Review on the Phyto-constituents in Selected Ornamentals belonging to Bignoniaceae.

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Abstract**:** Many medicinal plants are close to extinction due to their extensive use and over exploitation and or due to the habitat destruction. As a result of severe urbanization and population explosion the topographic conditions have begun to vary. Interest in growing plant species that are economic, ornamental as well as medicinal have on the contrary increased. Many members belonging to plant family Bignoniaceae has been known since ethnic times to being capable to cure a number of aliments. Keeping these ethnobotanical usages of the member of this plant family a comparative analysis was done inorder to find out the similarities and differences that are seen in the genus levels and the plant the leaves and flowers of Bignoniaceae. The present review is based on the GCMS based review on the phytochemicals found to be present in the leaves and flowers of three of the common ornamentals namely *Cresentia cujete* Linn., *Tecoma stans* L. (Juss.) ex. Kunth., *Kigelia africana* (Lam.) Benth. and *Jacaranda mimosifolia* D. Don are the those important parts without which the existence and propagation source won't be there respectively.

Keywords**: Bignoniaceae, Cresentia, Tecoma, Kigelia, Jacaranda, Cresentia GC-MS, leaves, flowers.**

I. INTRODUCTION

Bignoniaceae is the trumpet creeper or catalpa family with 110 genera and more than about 800 species of trees, shrubs and lianas. The members of this family constitute the tropical forest in the Indo-Malayan region. Plants predominantly have compound leaves, zygomorphic flowers, paired anthers, numerous ovules, silique like woody fruit capsule as well as winged and non endospermic seeds. Among the useful common ornamentals are the members of *Spathodea campanulata, Cresentia cujete, Kigelia africana, Campsis radicans, Bignonia capreolata, Dolichandra unquis-cati, Tabebuia, Jacaranda, Chilopsis linearis, Tecoma capensis,* and many more. Plants like *Catalpa bignonioides, Millingtonia, Oroxylum* are used as timber source whereas, *Cybistax* are used as dye [1, 2]. The ethnomedicinal scientific review shows that even though it is a small family yet it is a repository to many pharmacologically bioactive molecues (Rahmatullah et al, 2010). The present review paper is a compilation of the resukts obtained based on the GC MS analysis for four of the ornamental plants of Bignoniaceae. The attempt was to find out how close the genus's are with respect to the phytochemical based studies already done for the leaves and flowers of four common ornamental flowering and medicinal plants (Fig. 1, 2).

II. COMMON FEATURES OF BIGNONIACEAE MEMBERS

1. Habit: Trees, Shrubs, lianas, rarely herbs.
2. Roots: Taproot system, deep and well branched.
3. Stem: Hard, woody and branched; in climbers and twinners rootlets or tendrils are seen.
4. Leaves: Pinnately compound, opposite, decussate, exstipulate, terminal leaflets modifies to tendrils or adhesive discs.
5. Flowers: Bisexual, Bracteate, bracteolate, hypogynous, irregular and complete.
6. Calyx: 5 sepals, gamopetalous, lobed or valvate.
7. Androecium: 4 stamens, didynamous, epipetalous, posterior, staminode, bilobed anthers, disc present.
8. Gynoecium: 2 carpels, syncarpous ovary with 2 locules, ovary superior having axile placentation, ovules many in number, terminal style and bifid stigma.
9. Pollination: Entomophilous
10. Seeds: Non endospermic, flattened and winged.
11. Fruits: Capsule having two septa or sometimes berry.

1. Cresentia (https://www.gardensonline.com.au/gardenshed/plantfinder/show_4070.aspx); 2. Tecoma (http://uforest.org/Species/T/Tecoma_stans.php), 3. Kigelia (http://hasbrouck.asu.edu/neotrop/plantae/imagelib/imgdetails.php?imgid=183634), 4. Jacaranda (https://www.kalliergeia.com/en/jacaranda-mimosifolia-description-care-and-uses/).

Figure 1: Leaves of *Cresentia cujete* Linn., *Tecoma stans* L. (Juss.) ex. Kunth., *Kigelia africana* (Lam.) Benth. and *Jacaranda mimosifolia* D.Don

1. Cresentia(https://www.backyardnature.net/yucatan/calabash.htm), 2. Tecoma (http://www.levypreserve.org/Plant-Listings/Tecoma-stans), 3. Kigelia (http://tropical.theferns.info/viewtropical.php?id=Kigelia+africana), 4. Jacaranda (https://www.pinterest.com/pin/510947520196157046/).

Figure 2: Flowers of *Cresentia cujete* Linn., *Tecoma stans* L. (Juss.) ex. Kunth., *Kigelia africana* (Lam.) Benth. and *Jacaranda mimosifolia* D.Don.

III. GC-MS ANALYSIS

The GC analytical method was pioneered by Martin and Synge 1941, who suggested the use of gas and liquid partition chromatograms for analysis purpose. A refined separation of volatile substances on a column having permanent gas flowing over a gel impregnated with a non volatile solvent for more efficient separation and less time consuming. The concept of Martin became a reality in 1951 when A.T. James his co-worker published a paper the first gas chromatograph demonstrating the technique by quantifying and determining 12 components in a fatty acid mixture [5]. Gas Chromatography/Mass Spectrometry (GC/MS) instrument separates chemical mixtures and identifies the compounds separated at various molecular levels. It is a most accurate method for analyzing environmental samples. The principle of GC is that if a given mixture is subjected to heat all the individual components are separated components get carried in the heated gas which passes through a column having inert gas like Helium. The vapours of the heated mixture get cooled and then passed to the mass spectrometer which identifies the compounds on the bases of their mass with the help of a ÒlibraryÓ having mass spectra of known compounds. The only limitation for this analysis is that it is time consuming while it is the best way to separate the volatile components in a given mixture. The spectrometer constantly monitors the eicinerator emissions, in place of a standard method that collects samples from a gas stream[4] (Fig.3).

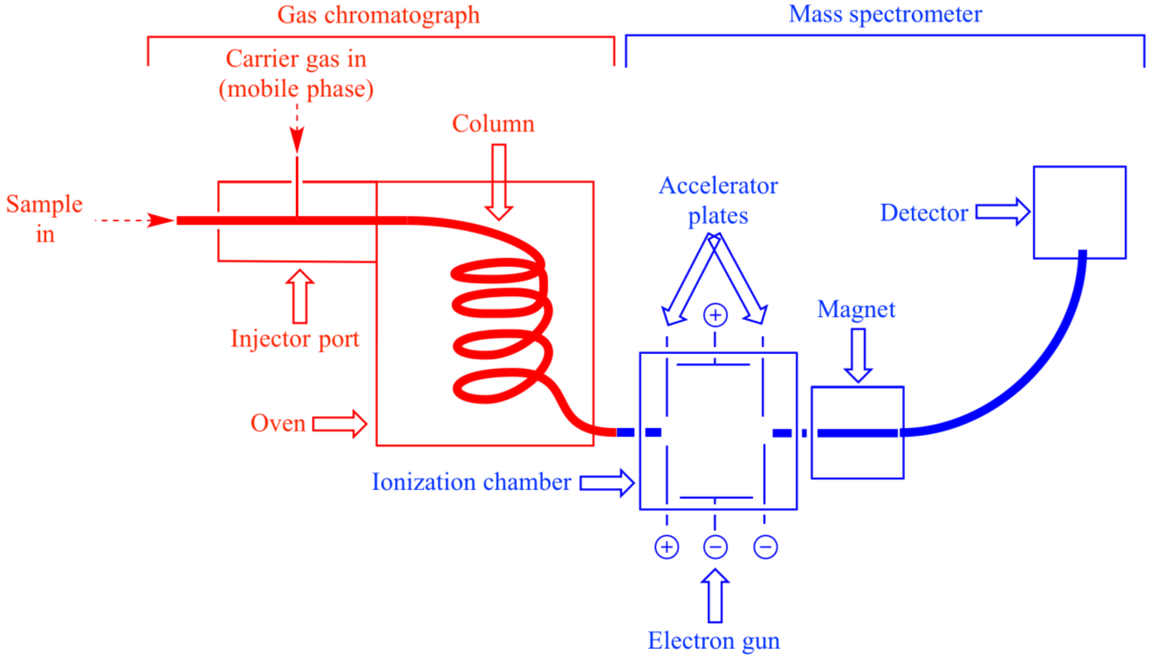

Figure 3: Pictorial representation of GC MS analysis. [Retrived -http://www.chem.ucla.edu/~harding/IGOC/G/gc_ms.html]

IV. GC-MS REVIEW OF SELECTED BIGNONIACEAE ORNAMENTAL PLANTS.

Plant extracts are a mixture of phytochemicals such as primary and secondary metabolites in varying concentrations. Every metabolite has a specific role to play in the physiological activities of the plants as well as for biological activity if consumed by humans. Bignoniaceae is family with many known phytochemical groups which could be identified using the GCMS studies. The table below shows the reviewed results of GC MS studies of leaves and flowers with respective percentage peak areas covered by each compound for selected ornamental member *Cresentia cujete* Linn., *Tecoma stans* L. (Juss.) ex. Kunth., *Kigelia africana* (Lam.) Benth. and *Jacaranda mimosifolia* D. Don belonging Bignoniaceae family (14, Saika et al, 2010; Goto et al, 2005; Komiya et al, 1999; Silva et al, 2014; Yeo et al, 1997; Tan et al, 2008; Ricke et al, 2003; Knothe et al, 2005 and Virendra et al, 2013).

Table 4.1 Phytochemistry of Leaves of Some Common Ornamentals of Bignoniaceae.

Sr.	Phytochemicals (Leaves)	*Cresentia*	*Tecoma*	*Kigelia*	*Jacaranda*
1	Hexadecane	0.5%	-	-	0.9%
2	1,1-Dimethyl-3-hexyl-cyclopentane	0.7%	-	-	
3	4-Methyl-2-heptanone	0.3%	-	-	
4	Trans-Pinane	8.3%	-	-	
5	Selina-4(15),6-diene	1.2%	-	-	
6	Allo-Aromadendrane	1.0%	-	-	
7	Globulol	0.4%	-	-	4.2%
8	Neophytadiene	2.3%	-	-	-
9	Hexadecanal	4.6%	-	-	-
10	Kaur-16-ene	33.6%	-	-	-
11	Phytol	29.4%	-	110mg	-
12	(Z)-9,17-Octadecadienal	3.4%	-	-	-
13	Monoterpene hydrocarbon	8.3%	-	-	-
14	Sesquiterpene hydrocarbon	2.2%	-	-	-
15	Oxygenated sesquiterpenes	0.4%	-	-	-

16	Diterpenes	75.8%	-	-	-
17	Hydrocarbon	1.5%	-	-	-
18	Fatty acids	10%	-	66.9%	-
19	2,3-dihydro-4,4-dimethylindol-4-ol-2-one	-	+	-	-
20	Indole-2,3-dione-1-Methyl,3-oxime	-	+	-	-
21	Benzoic acid amide	-	+	-	-
22	Boshniakine	-	+	-	-
23	β- Hydroxyskitanthine	-	+	-	-
24	Tecomine	-	+	-	-
25	4,4,dimethyl-1-Hydroxy-2-cyclo-pentene	-	+	-	-
26	Hentriacontane	-	-	55%	-
27	β- Tocopherol	-	-	45mg	-
28	3-Hydro-4,8-Phytene	-	-	40mg	-
29	1,3,3,5,6,6-Hexamethylcyclohexa-1,4-diene	-	-	90mg	-
30	(9Z,12Z)-Methyloctadeca-9,12-dienoate	-	-	120mg	-
31	Alkane Hydrocarbon	-	-	27%	-
32	Alcohol	-	-	6.02%	-
33	1-Octen-3-ol	-	-	-	10.8%
34	E,E-2,4-Heptadienal	-	-	-	1.1%
35	Limonene	-	-	-	3.4%
36	(E)-2-Octenal	-	-	-	0.8%
37	β- Linalol	-	-	-	5.5%
38	n-Nonanal	-	-	-	0.5%
39	Trans-cis-2,6-Nonadienal	-	-	-	0.3%
40	Methyl Phenylaceate	-	-	-	9.9%
41	Methyl salicylate	-	-	-	3.2%
42	β- Cyclocitral	-	-	-	0.4%
43	Ethyl phenylceate	-	-	-	0.8%
44	(E)-2-Decenal	-	-	-	1.1%
45	Dihydro-edulan I	-	-	-	Trace
46	1,1,6-Trimethyl-1,2,dihydroaphthalene	-	-	-	0.7%
47	α- Damascenone	-	-	-	1%
48	Trans-Geranylacetate	-	-	-	0.8%
49	α- Caryophyllene	-	-	-	Trace
50	α- Inone	-	-	-	1.1%
51	n-dodecanoic acid	-	-	-	Trace
52	Myristic acid	-	-	-	3%
53	Octadecane	-	-	-	0.9%
54	Hexahydrofarnesylacetone	-	-	-	0.4%
55	Benzyl salicylate	-	-	-	0.2%
56	Methyl hexadecannoate	-	-	-	3%
57	Ethyl hexadecannoate	-	-	-	0.3%
58	Eicosane	-	-	-	0.3%
59	Methyl Linolenate	-	-	-	26.7%
60	Ethyl Linoleate	-	-	-	4.2%
61	Bis(2-ethylhexyl)phthalate	-	-	-	2.2%
62	n-Heptacosane	-	-	-	0.1%
63	n-Nonacosane	-	-	-	1.3%
64	Palmitic acid	-	-	-	4.7%
65	2-Ethylhexyl-octadecyl ester	-	-	3.05%	-
66	Hexyloctyl ester	-	-	1.42%	-
67	Tetradecanoic acid	-	-	0.29%	-
68	Methyl-12-Methyl tetradecanoate	-	-	Trace	-

Table 4.2 Phytochemistry of Flowers of Some Common Ornamentals of Bignoniaceae.

Sr.	Phytochemicals (Flowers)	*Cresentia*	*Tecoma*	*Kigelia*	*Jacaranda*
1	Dimethyl disulfide	+	-	-	-
2	Trisulfide	+	-	-	-
3	Tetrasulfide	+	-	-	-
4	2,4-dithiapentane	+	-	-	-
5	2,3,5-trihiahexane	+	-	-	-
6	2,3,4,6-Tetrathiaheptane	+	-	-	-
7	2,3,5,7-tetrathiaoctane	+	-	-	-
8	2,3,5,6,8-pentathianonane	+	-	-	-
9	Isopropyl isothiocyanate	+	-	-	-
10	s-Butyl isothiocynate	+	-	-	-
11	Irregular terpenes	-	-	+	-
12	3-Hydroxyl-2-butanone	-	-	+	-
13	Hexylacetate(Z)-3-Hexnylacetate	-	-	+	-
14	(Z)-3-Hexen(E,Z)-1,3,5-undecatriene	-	-	+	-
15	Pentanoic acid	-	-	+	-
16	Trimethyl trisulphide	-	-	+	-
17	Dimethyl sulfoxide	-	-	+	-
18	Propane1,1,3-Triethoxy	-	0.72%	-	-
19	5-Hydroxymethylfurfural	-	1.34%	-	-
20	1-Hydroxy-4,3-dimethyl-bicycl	-	10.48%	-	-
21	9-Oxabicyclo[3.3.1]Nonan-2-one	-	3.25%	-	-
22	1,10-Decanediol	-	2.1%	-	-
23	1,2,3,4,7,7a-Hexahydro-2,4,7-Trimethyl-6H	-	1.98%	-	-
24	Tropane, 2-Acetyl-2,3-Methylene	-	0.95%	-	-
25	5-Undecanol, 2-Methyl	-	3.84%	-	-
26	6-Dodecanol	-	8.89%	-	-
27	Silacyclopentane, 1,1-Dimethyl	-	3.98%	-	-
28	Cyclobutanecarboxylic acid Decyl ester	-	10.06%	-	-
29	Propanamide,3-(1-Piperazinyl)-	-	0.57%	-	-
30	Tetradecanoic acid	-	0.57%	-	-
31	Tetradecanoic acid, Ethyl ester	-	0.55%	-	-
32	2(4h)-Benzofuranone, 5,6,7-ater	-	0.80%	-	-
33	L-(+)-Ascorbic acid, 2,6-Didexadecanoate	-	16.73%	-	-
34	Hexadecanoic acid, Ethyl ester	-	5.8%	-	-
35	N-Nonadecanol	-	0.41%	-	-
36	9,12-Octadecadienoic acid(Z,Z)	-	7.82%	-	-
37	Ethyl (9Z,12Z)-9,12-Octadecadien	-	3.87%	-	-
38	Octadecanoic acid	-	4.5%	-	-
39	N-propyl 9,12-Octadecadienoate	-	4.47%	-	-
40	9,12,15-Octadecatrienoic acid, ethyl ester	-	1.39%	-	-
41	Octadecanoic acid, ethyl ester	-	1.98%	-	-
42	Hexatriacontane	-	1.61%	-	-
43	β- Linalool	-	-	-	1.4%
44	n-Decanoic acid	-	-	-	7.9%
45	Germacrene D	-	-	-	1.19%
46	n-Dodecanoic acid	-	-	-	17.48%
47	α- Farnesene	-	-	-	0.3%
48	n-Hexadecane	-	-	-	0.28%
49	n-Tetradecanoic acid	-	-	-	15.59%
50	Octadecane	-	-	-	0.54%
51	Hexahydrofarnesyl acetone	-	-	-	8.2%
52	Farnesyl acetone	-	-	-	0.78%
53	Methyl hexadecanoate	-	-	-	1.65%
54	n-Hexadecanoic acid	-	-	-	10.98%
55	Methyl linoleate	-	-	-	3.81%
56	α- Linolenic acid	-	-	-	0.23%
57	n-Pentacosane	-	-	-	2.06%
58	n-Hexacosane	-	-	-	0.23%
59	n-Octacosane	-	-	-	0.79%
60	n-Nonacosane	-	-	-	7.71%
61	Aliphatic HC	--	-	-	11.61%
62	Oxygenated monoterpenes	-	-	-	1.4%

63	Sesquiterpene hydrocarbon	-	-	-	1.49%
64	Terpene related compounds	-	-	-	8.98%
65	Fatty acids	-	-	-	52.18%
66	Fatty acid ester	-	-	-	5.7%

V. REVIEWS AND DISCUSSION

The review shows there are various types of metabolites that play their specific roles with respect to plant's own physiological state and the ones who are consuming them. There are various properties of each components reviewed in leaves and flowers of different genus belonging to Bignoniaceae (Table: 4.1, 4.2). Emerging technology is using many plant based compounds for the purpose of developing newer efficient drugs. The properties of most of the compounds are pharmacologically studies inorder to understand their bioactive nature. On comparative reviewing of the GC MS study for the leaves (Table 4.1, 4.2) it was observed that in genus *Cresentia* and *Jacaranda* some similar compounds were seen in varying quantities for metabolites named Hexadecane (0.5% and 0.9%) and Globulol (0.4% and 4.2%). These two compounds Hexadecane and Globulol are having urea inclusion compound and antimicrobial property respectively (14, Yeo et al, 1997; Tan et al, 2008). Similarity was also seen with the presence of two more compounds namely Phytol (29.4% and 110mg) and Fatty acids (10% and 66.9%) in *Cresentia* and *Kigelia*. Phytol had the potentiality to resist bacterial and fungal growth, induce PPARα and PCD in human lymphoid leukemia Molt 4B cells, reduce cytokinin production, regulate gene expression for lipid metabolism, oxidative stress reduction and antitubercular activity (Saika et al, 2010; Komiya et al, 1999; Silvia, 2014); while Fatty acids had lubricating and antimicrobial properties (Ricke S.C. 2003; Knothe G. et. al. 2005). Based on this it can be said *Kigelia* and *Jacaranda* have higher and more potential as compared to *Cresentia*. It also can be said that there are some correlation to the genetic levels of the three genus's except *Tecoma*. However, it would be inappropriate to say that these mentioned for compounds are determining the potentials of the genus as there are many more compounds that could probably have more influence on their pharmacological efficiencies.

Observing the reviewed data for the flowers of four genus's of Bignoniaceae ornamental plants showed unpleasant floral odor due to sulphurous compounds in them attracting bats coordinating the phenomenon of pollination. There can be no such correlation in the inter-genus level as it was seen in the leaves. Each flower showed a vast variation in its phytochemistry, probable reason could possibly be due to the color variations, flowering time and henceforth more importantly to attract the pollinator. Cresentia and Kigelia flowers showed very high levels of sulphur based compounds (Virendra ,2013; Petterson et al, 2004); Tecoma showed the presence of L-(+)Ascorbic acid, 2,6-Didexadeconate (16.73%) and 1-Hydroxyl-4,3-dimethyl-bicycl(10%) with the maximum % peak area (Anburaj et al, 2016). Jacaranda showed the presence of n-dodecanoic acid (17.48), n-tetradecanoic acid (18.59%), n hexadecanoic acid (10.98%), Aliphatic hydrocarbon(11.61%) and fatty acids(52.18%) were among the highly active molecules in it (Mostafa et al, 2015). These bioactive molecules from the four genera that are review would be the main reasons to posses the ethno-medicinal properties in them.

VI. CONCLUSION

Bignoniaceae family member are an integral part of the folk medicines since the distant past. Four genus's of the members belonging to this family have been reviewed in this present work .It can be said that GC MS results could be correlated to the ethno-botanical properties, which can be confirmed from pharmacological aspect, for the development of replacements for synthetic medicines. The technological advancements have made the works easy for the researcher to find connecting as well as missing links between various genera's inter and intra familial levels.

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