblong (%)	Hilum and Striation	Size (µm)	Type
Cajanus cajan (L.) Mill Sp.	S*	40	20	-	10	30	Distinct	48.91×43.55	Simple
Lotus glaber Miller.	S	40	30	-	-	30	Distinct	33.5×26.8	Simple
Lupinus polyhyllus Lindley.	S	-	70	-	-	30	Distinct	35.5×16.76	Simple
Medicago intertexta (L.) Miller.	S	30	70	-	-	-	Distinct	35.5×20.1	Simple

* S = Shrub

Proteins have been observed in the seeds of Fabaceae investigated except in *Astragalus cicer*, *A. glycyphyllos* and *Cercis siliquastrum*. Tannins on the other hand have been recorded in 34 taxa of which 18 are herbaceous and 16 ligneous. Bete-Smith and Metcalfe (1957) demonstrated the importance of tannins as a taxonomic character and according to them, there tend to be a parallelism between the occurrence of tannins and phylogenetic status of the family in which they occur. The lack of tannins is often more marked in herbaceous than woody plants. In other words, the presence of tannins in a taxon is a primitive character and gets lost with increasing phylogenetic specialization.

Earlier, Gill and Abili (1989) reported the occurrence of starch grains in 17 out of 200 taxa they investigated. During the present study, starch grains have been recorded only in 27 taxa. It is interesting to note that 19 taxa containing starch grain are of herbaceous habit and only 8 ligneous. Also, simple starch grains have been recorded in all except *Crotalaris ochrolenca*, *Stizolobium deeringianum*, *Vigna mungo* and *V. radiata* which had compound starch grain. The shapes of starch grains in the majority of taxa investigated were circular, predominantly, followed by irregular and oblong shape grains. Gill *et al*. (1980 and 1984) also had reported the predominance of circular starch grains in Nigerian leguminous taxa. The size of starch grains in variable from the smallest (6.7×6.7 µm) in Arachis hypogeae to the largest size (80.4×60.3 µm) in *Voandzeia subterranean*.

The helium and striation were predominantly distinct. Apparently, there is no correlation between starch grains characteristics and phylogenetic position of the taxa investigated. Similar results had earlier been reported by Gill and Abili (1989) and Gill *et al*. (1991). Theoretically, compound starch grains are expected to be in herbaceous taxa, which was so during this study, while simple starch grains were found in ligneous taxa. The shape of starch grains where observed not to reflect the phylogenetic position of the taxa as circular starch grains were found more in woody taxa while irregular and other shapes of starch grains were observed among the herbaceous taxa. Therefore, the occurrence of starch grains, shape and size does not reflect the phylogenetic position of the taxa in which they are found.

Further, Gill and Ayodele (1986) and Gill *et al*. (1980, 1984 and 1991) have established a relationship between life form and the nature of ergastic substances. According to these workers, starch grains are generally associated with herbaceous habit and the results of the present investigation confirm this hypothesis. However, the relationship between the occurrence of starch grain and life form does not hold for the family Asteraceae (Omoigui and Gill, 1988; Idu and Gill, 1997, 1998). The foregoing account proves the utility of the nature of ergastic substances in the field of systematics and this has been comprehensively reviewed by Bate-Smith (1958) and Boulter *et al*. (1970).

From the foregoing discussion, it is apparent that the plant seeds showing the presence of proteins and fats and oil could be qualitatively analyzed and this needs further investigation. Those showing suitable quantities of fat and oil and proteins palatable for human consumption could be commercially exploited. The taxa, which gave positive test for alkaloids and tannins, need further investigation for possible exploitation in the pharmaceutical and leather industries.

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