REVIEW ARTICLE

# Distribution of flavonoids among Malvaceae family members – A review

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**Abstract**

Since ancient times, Malvaceae family plant members are distributed worldwide and have been used as a folk remedy for the treatment of skin diseases, as an antifertility agent, antiseptic, and carminative. Some compounds isolated from Malvaceae members such as flavonoids, phenolic acids, and polysaccharides are considered responsible for these activities. Although the flavonoid profiles of several Malvaceae family members are investigated, the information is scattered. To understand the chemical variability and chemotaxonomic relationship among Malvaceae family members summation of their phytochemical nature is essential. Hence, this review aims to summarize the distribution of flavonoids in species of genera namely *Abelmoschus*, *Abroma*, *Abutilon*, *Bombax*, *Duboscia*, *Gossypium*, *Hibiscus*, *Helicteres*, *Herissantia*, *Kitaibelia*, *Lavatera*, *Malva*, *Pavonia*, *Sida*, *Theobroma*, and *Thespesia*, *Urena*, In general, flavonols are represented by glycosides of quercetin, kaempferol, myricetin, herbacetin, gossypetin, and hibiscetin. However, flavonols and flavones with additional OH groups at the C-8 A ring and/or the C-5′ B ring positions are characteristic of this family, demonstrating chemotaxonomic significance.

**Key words:** Flavones, flavonoids, flavonols, glycosides, Malvaceae, phytochemicals

## INTRODUCTION

The Malvaceae is a family of flowering plants estimated to contain 243 genera with more than 4225 species. Plants belong to the genus *Sida*, *Abutilon*, *Urena*, *Pavonia*, *Kydia, Decaschistia*, *Hibiscus*, *Bombax*, *Eriodendron*, *Thespesia*, and *Cullenia* are commonly available throughout tropical countries like India. Morphological features of Malvaceae member include leaves are generally alternate, often palmately lobed or compound, and palmately veined. The margin may be entire, but when dentate, a vein ends at the tip of each tooth (malvoid teeth). Stipules are present. The stems contain mucous canals and often also mucous cavities. Hairs are a common and are most typically stellate. The flowers are commonly borne in definite or indefinite axillary inflorescences, which are often reduced to a single flower, but may also be cauliflorous, oppositifolious, or terminal. They often bear supernumerary bracts. They can be unisexual or bisexual, and are generally actinomorphic, often associated with conspicuous bracts, forming an epicalyx. They generally have five valvate sepals, most frequently basally connate, with five imbricate petals. The stamens are five to numerous, and connate at least at their bases, but often forming a tube around the pistils. The pistils are composed of two to many connate carpels. The ovary is superior, with axial placentation, with capitate or lobed stigma. The flowers have nectaries made of many tightly packed glandular hairs, usually positioned on the sepals. The fruits are most often loculicidal capsules, schizocarps or nuts.

A number of species are weeds in agriculture, including *Abutilon theophrasti* and *Modiola caroliniana*. Cotton (four species of *Gossypium*), kenaf (*Hibiscus cannabinus*), cacao (*Theobroma cacao*), kola nut (*Cola* spp.), and okra (*Abelmoschus esculentus*) are important agricultural crops. A number of species, including *Hibiscus syriacus*, *Hibiscus rosa-sinensis*, and *Alcea rosea*, are garden plants. Information involving the occurrence of flavonoids in the Malvaceae family is limited. However, flavonols and flavones with additional OH groups at the C-8 A ring and/or the C-5′ B

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ring positions are characteristic of this family, demonstrating chemotaxonomic significance. Hence, the present review focused on the distribution of flavonoids among the members of Malvaceae family.

## GENUS *ABELMOSCHUS*

*Abelmoschus moschatus* Medik is native to India. It is an aromatic, medicinally important species. It is used as an antidote for snake bites, due to its anti-spasmodic activity. It is also used as an insecticide, as an aphrodisiac and in the perfume industry. The presence of myricetin in *A. moschatus* was reported [Table 1] and its anti-hyperglycemic action was proven in streptozotocin-induced diabetic rats.[1]

*A. esculentus* (L.) Moench., known as ladies finger and bhendi or okra in India, is a flowering plant in the mallow family. It is valued for its edible green seed pods. The geographical origin of okra is disputed, with supporters of West African, Ethiopian, and South Asian origins. Different parts and different enrichment fractions of the water extracts of the related species *A. esculentus* contain phenolics and flavonoids with strong antioxidant effect.[2]

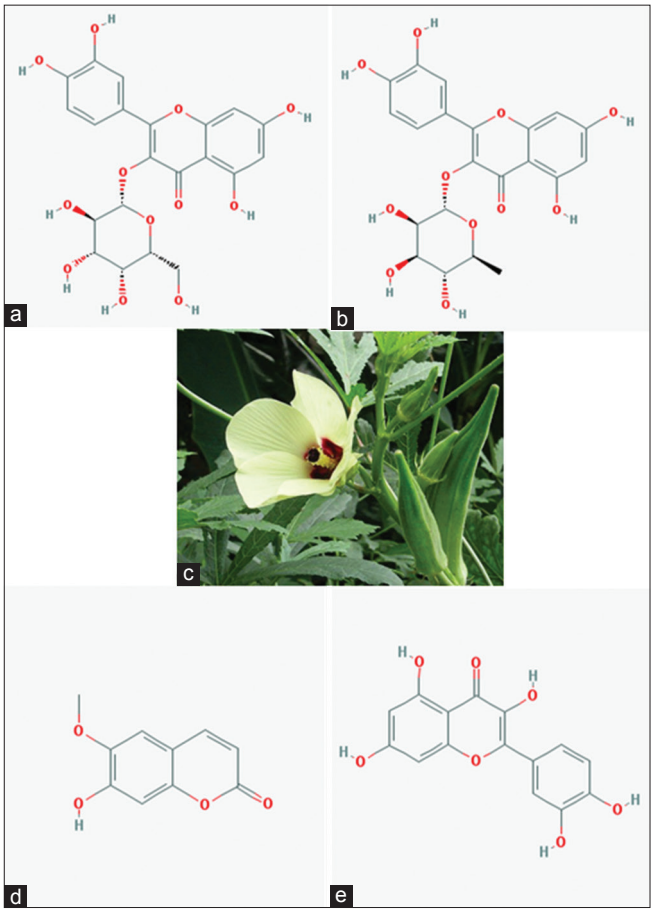


**Figure 1:** Flavonoids in *Abelmoschus esculentus* (L.) Moench, (a) Hyperoside, (b) quercetrin, (c) *A. esculentus*, (d) scopoletin, (e) quercetin

The presence of hyperoside, quercetin, scopoletin, uridine, 5, 7, 3′,4′-tetrahydroxy-4″-O-methyl flavonol-3-O-β-D-glucopyranoside and 5, 7, 3′,4′-tetrahydroxy flavonol-3-O-[β-D-glucopyranosyl-(1-6)]-β-D-glucopyranoside were reported in *A. esculentus* [Figure 1]. A new flavonol glycoside characterized as 5, 7, 3, 4-tetrahydroxy-4-O-methyl flavonol-3-O-D-glucopyranoside has been isolated from the fruit of *A. esculentus*.[3] Atawodi *et al*.[4] reported the occurrence of quercetin glucoside (quercetrin) and an unidentified flavonoid were detected in *A. esculentus* fruit [Table 1] with potent antioxidant/radical scavenging activities. A flavonoid glucuronide was identified from the related species *Abelmoschus manihot*.[5]

## GENUS *ABROMA*

*Abroma augustum* L., an evergreen shrub, is found throughout the hot and humid parts of India. Leaves and seeds of *Abroma augusta* are considered to be edible in India and New Guinea and has an all-embracing history in ayurvedic system. Leaves are used as a remedy for diabetes, inflammation, rheumatic pain of joints, uterine disorders, and headache.[6-8] High-performance liquid chromatography analysis revealed the presence of flavonoids *viz*. rutin (22.4 mg/g DW), myricetin (14.1 mg/g DW), quercetin

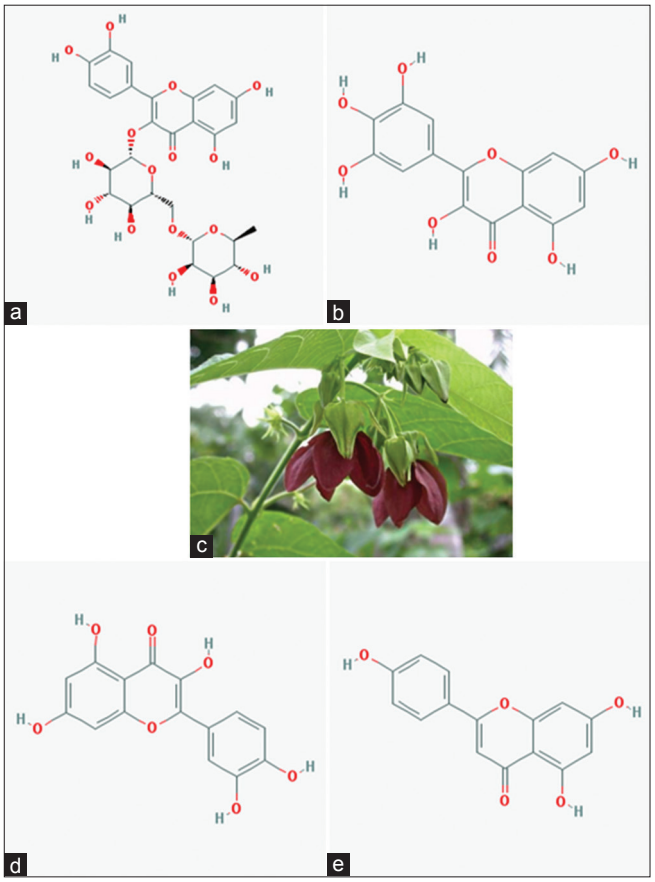


**Figure 2:** Flavonoids in *Abroma augustum* L., (a) Rutin, (b) myricetin, (c) *A. augustum*, (d) quercetin, (e) apigenin

**Table 1:** Flavonoid compounds identified in different genera of Malavaceae family

| Plant | Flavonoids | Reference |
|---|---|---|
| *A. moschatus* Medik | Myricetin | Liu *et al*., 2005[32] |
| *A. esculentus* (L.) Moench | Hyperoside, quercetin, quercetrin, scopoletin, uridine, 5, 7, 3′ ,4′ -tetrahydroxy-4′ ′ -O-methyl flavonol-3-O-β-D-glucopyranoside, 5,7,3,4-tetrahydroxy-4-O-methyl flavonol-3-O-D-glucopyranoside and 5, 7, 3′ ,4′ -tetrahydroxy flavonol -3-O-[β-D-glucopyranosyl-(1-6)]-β-D- glucopyranoside | Liao *et al*., 2012a[29] and 2012b;[30] Atawodi *et al*.[4] |
| *A. augustum* L. | Rutin, myricetin, quercetin and apigenin | Khanra *et al*., 2015[27] |
| *A. indicum* (Link) sweet | Luteolin, chrysoeriol, luteolin 7-O-β-glucopyranoside, chrysoeriol 7-O-β-glucopyranoside, apigenin 7-O-β-glucopyranoside, quercetin 3-O-β-glucopyranoside, quercetin 3-O-α-rhamnopyranosyl (1-6)-β-glucopyranoside | Matławska and Sikorska, 2002[34] |
| *A. pakistanicum* | Abutilins A and B, 5-hydroxy-4′ ,6,7,8- tetramethoxyflavone, kaempferol, luteolin and luteolin 7-O-β-D-glucopyranoside | Ali *et al*., 2010[3] |
| *A. grandiflorum* | Kaempferol 3-O-β-(6”-p-coumaroyl)- glucopyranoside, kaempferol and quercetin 3-O-β-glucopyranosides and 3-O-β-rutinosides | Sikorska and Matławska, 2008[54] |
| *A. theophrasti* | Catechin, rutin, quercetin and syriacusin A, kaempferol 3-0-ß-(6”-p-coumaroyl)-glucopyranoside, myricetin 3-O-ß-glucopyranoside, quercetin 3-0-ß-glucopyranoside, quercelin 3-0-a-rhamnopyranosyl (l-»6)-ß-g!ucopy-ranoside, kaempferol 3-0-ß-glucopyranoside, kaempferol 3-0-a-rhamnopyranosyl (l-6)-ß-glucopyranoside, quercetin 7-0-ß-glucoside, quercetin 7-0-ß-diglucoside and kaempferol 7-0-ß-diglucoside | Tian *et al*., 2014;[61] Matlawska and Sikorska, 2005[37] |
| *B. ceiba* L. | Quercetin, shamimin, rutin, vitexin, isovitexin, vicenin, isomangiferin, mangiferin, esculetin, scopoletin, fraxetin, scopolin quercetin-3-O-β-D-glucopyranoside, quercetin-3-O-β-D- glucuronopyranoside, sexangularetin-3-O-sophoroside, kaempferol-3-O-rutinoside, kaempferol-3-O-β-D-glucuronopyranoside and 7-O-methyl mangiferin | Saleem *et al*., 1999;[49] Joshi *et al*., 2013[24] |
| *D. macrocarpa* Bocq. | Dubosciasides A (6-C-β-d-apiofuranosyl-(1-4)-β -d-galactopyranosylnaringetol) and dubosciasides B (1-O-α-l-rhamnopyranosyl-(1-4)-β-d-xylopyranosyl-3,4,5-trimethoxyphenol) | Tchuendema *et al*., 2014[60] |
| *G. herbaceum* L. | Gossypin, gossypetin 8-O-rhamnoside, quercetin 7-O-glucoside, quercetin 3-O-glucoside and quercetin 3′-O-glucoside | Waage and Hedin, 1984;[64] Duraisami *et al*., 2008[15] |
| *H. sabdariffa* L. | Hibiscetin, gossypitrin, sabdaritrin, quercetin, rutin, catechin, kaempferol, luteolin, delphinidin-3-glucoside; cyanidin-3-glucoside (chrysanthenin); cyanidin-3-sambubioside, cyanidin-3, 5-diglucoside and cyanidin-3-(2G-glucosylrutinoside); delphinidin-3-sambubioside; gossypetin-8-glucoside (0.4%) and gossypetin-7-glucoside | Yamamoto and Osima, 1936;[66] Rao and Seshadri, 1942;[46] Rao and Seshadri, 1948;[48] Seshadri and Thakur, 1961;[52] Du and Francis, 1973;[14] Subramanian and Nair, 1972;[57] Khafaga *et al*., 1980;[26] Takeda and Yasui, 1985;[59] Salah *et al*., 2002;[48] Rodriguez-Medina *et al*., 2009; Beltrán-Debón *et al*., 2010;[7] Peng *et al*., 2011;[41] Ramirez-Rodrigues *et al*., 2011;[44] Herranz-Lopez *et al*., 2012;[21] Alarcón-Alonso *et al*., 2012;[2] Lin *et al*., 2012[31] |

*(Cont...)*

**Table 1: *(Cotnd...)***

| Plant | Flavonoids | Reference |
|---|---|---|
| *H. isora* L. | Isoscutellarein 4′ -methyl ether 8-O-β-o-glucuronide 6′ -n-butyl ester, isoscutellarein 4′ -methyl ether 8-O-β-o-glucuronide 2′ , 4′ -disulfate and isoscutellarein 8-O-β-D-glucuronide 2′ ,4′ -disulfate | Kamiya *et al*., 2001[25] |
| *H. tiubae* Medik. | 5-hydroxyauranetin, araneosol, calycopterin, sarothrin, kaempferol-3-O-β-d-(6′ -E-p-coumaroyl) glucopyranoside (tiliroside), kaempferol 7-O-α-l- rhamnopyranoside and 4′ ,5-dihydroxy-3,6,7,8,3′ -pentamethoxyflavone | Silva *et al*., 2005;[56] Falcão-Silva *et al*., 2009;[16] Silva *et al*., 2009[55] |
| *K. vitifolia* L. | Kaempferol 3-O-(6”-p-coumaroyl)-β-glucoside (trans-tiliroside); quercetin and kaempferol - 3-O-β-xylopyranosyl (1-2)-β-glucopyranoside (3-O-sambubioside); quercetin and kaempferol - 3-O-sambubioside-7-O-glucoside; apigenin, 7-O-sambubioside, luteolin and chrysoeriol, 7-O-xylosylglucosides also apigenin 7-O-α-rhamnopyranosyl (1-2)-β-glucopyranoside | Matlawska, 2001[33] |
| *L. trimestris* L. | Kaempferol 3-O-β-glucoside, kaempferol and quercetin 3-O-rutinosides, cis- and trans-tiliroside | Matławska *et al*., 1999;[38] Głowniak *et al*., 2005[17] |
| *L. macrophyllum* Graham | Cis-tiliroside and 4′ -methoxy-trans-tiliroside | Timmers and Urban, 2012[62] |
| *M. sylvestris* L. | Gossypin, malvidin; delphinidin; genistein; myricetin; leucoanthocyanins; cyanidin; petunidin and derivatives of apigenin, quercetin and kaempferol; hypolaetin-3-sulfate; 3-O-b-dglucopyranosyl-8-O-b-d-glucuronopyranoside; hypolaetin-4-methyl ether 8-O-b-d-glucuronopyranoside; hypolaetin-8-O-b-d-glucuronopyranoside and isoscutellarein-8-O-bd-glucuronopyranoside; malvidin 3,5-diglucoside, malvidin 3-O-glucoside; delphinidin 3-O-glucoside; malvidin 3-O-(6′ -Omalonylglucoside)-5-O-glucoside | Barros *et al*., 2010;[6] Billeter *et al*., 1991;[8] Nawwar and Buddrus, 1981;[40] Pourrat *et al*., 1990;[42] Schulz and Baranska, 2007;[51] Sikorska, 2004;[53] Alesiani *et al*., 2007 |
| *M. crispa* L. | Kaempferol 3-O-beta-glucopyranoside, 3-O-(6”-tran-p-coumaroyl)-beta-D-glucopyranoside, 7-O-beta-D-glucopyranoside, 3-O-alpha-L-rhamnopyranosyl (1-6)-beta-D-glucopyranoside and 3,7-O-diglucoside as well as quercetin 3-O-beta-D-glucopyranoside, 3-O-alpha-L-rhamnopyranosyl (1-6)-beta-D-glucopyranoside and apigenin 7-O-beta-D-glucopyranoside | Matławska and Sikorska, 2004[35] |
| *M. parviflora* L. | Kampeferol-3-(6”-p-coumaroyl-O-β-D-glucoside (tribuloside) | Abdel-Ghani *et al*., 2013[1] |
| *P. xanthogloea* Cav | Tiliroside | Mostardeiro *et al*., 2014[39] |
| *S. cordifolia* L. | 5,7-dihydroxy-3-isoprenyl flavone and 5-hydroxy-3-isoprenyl flavones | Sutradhar *et al*., 2008[58] |
| *S. rhombifolia* L. | 5,4′ -dihydroxy-6,7-dimethoxyflavonol-3-β-D- glucopyranoside | Harikant *et al*.[19] |
| *S. hermaphrodita* L. | Rutin | Bandyukova and Ligai[5] |
| *S. tuberculata* | Delphinidin; hibiscin; gossypicyanin; cyanidin-3,5-diglucoside kaempferol-3-O-β-d-(6′ -E-p-coumaroyl)-glucopyranoside | Da Rosa *et al*., 2015;[10] Williamson *et al*., 2013[65] |
| *T. grandiflorum* (Willd. ex Spreng.) K.Schum. | Theograndins I and II; catechin, epicatechin, isoscutellarein 8-O-β-D-glucuronide, hypolaetin 8-O-β-D-glucuronide, quercetin 3-O-β-D-glucuronide, quercetin 3-O-β-D-glucuronide 6′ -methyl ester, quercetin, kaempferol, and isoscutellarein 8-O-β-D-glucuronide 6′ -methyl esterisoscutellarein (5,7,8,4′ - tetrahydroxyflavone); hypolaetin (5,7,8,3′ ,4′ -pentahydroxyflavone); 8-hydroxychrysoeriol (5,7,8,4′ -tetrahydroxy-3′ -methoxyflavone); C-glycosidic flavan, an O-glycoside of a dimeric and two O-glycosides of trimeric A-linked proanthocyanidins | Hatano *et al*.;[20] Yang *et al*.;[67] Pugliese *et al*., 2013[43] |
| *T. populnea* (L.) Sol. ex Correa | Kaempferol, quercetin and its glycosides, herbacetin and its glucoside, populneol, populnin, populnetin, rutin, gossipetin, gossypol and lupeol | Sarma and Babu, 2011[50] |

*(Cont...)*

**Table 1: *(Cotnd...)***

| Plant | Flavonoids | Reference |
|---|---|---|
| *U. lobata* L. | kaempferol-3-O-β-d-apiofuranosyl (1-2)-β-d-glucopyranosyl-7-O-α-l-rhamnopyranoside; kaempferol-4′ -O-β-d-apiofuranosyl-3-O-β-d-glucopyranosyl-7-O-α-l-rhamnopyranoside; 5,6,7,4′ -tetrahydroxy-flavone-6-O-β-d-arabinopyranosyl-7-O-α-l-rhamnopyranoside; kaempferol 3-O-(6-O-trans-p-coumaroyl)-β-glucoside (tiliroside); dihydrokaempferol 4'-O-β-glucopyranoside; kaempferol and quercetin 3-O-β-glucosides and 3-O-β-rutinosides, lutroline 4'-O-β-glucopyranoside; quercetin, kaempferol and kaempferol 7-O-glucoside | Matławska and Sikorska, 1999;[36] Jia *et al*., 2011[23] |

*A. moschatus: Abelmoschus moschatus, A. esculentus: Abelmoschus esculentus, A. augustum: Abroma augustum, A. indicum: Abutilon indicum, A. pakistanicum: Abutilon pakistanicum, A. grandiflorum: Abutilon grandiflorum, A. theophrasti: Abutilon theophrasti, B. ceiba: Bombax ceiba, D. macrocarpa: Duboscia macrocarpa, G. herbaceum: Gossypium herbaceum, H. sabdariffa: Hibiscus sabdariffa, H. isora: Helicteres isora, H. tiubae: Herissantia tiubae, K. vitifolia: Kitaibelia vitifolia, L. trimestris: Lavatera trimestris, L. macrophyllum: Lasiopetalum macrophyllum, M. sylvestris: Malva sylvestris, M. crispa: Malva crispa, M. parviflora: Malva parviflora, P. xanthogloea: Pavonia xanthogloea, S. cordifolia: Sida cordifolia, S. rhombifolia: Sida rhombifolia, S. hermaphrodita: Sida hermaphrodita, S. tuberculata: Sida tuberculata, T. grandiflorum: Theobroma grandiflorum, T. populnea: Thespesia populnea, Urena lobata; Urena lobata*

(19.8 mg/g DW), and apigenin (19.2 mg/g DW) [Table 1 and Figure 2].[9]

## GENUS *ABUTILON*

*Abutilon indicum* (Link) sweet (Indian Mallow) is a small shrub in the Malvaceae family, native to tropic and subtropical regions and sometimes cultivated as an ornamental. This plant is often used as a medicinal plant and is considered invasive on certain tropical islands. Seven flavonoid compounds, such as luteolin, chrysoeriol, luteolin 7-O-beta-glucopyranoside, chrysoeriol 7-O-beta-glucopyranoside, apigenin 7-O-beta-glucopyranoside, quercetin 3-O-beta-glucopyranoside, quercetin 3-O-alpha-rhamnopyranosyl (1-6)-beta-glucopyranoside, were isolated and identified from the flowers of *A. indicum* [Table 1].[10]

Two new flavonoids, abutilins A and B, were isolated from the chloroform soluble fraction of *Abutilon pakistanicum*.[11] Ferulic acid, cinnamic acid, 5-hydroxy-4′, 6, 7, 8-tetramethoxyflavone, kaempferol, luteolin and luteolin 7-O-β-D-glucopyranoside have also been reported from this species [Table 1]. The related species *Abutilon grandiflorum* leaf was reported to contain flavonol glycosides such as kaempferol 3-O-β-(6”-p-coumaroyl)- glucopyranoside, kaempferol and quercetin 3-O-β-glucopyranosides and 3-O-β-rutinosides and phenolic acids including p-hydroxy benzoic, p-coumaric, syringic, and vanillic acid.[12] Flowers of the related species *A. theophrasti* Medic showed the presence of nine flavonoids: Kaempferol 3-0-β-(6”-p-coumaroyl)- glucopyranoside, myricetin 3-O-β-glucopyranoside, quercetin 3-0-β-glucopyranoside, quercelin 3-0-a-rhamnopyranosyl (l-6”)-β-glucopyranoside, kaempferol 3-0-β-glucopyranoside, kaempferol 3-0-a-rhamnopyranosyI (l-6)-β-glucopyranoside, quercetin 7-0-β-glucoside, quercetin 7-0-β-diglucoside, and kaempferol 7-0-β-diglucoside.[13] Catechin, rutin, quercetin, and syriacusin A were identified in the ethanolic extracts from the five parts (roots, stems, leaves, seeds and exocarps) of *A. theophrasti*.[14]

## GENUS *BOMBAX*

*Bombax ceiba* L. is commonly known as cotton tree. This Asian tropical tree has a straight tall tree and its leaves are deciduous in winter. Red flowers with five petals appear in the spring before the new foliage. It produces a capsule which, when ripe, contains white fibres like cotton. Quercetin, quercetin-3-O-β-D-glucopyranoside, quercetin-3-O-β-D-glucuronopyranoside, rutin, sexangularetin-3-O-sophoroside, vitexin, isovitexin, vicenin, kaempferol-3-O-rutinoside, kaempferol-3-O-β-D-glucuronopyranoside, isomangiferin, mangiferin, 7-O-methyl mangiferin, esculetin, scopoletin, fraxetin, and scopolin were identified flowers of *B. ceiba* L. [Figure 3].[15] Shamimin, a C-flavonol glucoside isolated from *B. ceiba* leaves [Table 1] showed significant potency as a hypotensive agent at the doses of 15 mg/kg, 3 mg/kg, 1 mg/kg and significant hypoglycemic activity at 500 mg/kg in Sprague-Dawley rats.[16]

## GENUS *DUBOSCIA*

*Duboscia macrocarpa* Bocq. occurs from Nigeria to the Democratic Republic of Congo. It is a tree which grows to 30 m, and often has a fluted trunk. The leaves and young stems are covered in dense hairs. The flowers are pink-reddish brown, with bracts below. The fruits are ribbed and very fibrous dubosciasides A (6-C-β-d-apiofuranosyl-

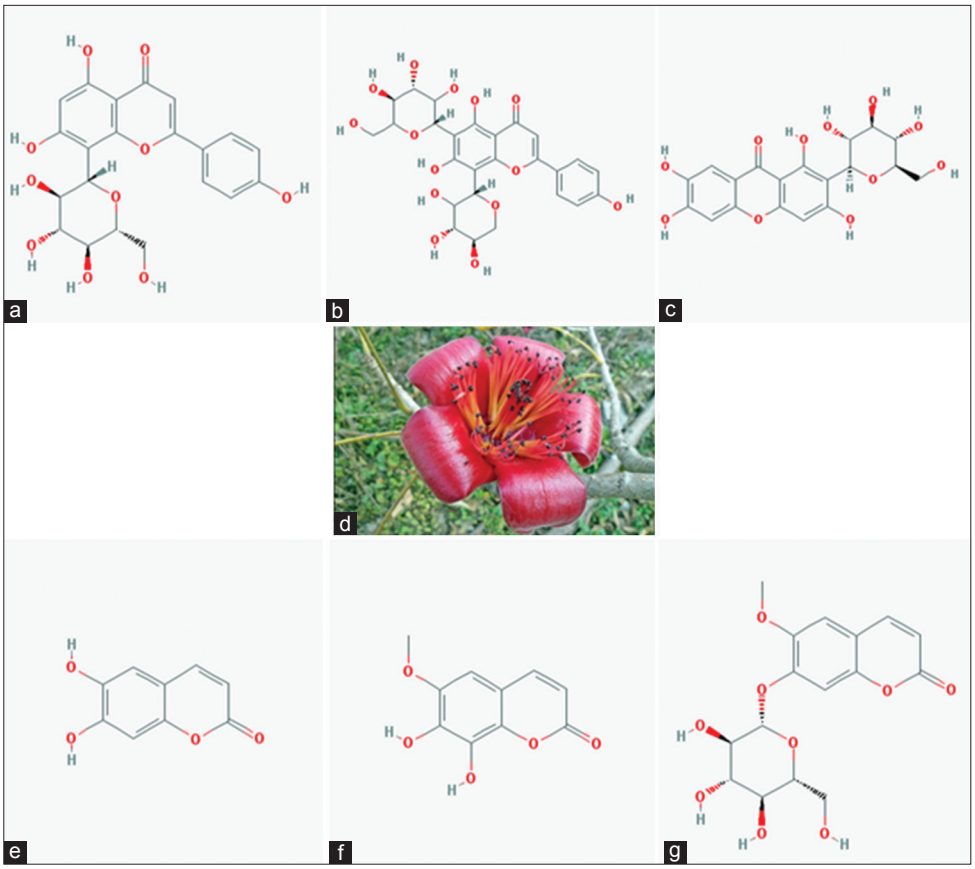


**Figure 3:** Flavonoids in *Bombax ceiba* L. (a) Vitexin, (b) vicenin, (c) mangiferin, (d) *B. ceiba*, (e) esculetin, (f) fraxetin, (g) scopolin

(1-4)-β-d-galactopyranosylnaringetol) and dubosciasides B (1-O-α-l-rhamnopyranosyl-(1-4)-β-d-xylopyranosyl-3,4,5-trimethoxyphenol) were isolated from stem bark of *D. macrocarpa* [Table 1].[17]

## GENUS *GOSSYPIUM*

*Gossypium herbaceum* L. is commonly known as cotton, and the cultivated types are found in India, China and Middle East countries. It has been widely used in the production of food and medicine. The parts of the plant used in medicine are seeds, leaves, flowers, root and root bark. The plant possesses antifertility, anti-spermatogenic, antitumor, abortifacient, contraceptive, anti-diabetic, antiulcer, antiviral, and antibacterial activities. Gossypin is a bioflavonoid compound and is found in various herbs, especially in the genus *Gossypium* [Table 1]. The pharmacological properties of gossypin have been rarely reported with the exception of its antioxidant and anti-inflammatory activity. Duraisami *et al*.[18] reported the antidepressant and anxiolytic activities of gossypin. Waage and Hedin[19] reported the presence of a new flavonol glycoside (gossypetin 8-O-rhamnoside) from the flower petals of *Gossypium arboreum* along with quercetin 7-O-glucoside, quercetin 3-O-glucoside and quercetin 3′-O-glucoside [Figure 4], and all these compounds were shown to exhibit antibacterial activity against *Pseudomonas maltophilia* and *Enterobacter cloacae*.

## GENUS *HIBISCUS*

The members of the genus *Hibiscus* have been used as a folk remedy for the treatment of skin diseases, as an antifertility agent, antiseptic, and carminative. Some compounds isolated from the species, such as flavonoids and phenolic acids, are considered responsible for these activities.[20] *Hibiscus sabdariffa* L. is an attractive plant believed to be native to Africa, cultivated in the Sudan and Eastern Taiwan. Anthocyanins extracted from the dried calyx of this plant exhibited antioxidant activity, liver protection, and anticancer potential.[21] The first anthocyanin from the calyx of *H. sabdariffa* to be isolated was hibiscetin, which was later renamed as delphinidin-pentoside-glucoside.[22] From the pigments of *H. sabdariffa*, three different anthocyanins were isolated: Delphinidin-3-sambubioside (hibiscetin), delphinidin-3-glucoside, and cyanidin-3-glucoside (chrysanthenin) using material from Taiwan and Trinidad [Table 1].[23] Then, cyanidin-3-sambubioside (gossypicyanin) was also identified and later, the presence of cyanidin-3, 5-diglucoside and cyanidin-3-(2G-glucosylrutinoside) in the flower pigments of *H. sabdariffa* var. *altissima* was reported.[24] A study conducted with five different strains of *H. sabdariffa* var. *sabdariffa* reported cyanidin-3-sambubioside and cyanidin-3-glucoside as the major compounds present in this plant.[25] Rocha *et al*.[26] observed that the anthocyanin

content reached 1.7-2.5% of the dry weight in all strains. Several studies have identified delphinidin-3-sambubioside and cyanidin-3-sambubioside as the major anthocyanins present in extracts from *H. sabdariffa* calyx and leaves.[27-29]

The flowers of *H. sabdariffa* were recorded to contain 3-monoglucoside of hibiscetin (hibiscitrin),[30] 7-glucoside of gossypetin (gossypitrin) and sabdaritrin, which on acid hydrolysis yielded a hydroxyflavone named sabdaretin.[31] In 1961, gossypetin-3-glucoside (gossytrin) was isolated.[32] The petals of *H. sabdariffa* var. *altissima* also contain gossypetin-8-glucoside (0.4%) and gossypetin-7-glucoside.[24] Quercetin had already been identified in *H. sabdariffa*.[33] The methanolic extract of the flowers also contains quercetin, luteolin and its glycoside.[34] One study reported that the amount of quercetin present in *H. sabdariffa* was 3.2 mg/g while rutin was 2.1 mg/g.[35] Quercetin and its conjugated glycosides (quercetin-3-glucoside), as well as, rutin (quercetin-3-rutinoside) were frequently identified in *H. sabdariffa* alongside with kaempferol.[36] The water extract of the dried leaves showed the presence of catechin (4.25%) and ellagic acid (28.20%) [Figure 5].[37]

## GENUS *HELICTERES*

*Helicteres isora* L., also called the Indian screw tree, is a species of small tree or large shrub found in Asia including Indian Subcontinent, South China, Malay Peninsula, Java and Saudi Arabia. It possesses an impressive range of nutritional and medicinal properties. Three new flavonoid glucuronides were obtained from the fruit of *H. isora* such as isoscutellarein 4′-methyl ether 8-O-β-o-glucuronide 6″-n-butyl ester, isoscutellarein 4′-methyl ether 8-O-β-o-glucuronide 2″, 4″-disulfate and isoscutellarein 8-O-β-D-glucuronide 2″,4″-disulfate [Table 1].[38]

## GENUS *HERISSANTIA*

*Herissantia* is a small genus of flowering plants in the mallow family sometimes referred to as bladder mallows. These are five species of annual and perennial herbs with trailing stems and bladder-like fruits. They are native to the tropical and warm temperate Americas. In Brazil, kaempferol-3-O-β-d-(6″-E-p-coumaroyl) glucopyranoside (tiliroside) isolated from *Herissantia tiubae* Medik. has been investigated for modulation of drug resistance in *Staphylococcus aureus*.[39] Four phenolic compounds (i.e., a benzoic acid derivative, a coumarin and two flavonoids, kaempferol 7-O-α-l- rhamnopyranoside and 4′,5-dihydroxy-3, 6, 7, 8,3′-pentamethoxyflavone were isolated from the aerial parts of *H. tiubae* [Table 1].[40] Four known flavones, 5-hydroxyauranetin, araneosol, calycopterin and sarothrin [Figure 6] were also isolated from the aerial parts of this plant by Silva *et al*.[41]

## GENUS *KITAIBELIA*

*Kitaibelia vitifolia* L. is a perennial plant can flower the 1st year from seed if sown early. It can grow up to 8 feet high with unusual, vine-like leaves and large, showy, cup-shaped, white or pale rose-pink flowers from July to September. Flowers of *K. vitifolia* were reported to contain kaempferol 3-O-(6”-p-coumaroyl)-β-glucoside (trans-tiliroside); quercetin and kaempferol-3-O-β-xylopyranosyl (1-2)-β-glucopyranoside (3-O-sambubioside); quercetin and kaempferol-3-O-sambubioside-7-O-glucoside; apigenin, 7-O-sambubioside, luteolin and chrysoeriol, 7-O-xylosylglucosides also apigenin 7-O-α-rhamnopyranosyl (1-2)-β-glucopyranoside [Table 1].[42]

## GENUS *LAVATERA*

*Lavatera trimestris* L. (annual or rose mallow) is annual growing to 120 cm tall by 45 cm (18 in) wide, producing shallow funnel-shaped flowers in summer, in shades of white and pink, with maroon centres and maroon veining

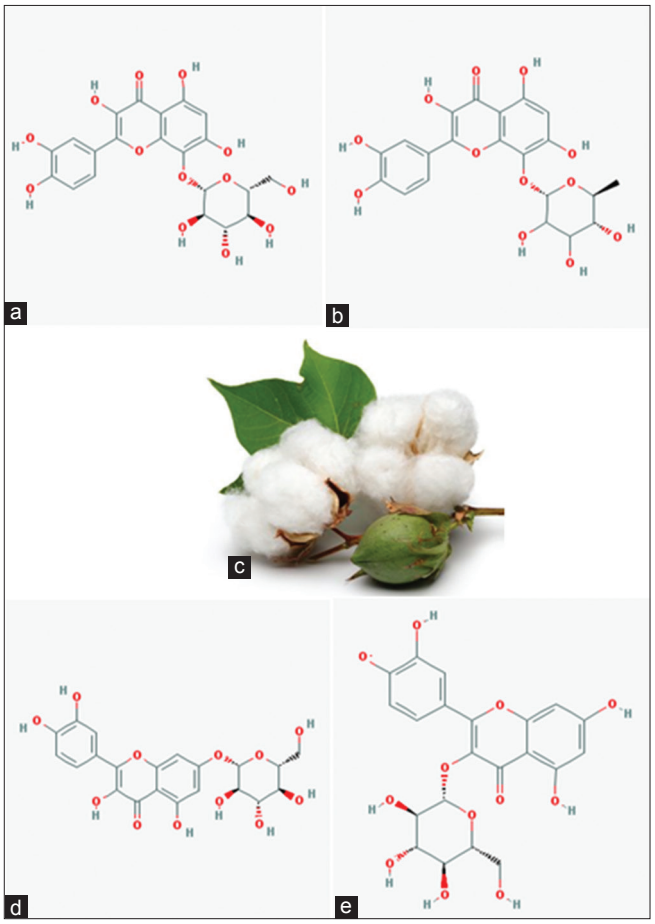


**Figure 4:** Flavonoids in *Gossypium herbaceum* L. (a) Gossypin, (b) gossypetin 8-O-rhamnoside, (c) *G. herbaceum*, (d) quercetin-7-O-glucoside, (e) quercetin-3-O-glucoside

on the petals. Four aglycones, 7 glycosides and 11 phenolic acids were identified in the flowers of *L. trimestris*.[43] The presence of kaempferol 3-O-β-glucoside, kaempferol and quercetin 3-O-rutinosides, cis- and trans-tiliroside, and p-coumaric acid were identified in the flowers of *Lavatera thuringiaca* [Table 1].[44] Similarly, cis-tiliroside and 4′-methoxy-trans-tiliroside compounds were identified in the related plant *Lasiopetalum macrophyllum* Graham.[45] This plant is commonly known as shrubby velvet bush, is a common shrub of the mallow family found in eastern Australia. It grows up to a meter tall, much of the plant is covered in rusty hairs. It was introduced to cultivation in England in 1835. Its flushes of rust-colored new growth have some ornamental appeal, and it grows fairly readily in part-shade in the garden.

## GENUS *MALVA*

*Malva sylvestris* L. is a vigorously healthy plant with showy flowers of bright mauve-purple, with dark veins; a handsome plant, often standing 3 or 4 feet (1 m) high and growing freely in fields, hedgerows and in fallow fields. *M. sylvestris* has significant quantities of flavonoids as showed in a study involving the nutraceutical potential of its extracts; the total flavonoids were 210.8, 46.6, 25.4 and 143.4 mg/g in the leaves, flowers, immature fruits and flowered stems, respectively.[46] In the leaves, gossypetin 3-sulfate-8-O-b-dglucoside (gossypin) and hypolaetin 3′-sulfate were identified as the major constituents, followed by 3-O-b-dglucopyranosyl-8-O-b-d-glucuronopyranoside, hypolaetin 4′-methyl ether 8-O-b-d-glucuronopyranoside, hypolaetin 8-O-b-d-glucuronopyranoside, and isoscutellarein 8-O-bd-glucuronopyranoside [Table 1].[47,48] Flavonoids have been found mostly in the flowers, especially anthocyanins such as malvidin 3,5-diglucoside (malvin), which occurs exclusively in the flavylium cationic form.[49,50] Malvidin 3-O-glucoside (oenin); malvidin; delphinidin 3-O-glucoside; malvidin 3-O-(6″-Omalonylglucoside)-5-O-glucoside; delphinidin; malvidin chloride; genistein; myricetin; and derivatives of apigenin, quercetin and kaempferol have also been found in the flowers, with total anthocyanin content ranging from 0.42% to 7.3% of dry matter.[51,52] Likewise, leucoanthocyanins, cyanidin and petunidin have been found, but in very low concentrations [Figure 7].[49] Kaempferol 3-O-beta-glucopyranoside, 3-O-(6”-tran-p-coumaroyl)-beta-D-glucopyranoside, 7-O-beta-D-glucopyranoside, 3-O-alpha-L-rhamnopyranosyl (1-6)-beta-D-glucopyranoside and 3,7-O-diglucoside as well as quercetin 3-O-beta-D-glucopyranoside, 3-O-alpha-L-rhamnopyranosyl

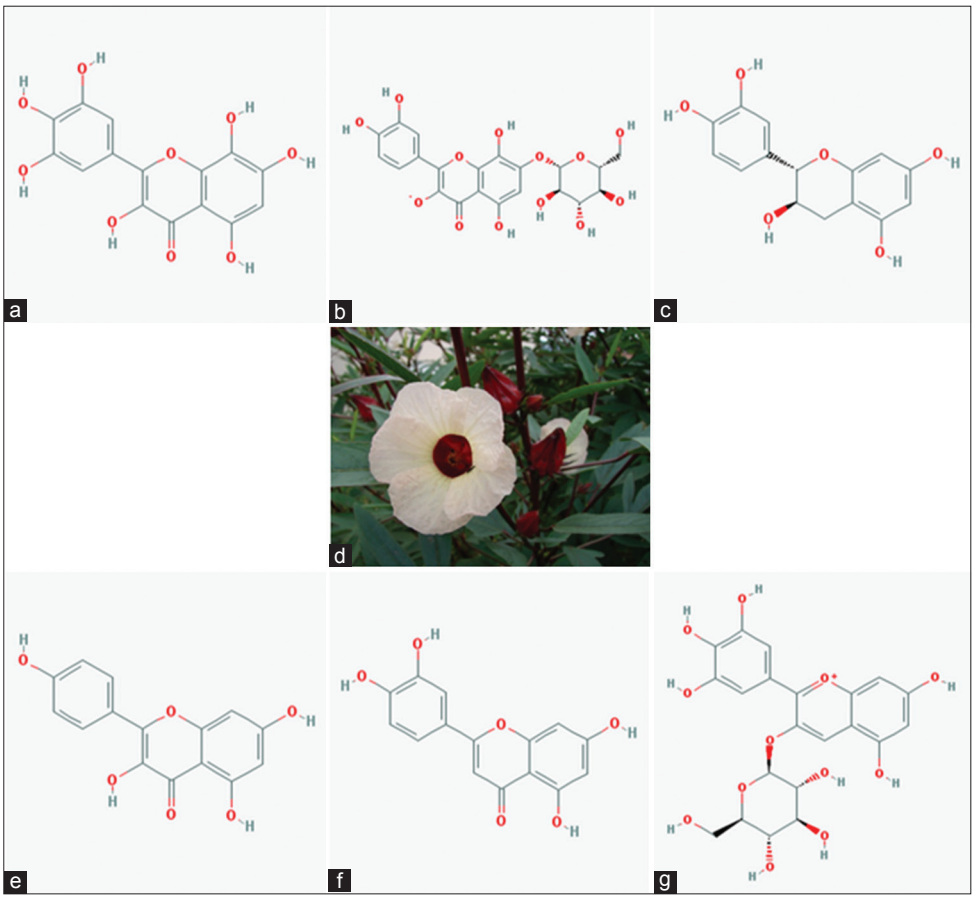


**Figure 5:** Flavonoids in *Hibiscus sabdariffa* L. (a) Hibiscetin, (b) Gossypitrin, (c) Catechin, (d) *H. sabdariffa*, (e) kaempferol, (f) luteolin, (g) delphinidin-3-glucoside

(1-6)-beta-D-glucopyranoside and apigenin 7-O-beta-D-glucopyranoside were isolated and identified from the flowers of *Malva crispa* L.[53]

*Malva parviflora* L. is also known as cheese weed growing in waste ground, roadsides and plains in India. It is an annual or perennial herb that is native to Northern Africa, Europe and Asia and is widely naturalized elsewhere. *M. parviflora* leaf extracts possess anti-inflammatory and antioxidant activities. It has a decumbent or erect habit, growing to 50 cm in height. The broad leaves have 5-7 lobes and are 8-10 cm in diameter. It has small white or pink flowers with 4-6 mm long petals. The plant does not have an especially strong or exciting taste, but does make a pleasant addition to salads and can be cooked as a green. Both the leaves and the immature fruit are edible. Kampeferol-3-(6''-p-coumaroyl-O-β-D-glucoside (tribuloside) has been isolated from the ethyl acetate fraction of *M. parviflora* [Table 1].[54] Total flavonoid content (6.22-95.67 mg quercetin equivalents/g) in different extracts of *Malvastrum coromandelianum* (L.) Garcke has been investigated by Sanghai *et al*.[55] Indians use the crushed leaves of this herb along with salt or alcohol to cure ringworm infection. Bhil tribes of Rajasthan use this plant in the form of decoction to cure jaundice and in Mexico leaf infusion of this plant is used to cure diabetes.

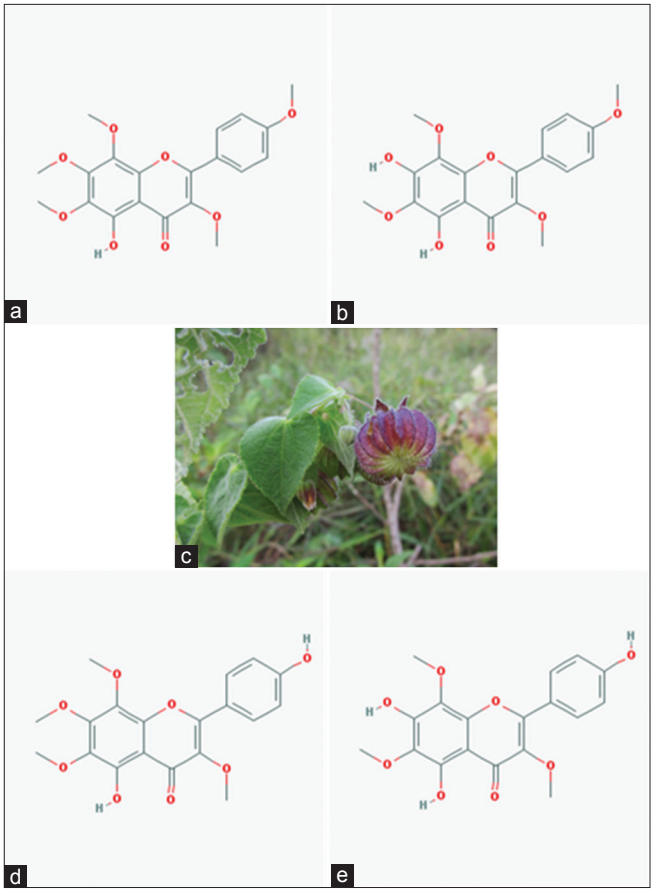


**Figure 6:** Flavonoids in *Herissantia tiubae* Medik. (a) 5-Hydroxyauranetin, (b) araneosol, (c) *H. tiubaei*, (d) calycopterin, (e) sarothrin

## GENUS *PAVONIA*

*Pavonia* is a genus of flowering plants in the mallow family, Malvaceae. Several species of this genus are known as swamp mallows. Tiliroside was detected in hexane, dichloromethane, ethyl acetate, n-butanol, and water fractions of ethanolic extract of the aerial part of *Pavonia xanthogloea* Cav [Table 1].[56]

## GENUS *SIDA*

*Sida cordifolia* L. grows to a height of 3-5 feet and is used as a common herbal drug in the Indian subcontinent. The roots, leaves, stem, and seeds of *S. cordifolia* are used in traditional medicine against chronic dysentery, asthma, and gonorrhea and the aqueous extract of the whole plant is specifically used in the treatment of rheumatism.[57] The flavones such as 5,7-dihydroxy-3-isoprenyl flavone and 5-hydroxy-3-isoprenyl flavone have been isolated from this plant [Table 1].[58] Harikant *et al*.[59] have identified a new flavonol glycoside (5,4′-dihydroxy-6,7-dimethoxyflavonol-3-β-D-glucopyranoside) from *Sida rhombifolia*. Kinetics of the extraction of rutin from *Sida hermaphrodita* was investigated by Bandyukova and Ligai[60] and they found highest yield of rutin can be obtained from raw material ground to 2.5-3.0 mm with the use of 70% ethanol and a time of maceration of 12 h. Kaempferol-3-O-β-d-(6″-E-p-coumaroyl)-glucopyranoside has been identified in *Sida tuberculata*.[61] Delphinidin and cyanidin-based anthocynins include delphinidin-3-sambubioside (hibiscetin), cyanidin-3-sambubioside (gossypicyanin), cyanidin-3,5-diglucoside were also reported in this plant.[62]

## GENUS *THEOBROMA*

*Theobroma grandiflorum* (Willd. ex Spreng.) K.Schum. is a tropical rainforest tree related to cacao. Common throughout the Amazon basin, it is widely cultivated in the jungles of Colombia, Bolivia and Peru and in the north of Brazil. Tree height usually ranges from 5 to 15 m, and they have brown bark and leaves with 9 or 10 pairs of veins. As they mature, the leaves change from pink-tinted to green, and eventually they begin bearing fruit. Its fruits are oblong, brown, and fuzzy and covered with a thick and hard exocarp. Flavonoids such as isoscutellarein (5,7,8,4′- tetrahydroxyflavone), hypolaetin (5,7,8,3′,4′-pentahydroxyflavone), and 8-hydroxychrysoeriol (5,7,8,4′-tetrahydroxy-3′-methoxyflavone), also known as hypoaletin 3′-methyl ether were identified and quantified in *T. grandiflorum* pulp and seeds.[63] Yang *et al*.[64] identified two new sulfated flavonoid glycosides, theograndins I and II, in addition to nine known flavonoid antioxidants namely (+)-catechin, (−)-epicatechin, isoscutellarein 8-O-β-D-glucuronide, hypolaetin 8-O-β-D-glucuronide, quercetin 3-O-β-D-glucuronide, quercetin 3-O-β-D-glucuronide

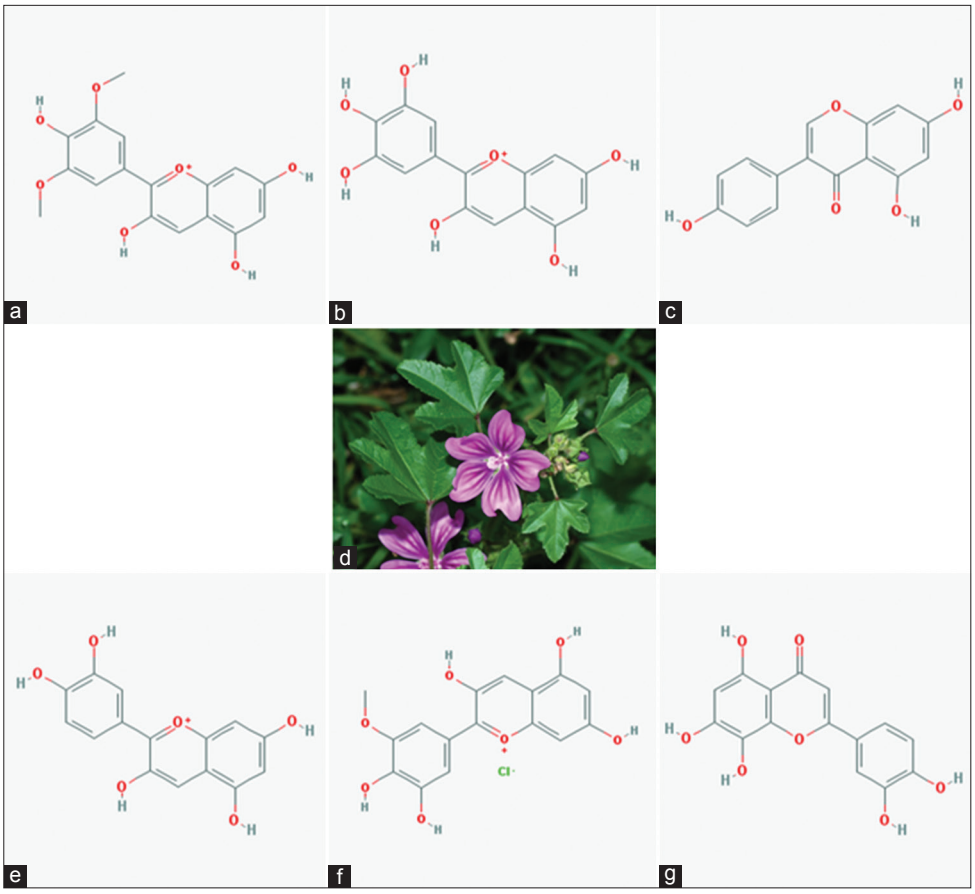


**Figure 7:** Flavonoids in *Malva sylvestris* L. (a) Malvidin, (b) delphinidin, (c) genistein, (d) *M. sylvestris*, (e) cyaniding, (f) Petunidin, (g) hypolaetin

6″-methyl ester, quercetin, kaempferol, and isoscutellarein 8-O-β-D-glucuronide 6″-methyl ester [Table 1]. Among these compounds, theograndin II displayed antioxidant activity (inhibitory concentration 50% [$IC_{50}$] = 120.2 μM) as well as weak cytotoxicity in the HCT-116 and SW-480 human colon cancer cell lines ($IC_{50}$ values of 143 and 125 μM, respectively). Purification of polar fractions from cacao liquor extracts gave 17 phenolics including four new compounds such as C-glycosidic flavan, an O-glycoside of a dimeric and two O-glycosides of trimeric A-linked proanthocyanidins.[65]

## GENUS *THESPESIA*

*Thespesia populnea* (L.) Sol. ex Correa is commonly known as the Portia tree. It is a small tree or arborescent shrub that has a pantropical distribution, found on coasts around the world. It is originated in India and its name is different in different languages in India. Nowadays, its wood is mainly used in making furniture because of its good ability to undergo carving. The main chemical constituents of *T. populnea* are kaempferol, quercetin and its glycosides, herbacetin and its glucoside, populneol, populnin, populnetin, rutin, gossipetin, gossypol, and lupeol [Table 1].[66]

## GENUS *URENA*

*Urena lobata* L., commonly known as Caesar weed or Congo jute, is an annual, variable, erect, ascendant under shrub and measuring up to 0.5-2.5 m tall. The stems are covered with minute star-like hairs and often tinged purple. It is widely distributed as a weed in the tropics of both hemispheres including Brazil and Southeast Asia. Three new flavonoid glycosides, kaempferol-3-O-β-d-apiofuranosyl(1-2)-β-d-glucopyranosyl-7-O-α-l-rhamnopyranoside, kaempferol-4′-O-β-d-apiofuranosyl-3-O-β-d-glucopyranosyl-7-O-α-l-rhamnopyranoside, and 5, 6, 7, 4′-tetrahydroxy-flavone-6-O-β-d-arabinopyranosyl-7-O-α-l-rhamnopyranoside were isolated from the aerial parts of *U. lobata*.[67] Matławska and Sikorska[68] reported the presence of kaempferol 3-O-(6-O-trans-p-coumaroyl)-β-glucoside (tiliroside), dihydrokaempferol 4'-O-β-glucopyranoside, kaempferol and quercetin 3-O-β-glucosides and 3-O-β-rutinosides, lutroline 4'-O-β-glucopyranoside, quercetin, kaempferol and kaempferol 7-O-glucoside in the flowers of flowers of *U. lobata* [Table 1].

## CONCLUSION

The present review work has given an outline on the distribution of different types of flavonoids among the members of Malvaceae family. Flavonoids, such as rutin, myricetin, quercetin, luteolin, tiliroside, and kaempferol, were commonly found in Malvaceae members while hyperoside, abutilin, syriacusin A, esculetin, dubosciasides, gossypin, isoscutellarein, araneosol, calycopterin, theograndins, and populnin were very specific to particular genera. Such chemical diversity among Malvaceae family members could leads to their wide biological activity and use in traditional medicine for a wide range of diseases. Still several Malvaceae plants have not been investigated for their phytochemical composition and unravelling their chemical profile with bioactivity could be helpful to achieve the drug developing targets for several chronic diseases. Furthermore, structural and activity relationship should be investigated for different flavonoids present in Malvaceae members so that their molecular mechanisms against specific drug targets will be elucidated.

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