The genus *Sterculia* is represented by 200 species which are widespread mainly in tropical and subtropical regions. Some of the *Sterculia* species are classified under different genera based on special morphological features. These are *Pterygota* Schott & Endl., *Firmiana* Marsili, *Brachychiton* Schott & Endl., *Hildegardia* Schott & Endl., *Pterocymbium* R.Br. and *Scaphium* Schott & Endl. The genus *Sterculia* and the related genera contain mainly flavonoids, whereas terpenoids, phenolic acids, phenylpropanoids, alkaloids, and other types of compounds including sugars, fatty acids, lignans and lignins are of less distribution. The biological activities such as antioxidant, anti-inflammatory, antimicrobial and cytotoxic activities have been reported for several species of the genus. On the other hand, there is confusion on the systematic position and classification of the genus *Sterculia*. However, the wide range of the reported flavonoids in the present review is quite significant and can act as a guide for further studies from the chemosystematic point of view. Also the value of the genus *Sterculia* and its related genera in the traditional medicine and their effective biological activities led to the possibilities of finding new sources of drugs for prospect applications.
of the distribution of a wide range of flavonoid constituents, which are believed to play a considerable role in plant chemotaxonomy[5]. Moreover, most of them have shown to possess different biological activities[4].

The following chronological literature survey was achieved aiming to provide helpful guidelines for further studies. In this respect, data on isolation and identification of different types of chemical compounds from plants of the genus Sterculia and the related genera were gathered and reported in addition to those concerned with the biological activities of these plants.

2. Chemical constituents of the genus Sterculia and the related genera

2.1. Flavonoids

A survey of the genus Sterculia and the related genera showed a wide range of flavonoid compounds. They occurred mostly as flavone and flavonol glycosides. The flavone glycosides mainly present are as 7-O-glucoside and 7-O-glucuronide of apigenin, luteolin and chrysoeriol, whereas diosmetin glycosides were not often present. The glycosylation of flavonols at position 3 were common, generally based on quercetin and/or kaempferol. 6- or 8-hydroxyflavones, scutellarein, isoscutellarein, 6-hydroxyluteolin, and hypolaetin were also detected, but that of 6- or 8-hydroxyflavonols were absent. C-glycosylflavonoids were rare; vitexin and apigenin 6,8-di-C-β-D-glucoside were reported in Sterculia colorata Roxb. (S. colorata) and Sterculia foetida L. (S. foetida), respectively[6,7]. A single isoflavone structure with C-glucosyl substituent at position 8 (puerarin) had been also characterized for S. foetida[7]. The determined anthocyanins were pelargonidin and cyanidin derivatives. The classes of the flavonoids reported are outlined in Table 1 and classified based on their chemical structures according to Harborne[5].

2.2. Other phenolic constituents

Mono- and dihydroxy-phenolic acids were isolated from the leaves of S. foetida and S. lychnophora seeds[9,16,18]. Phenolic

| Compound | Organ | Species | References |
|----------|-------|---------|------------|
| Flavones | A. pigment | Leaves | S. colorata | [6] |
| | Flower | F. plataniolius | [8] |
| | Leaves | S. foetida | [9] |
| | Stem, leaves | P. alata | [10] |
| | Leaves | B. acerifolius | [11] |
| | Leaves | B. acerifolius | [11] |
| | Leaves | S. colorata | [6] |
| | Leaves | B. acerifolius | [11] |
| | Leaves | S. foetida | [12] |
| | Leaves | S. foetida | [12] |
| | Leaves | S. colorata | [13] |
| | Leaves | S. foetida | [7,9] |
| | Leaves | S. colorata | [6] |
| | Leaves | B. acerifolius | [11,14] |
| | Leaves | S. foetida | [9] |
| | Leaves | S. foetida | [9] |
| | Leaves | S. colorata | [6] |
| | Leaves | S. foetida | [9] |
| | Leaves | B. acerifolius | [11] |
| | Leaves | S. foetida | [9] |
| | Leaves | S. villosa | [15] |
| | Leaves | S. foetida | [9] |
| | Leaves | S. villosa | [15] |
| | Leaves | S. foetida | [9] |

(continued on next page)
| Compound | Organ | Species | References |
|----------|-------|---------|------------|
| Chrysoeriol 7-O-β-D-glucuronide 6'-methyl ester | | | |
| Chrysoeriol 7-O-β-D-glucuronide 6'-ethyl ester | | | |
| Luteolin 4'-methyl ether (diosmetin) | Leaves | *S. villosa* | [15] |
| Diosmetin 7-O-β-D-glucoside | | | |
| 6-Hydroxyluteolin | Leaves | *S. colorata* | [6] |
| 6-Hydroxyluteolin 6-O-β-D-glucuronide | Leaves | *S. colorata* | [6] |
| | Leaves | *S. foetida* | [13] |
| 8-Hydroxyluteolin 8-O-β-D-glucuronide (hypolaetin 8-O-β-glucuronide) | Leaves | *S. foetida* | [9,16] |
| Hypolaetin 8-O-β-D-glucuronide 6'-methyl ester | | | |
| Hypolaetin 8-O-β-D-glucuronide 6'-ethyl ester | | | |
| 6-Hydroxyluteolin | Leaves | *S. colorata* | [6] |
| 6-Hydroxyluteolin 6-O-β-D-glucuronide | Leaves | *S. foetida* | [13] |
| 6-Hydroxyluteolin 6'-O-β-D-glucuronide | Leaves | *S. foetida* | [9,16] |

**Flavonols**

| Compound | Organ | Species | References |
|----------|-------|---------|------------|
| Kaempferol | Leaves | *F. simplex* | [15] |
| | Leaves | *B. rupestris* | [17] |
| | Stem bark | *S. diversifolia* | [17] |
| | Leaves | *B. acerifolius* | [11,14] |
| Kaempferol 3-O-β-D-glucoside | Stem bark | *S. diversifolia* | [17] |
| | Seeds | *S. lychnophora* | [18] |
| | Fruit | *S. scaphigerum* | [19] |
| Kaempferol 3-O-β-D-rutinoside | Leaves | *F. simplex* | [15] |
| | Leaves | *B. rupestris* | [17] |
| | Stem bark | *S. diversifolia* | [17] |
| | Seeds | *S. lychnophora* | [18] |
| | Fruit | *S. scaphigerum* | [19] |

| Compound | Organ | Species | References |
|----------|-------|---------|------------|
| Kaempferol 3-O-(2",6"-dirhamnosyl)-β-glucoside (K 3-O-(2"-rhamnosylrutinoside)) | Leaves | *B. rupestris* | [17] |
| | Stem bark | *S. diversifolia* | [17] |
| Kaempferol 3-O-(2",6"-dirhamnosyl)-β-galactoside (K 3-O-(2"-rhamnosylrobinoside)) | Leaves | *B. rupestris* | [17] |

**Quercetin**

| Compound | Organ | Species | References |
|----------|-------|---------|------------|
| Quercetin 3-O-arabinoside | Stem bark | *S. diversifolia* | [17] |
| Quercetin monorhamnoside | Roots | *S. foetida* | [23] |
| Quercetin 3-O-rhamnoside (quercitrin) | Stem bark | *F. platanifolia* | [24] |
| | Stem | *F. simplex* | [25,26] |
| | Leaves | *B. discolor* | [22] |
| | Leaves | *S. foetida* | [9] |
| Quercetin 3-O-β-D-glucoside | Leaves | *S. pallens* | [20] |
| | Leaves | *F. simplex* | [15] |
| | Leaves | *B. rupestris* | [17] |
| | Stem bark | *S. diversifolia* | [17] |
| | Leaves | *B. australis* | [21] |
| | Leaves | *B. acerifolius* | [11,14] |
| | Leaves | *B. discolor* | [22] |
| Quercetin 3-O-β-D-galactoside | Leaves | *S. pallens* | [20] |
| | Leaves | *B. australis* | [21] |
| | Leaves | *S. foetida* | [7] |
| Quercetin 3-O-galactoside (hyperoside) | Leaves | *F. simplex* | [15] |
| | Leaves | *B. acerifolius* | [11,17] |
| Quercetin 3-O-(6"-α-rhamnosyl)-β-glucoside (rutin) | Leaves | *F. simplex* | [27] |
| | Leaves | *B. australis* | [21] |
| | Leaves | *B. acerifolius* | [11,14] |
| Quercetin 3-O-(2"-α-rhamnosyl)-β-D-glucoside | Leaves | *F. simplex* | [15] |
| Quercetin 3-O-diglucoside | Leaves | *S. pallens* | [20] |
| Quercetin 7-methyl ether (rhamnetin) | Leaves | *B. discolor* | [22] |
| Quercetin 3'-methyl ether (isorhamnetin) | Leaves | *B. rupestris* | [17] |
| | Stem bark | *S. diversifolia* | [17] |
| | Leaves | *B. acerifolius* | [14] |
| | Leaves | *B. australis* | [21] |
| | Seeds | *S. lychnophora* | [18] |
| | Fruit | *S. scaphigerum* | [19] |

(continued on next page)
aldehydes were rare. The genus *Sterculia* comprises two major classes of phenylpropanoids: cinnamic acids and coumarins. Cinnamic acid was isolated from *P. alata*, while the common cinnamic acid derivatives, *p*-coumaric and ferulic acids were reported in *S. foetida*. Lignans and lignins were reported in *P. alata*, while dioxane lignin was obtained from the leaves of *Pterygota macrocarpa* K. Schum. (*P. macrocarpa*) as shown in Table 2 [25,34].

### 2.3. Terpenoids and steroids

Limited terpenoids have been reported in the genus *Sterculia* and all are represented by triterpenes. Three new ursane triterpenes saponins were recently isolated from the stems of *F. simplex*: 28-β-[β-D-glucopyranosyl-(1→6)]-β-D-glucopyranosyl-2α,3α,19α-trihydroxy-12-en-28-ursolic acid, 28-O-[β-D-glucopyranosyl-(1→6)]-β-D-glucopyranosyl-2α,3α,19α,23-tetrahydroxy-12-en-28-ursolic acid and 28-O-[β-D-glucopyranosyl-(1→6)]-β-D-glucopyranosyl-2α,3β,19α-trihydroxyurs-12-ene-24,28-dioic acid [34]. Steroids were also found in some species of the same genus; β-sitosterol and stigmastanol were isolated from certain parts of some species, while β-sitosterol-3-O-β-D-glucopyranoside was reported in *S. foetida* and *Sterculia striata* St. Hil. et Naud (S. striata) [28,35]. Table 3 describes the terpenoids and steroids reported in the genus *Sterculia* and related genera.

### 2.4. Miscellaneous compounds

Species of the genus *Sterculia* were also reported to contain several compounds from other classes, as shown in Table 4. Two

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**Table 1 (continued)**

| Compound | Organ | Species | References |
|----------|-------|---------|------------|
| Quercetin 3'-methyl ether (isorhamnetin) | Leaves | *B. rupestris* | [17] |
| Isorhamnetin 3-O-β-D-rutinoside | Stem bark | *S. diversifolia* | [17] |
| | Leaves | *B. acerifolius* | [14] |
| | Leaves | *B. rupestris* | [17] |
| | Stem bark | *S. diversifolia* | [17] |
| | Leaves | *B. australis* | [21] |
| | Seeds | *S. lychnophora* | [18] |
| F. simplex | Fruit | *S. scaphigerum* | [19] |
| | | *F. j. Muell.* | |
| | | *S. kurzleri* | |
| | | *S. diversifolia* | [17] |
| | | *S. pallens* | |
| Quercetin 4'-methyl ether-3-O-rhamnose (tamarixetin 3-O-rhamnoside) | Stem bark | *F. simplex* | [25,26] |
| Quercetin 3,7,3',4'-tetramethyl ether (retusin) | Stem bark | *S. foetida* | [28] |
| Quercetin 5,7,3',4'-tetramethyl ether | Stem bark | *S. foetida* | [28] |
| Flavans 5,7-Dihydroxy-2-(4-hydroxyphenyl)-6,8-dimethylchroman-4-one (farrerol) | Roots | *H. barteri* | [29] |
| C-Glycosyl flavonoids | Leaves | *S. colorata* | [6] |
| A pigment 6,8-di-C-β-glucoside (vitisin) | Leaves | *S. foetida* | [7] |
| A pigment 6,8-di-C-β-glucoside (vitisin) | Leaves | *S. foetida* | [7] |
| Isoflavones 8-C-glucoside-7,4'-dihydroxysoflavone (Puerarin) | Leaves | *S. foetida* | [7] |
| Isoflavones (3'R)-6, 2'-dihydroxy-7-methoxy-4', 5'-methylenedioxysoflavan (hildegardol) | Roots | *H. barteri* | [29] |
| 2-Hydroxyxmaackiain | Roots | *H. barteri* | [29] |
| Anthocyanins | Follicles | *S. parviflora* | [30] |
| Pelargonidin | Follicles | *S. kunstleri* | [30] |
| Pelargonidin 3-O-arabinoside | Follicles | *S. parviflora* | [30] |
| Pelargonidin 3-O-galactoside | Follicles | *S. parviflora* | [30] |
| Pelargonidin 3-O-glucose | Follicles | *S. kunstleri* | [30] |
| Pelargonidin 3-O-arabinoside | Flower | *B. acerifolius* | [11] |
| Cyanidin 3-O-arabinoside | Follicles | *S. parviflora* | [30] |
| Cyanidin 3-O-galactoside | Follicles | *S. parviflora* | [30] |
| Cyanidin 3-O-glucose | Flower, Leaves | *S. foetida* | [30] |
| | Leaves | *F. plattnoflia* | [31] |
| | | *S. foetida* | [13] |
| Cyanidin 3-O-rutinoside | Flower | *B. acerifolius* | [11] |
| Leucoanthocyanidin-3-O-α-L-rhamnopyranoside | Roots | *S. foetida* | [23] |
| Procyanoquinon-β-D-glucoromane | Leaves | *S. foetida* | [13] |

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F. plattnoflia: *Firmiana plattnoflia* Schott et Endl.; P. alata: *Pterygota alata* (Roxb.) R. Br.; B. acerifolius: *Brachychiton acerifolius* (A.Cunn.ex G.Don) Macarthur; S. villosa: *Sterculia villosa* Roxb.; B. rupestris: *Brachychiton rupestris* (Lindl.) K. Schum; S. diversifolia: *Sterculia diversifolia* G. Don; S. lychnophora: *Sterculia lychnophora* Hance; S. scaphigerum: *Scaphium scaphigerum* (G. Don) Guib. & Planch.; S. pallens: *Sterculia pallens* Wall. Ex. Hochr.; B. australis: *Brachychiton australis* (Schott & Endl.) A. Terrac. B. discolor: *Brachychiton discolor* F. J. Muell.; H. barteri: *Hildegarda barteri* (Mast.) Kostern.; S. parviflora: *Sterculia parviflora* Roxb.; S. kunstleri: *Sterculia kunstleri* King.
3. Biological activities of the genus Sterculia

Several biological activities have been reported in different extracts of certain parts of some species of the genus Sterculia and related genera. Collectively, Table 5 shows the reported activities viz: antimicrobial, antioxidant, anticancer, anti-inflammatory and others.

4. Economical uses

Plants from the genus Sterculia have some economical uses in several countries. Almost leaves and gum were reported to exhibit a broad range of economical properties (Table 6).

Table 2

Phenolics from the genus Sterculia and the related genera.

| Compounds                  | Organ          | Species     | References |
|----------------------------|----------------|-------------|------------|
| Phenolic acids and aldehydes |                |             |            |
| 3-Hydroxy-benzaldehyde      | Leaves         | S. foetida  | [9]        |
| 4-Hydroxy-3,5-dimethoxy-benzaldehyde | Leaves | F. hainanensis | [32]      |
| 3-0-β-Acyl-lupeol            | Leaves         | S. striata  | [26]       |
| 3-0-β-Acyl-lupeol            | Leaves         | B. australis| [35]       |
| Oleaonic acid               | Leaves         | B. australis| [21]       |
| 28-0-β-D-Glucopyranosyl-1-6-0-β-D-glucopyranosyl | Leaves | B. australis | [21]       |

5. Conclusion

The chronological literature survey confirmed what was originally believed, that the major production of genus Sterculia and related genera is indeed flavonoid metabolites. These results also confirm that flavonoid patterns play a significant role in plant chemotaxonomy. They include flavones, flavone C-glycosides, flavonols, flavans, isoflavones, isoflavans and anthocyanins. Other phenolic constituents such as, phenolic acids and aldehydes, phenyl propanoids, coumarins, lignans and lignins were identified with a much less significance than flavonoids.
Table 4
Miscellaneous compounds from the genus *Sterculia* and the related genera.

| Compounds             | Organ        | Species   | References |
|-----------------------|--------------|-----------|------------|
| Alkaloids             | Seeds        | *B. discolor* | [22]       |
| Caffeine              | Seeds        | *B. discolor* | [22]       |
| Putine                | Seeds        | *S. lychnophora* | [18]       |
| Sterculine I          | Seeds        | *S. lychnophora* | [18]       |
| Sterculine II         | Seeds        | *S. lychnophora* | [18]       |
| Non-alcohol non-nitrogenous bases | Leaves | *S. lychnophora* | [18]       |
| Choline               | Leaves      | *F. planatoflia* | [37]       |
| Betaine               | Leaves      | *F. planatoflia* | [37]       |
| Alcohol               | Seeds        | *S. lychnophora* | [18]       |
| n-Octacosanol         | Leaves      | *S. foetida* | [28]       |
| Hexacosanol           | Heart-wood  | *S. foetida* | [18]       |
| Docosanol             | Leaves      | *S. guttata* | [38]       |
| Carboxylic acids      | Seeds        | *S. foetida* | [39]       |
| Ascorbic acid         | Leaves      | *S. acurens* | [39]       |
| Succinic acid         | Seeds        | *S. lychnophora* | [18]       |
| Amides                | Seeds        | *S. lychnophora* | [18]       |
| Triglycerides         | Seeds        | *B. luridum* | [40]       |
| 2-oleodipalmitin      | Leaves      | *B. diversifolium* | [41]       |
| 2-oleo-3-stearopalmi tin | Leaves | *B. diversifolium* | [41]       |
| Sugars                | Stem bark   | *F. planatoflia* | [42]       |
| Arabinose             | Leaves      | *F. planatoflia* | [42]       |
| Rhamnose              | Leaves      | *S. lychnophora* | [44]       |
| Galactose             | Leaves      | *S. acurens* | [43]       |
| Glucuronic acid       | Stem bark   | *S. foetida* | [6]         |
| Galacturonic acid     | Leaves      | *S. foetida* | [43]       |
| Sucrose               | Leaves      | *S. lychnophora* | [18]       |
| n-butyln-D-mannopyranoside | Seeds | *B. acuminatus, B. gregorii, B. luridum, Brachychiton cu 'Hybridum', B. populneus, S. foetida, B. diversifolium, B. rupestris, B. acerifolius, B. discolor and B. aurous* | [38,39] |
| Fatty acids           | Seeds        | *B. acuminatus, B. gregorii, B. luridum, Brachychiton cu 'Hybridum', B. populneus, S. foetida, B. diversifolium, B. rupestris, B. acerifolius, B. discolor and B. aurous* | [38,39] |
| Oleic, linoleic, malic, tartaric | Seeds | *B. acuminatus, B. gregorii, B. luridum, Brachychiton cu 'Hybridum', B. populneus, S. foetida, B. diversifolium, B. rupestris, B. acerifolius, B. discolor and B. aurous* | [38,39] |
| Palmitic              | Seeds        | *B. aurous* | [23]       |
| Dihydroxymalic and dihydroxsteric | Seeds | *B. diversifolium* | [37]       |
| Myristic              | Stem bark, leaves | *B. diversifolium* | [37]       |
| Cyclopropenoid fatty acids | Fruits | *S. strina* | [48]       |

Table 5
The biological/modes of action screened for the genus *Sterculia* and related genera.

| Biological activity/mode of action | Organ | Species | References |
|-----------------------------------|-------|---------|------------|
| Antimicrobial activity            | Leaves | *S. acurens* | [53]       |
| Cytomegalovirus and encephalomyocarditis viral infections | Leaves | *S. acurens* | [54]       |
| M lid antiprotozoal effect        | Seeds  | S. guttata | [42]       |
| Active against larvae of *Aedes aegypti* and *Culex quinquefasciatus* | Seeds  | S. guttata | [42]       |
| Bactericidal against *S. aureus*  | Stem bark, leaves | P. milvraedii | [55]       |
| Strong anti-schistosomal activity (LC50: 11.6 µg/mL) | Leaves, branches | *B. rupestris* | [56]       |
| Potent antifungal plant           | Leaves | *S. africana* | [57]       |
| Antibacterial activity            | Leaves | *S. foetida* | [58]       |
| Inhibiting the growth of *Staphylococcus aureus* and *Escherichia coli* and *Entamoeba histolytica* parasite | Leaves | P. macrocarpa | [59]       |
| Active against *Escherichia coli, S. aureus, Pseudomonas aeruginosa and Bacillus subtilis* but less active against *Candida albicans* | Leaves | P. macrocarpa | [59]       |
| Moderate antibacterial activity   | Wood, branches | *B. diversifolium* | [60]       |
| Enhanced the antioxidant activity of components | Leaves, fruit | *B. diversifolium* | [60]       |
| Moderate activity                 | Wood, branches | *B. diversifolium* | [60]       |
| Efficient reducing power as well as free radical scavenging property | Leaves | P. alata | [62]       |
| Chinese pharmaceutical formulation for malignant tumours | Leaves | *S. africana* | [57]       |
| High cytotoxic effect in almost all tests | Leaves | *S. foetida* | [7,9]       |
| The ethanol extracts had moderate activity against BGC-823, Bel-7402 and HCT-8 cell lines | Leaves | *S. lychnophora* | [63]       |
| Anti-inflammatory activity         | Leaves | *S. lychnophora* | [64-66]     |
| Anti-inflammation                   | Leaves | *S. foetida* | [9,67]      |
| Laryngopharyngitis diseases and tussilitis | Leaves | *P. macrocarpa* | [59]       |
| Cardiovascular diseases            | Leaves | *S. lychnophora* | [70-72]     |
| Induced thrombus formation         | Seeds   | *F. simplex* | [73]       |
| Cardiac arrest                     | Leaves | *S. lychnophora* | [76]       |
| Digestive system disorders         | Soaked leaves | *P. macrocarpa* | [59]       |
| Stomachache, pains and disorders of digestion | Leaves | *S. lychnophora* | [77,78]     |
| Antiflatulent                      | Leaves | *P. macrocarpa* | [59]       |
| Urinary tract disorders            | Leaves | *S. lychnophora* | [79]       |
| Urolithiasis                       | Leaves | *S. lychnophora* | [80,81]     |
| Skin problems treatment            | Leaves | *S. lychnophora* | [82]       |
| Anti-aging cosmetics               | Leaves | *F. planatoflia* | [83]       |
| Skin problems treatment            | Leaves | *S. foetida* | [84]       |
| M oxidizing agent                  | Leaves | *S. lychnophora* | [85]       |
| Tyrosinase inhibitors in skin lightening cosmetics | Leaves | *F. planatoflia* | [86]       |
| Alopoeia and anti-dandruff agent   | Leaves | *S. foetida* | [87]       |
| Hair growth stimulation            | Leaves | *F. simplex* | [87]       |
| Treatment of UV- induced skin disorders, such as wrinkles, skin thickenings and skin tumors | Leaves | *F. simplex* | [87]       |

(continued on next page)
other hand, other metabolites were also reported; e.g. terpenoids, steroids, alkaloids as well as sugars and fatty acids. The stems, barks, leaves, fruits and roots of the Sterculia species have various and numerous traditional and medicinal uses in various countries to treat a broad range of ailments, digestive diseases, diabetes, respiratory-related diseases and skin diseases. In addition, various biological activities such as antimicrobial, anti-inflammatory, antioxidant and anticancer have been reported for Sterculia species. The authors recommend further investigations to study infrageneric relationships within Sterculia species to better understand their classification problems.

Table 5

| Biological activity/mode of action | Organ | Species | References |
|----------------------------------|-------|---------|------------|
| Anti-obesity drugs               | Leaves| F. simplex | [89]       |
| Nutrient agent                   | Vitamin C (52 mg/100 g) | Plant gum | Sterculia spp. | [96] |
| Oral and throat diseases         | Throat moisturizing agents | Seeds | S. scaphigera | [97] |
| Promoting salivation             | Leaves | S. lychnophora | [98]       |
| Relieving sore throat            | Leaves | S. lychnophora | [99]       |
| Bronchitis                       | Roots | F. simplex | [100]      |
| Central nervous system           | Treating narcotic drug abuse | Leaves | S. lychnophora | [101] |
| Depressant activity on CNS with a sleeping effect | Leaves | S. fortitad | [7,166] |
| Naso-sinusitis                   | Leaves | S. lychnophora | [103] |
| Anti-hyperlipidemic              | Leaves | S. fortitad | [93]       |
| Hepato-protective agent          | Lowered serum SGOT, SGPT and A LP levels | Leaves | S. fortitad | [93] |
| To attenuate the development of alcoholic liver disease | Stem bark | F. simplex | [27] |
| Miscellaneous diseases treatment | A cute and chronic faucitis and symptoms of hoarseness and aphonia | Leaves | S. lychnophora | [104] |
| Obstinate halitosis              | Seeds | S. scaphigera | [105] |
| Berberi                          | Leaves | F. simplex | [106]      |
| Bone fracture, trauma-induced paralysis and osteonecrosis | Roots, stem bark | F. simplex | [107] |
| Health care                      | Multiple health care functions | Leaves | S. lychnophora | [76,108] |
| Blood circulation promoting, blood stasis removing, anti-aging and immunity enhancing effects | Leaves | S. lychnophora | [99] |
| Clearing lung, relieving cough and improving immunity | Leaves | S. lychnophora | [109] |
| Improving intelligence, eye sight, blood circulation, coronary circulation, nourish liver, lung and throat, body fluid production, regulating nerve, nourishing liver, dispelling blood stasis. Treating malaria, constipation, arteriosclerosis, obesity, hypertension, hyperlipemia, hyperglycemia, thrombosis, intracerebral hemorrhage and relieving itching | Leaves, S. tragacantha stem bark and seeds | [111] |
| Sterile materials                | S. africana | Leaves | [112] |
| Wastewater treatment             | Preparation of activated carbon for removing Cu (II) from aqueous solutions | Seeds | S. lychnophora | [114] |
| Sorption and desorption properties for Pb and Cd | Preparation of activated carbons to adsorb phenol from wastewater | Leaves | F. simplex | [115] |
| Preparing for treatment | Leaves | P. macrocapra | [118] |
| Efficiently remove Cd (II) from aqueous solutions | Leaves | S. simplex | [119] |
| Miscellaneous                    | Production of cement-bonded wood floor boards | Heart wood | P. alata | [120] |
| Raw material for making pulp and paper | Leaves | S. villosa | [121] |
| As a base for cosmetics, bath preparations and detergent formulations | Leaves | F. simplex | [82] |
| A wood vinegar composition used as: pest controlling agent, bactericidal agent, detergent, environment improver, plant nutrient, soil conditioner and odor remover | Leaves | S. africana | [122] |
| Nutritious effervescent tablets | Leaves | S. africana | [123] |
| Effective polymer for the design of different ocular dosage forms: solution or drops, nano-particles, nano-suspensions or suspensions, micro or nano-emulsions, lotions, gels, hydro-gels, in situ forming gels, ointments, inserted films and minitablets | Plant gum | S. fortitad | [124] |

P. milbraedii: Pterygota milbraedii Engi; S. africana: Sterculia africana (Lour.) Fiori; S. scaphigera: Sterculia scaphigera Wall; S. tragacantha: Sterculia tragacantha Lindl.

Table 6

| Uses | Organ | Species | References |
|------|-------|---------|------------|
| Cigarette manufacturing | Flavoring agent and as an additive sprayed on tobacco | Leaves | S. scaphigera | [112] |
| Cigarette manufacturing | A leafy plant cigarette which meet the requirements of smokers without harm to health | Leaves | F. simplex | [113] |
| Wastewater treatment | Preparation of activated carbon for removing Cu (II) from aqueous solutions | Seeds | S. lychnophora | [114] |
| Sorption and desorption properties for Pb and Cd | Preparation of activated carbons to adsorb phenol from wastewater | Leaves | F. simplex | [115] |
| Preparing for treatment | Leaves | P. macrocapra | [118] |
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Conflict of interest statement

We declare that we have no conflict of interest.

References

[1] Wilkie P, Clark A, Pennington RT, Cheek M, Bayer C, Wilcock CC. Phyllogenetic relationships within the subfamily sterculioideae (Malvaceae/Sterculiaceae-Sterculieae) using the chloroplast gene ndhF. Syst Bot 2006; 31: 160-70.
[2] Stewart Robert Hinsley. Classification: Sterculiaceae. Malvaceae Info; 2005. [Online] Available from: http://www.malvaceae.info/Classification/Sterculiaceae.html [Accessed on 10th March, 2006]
[3] Upson TM, Cullen J. 736. Phytochemistry, Amsterdam: Elsevier; 2006; 39: 170-81.
[4] A I Mughrabun LM, Ahmat N. Medicinal uses, phytochemistry and pharmacology of family Sterculiaceae: a review. Eur J Med Chem 2015; 92: 514-30.
[5] Harborne JB. Flavonoids. In: Natural products of woody plants. Rowe JW, editor. Heidelberg: Springer Berlin Heidelberg; 1989, p. 533-70.
[6] Rajasekharreddy P, Pathipati UR. Biofabrication of Ag nanoparticles using Sterculia foetida L. seed extract and their toxic potential against mosquito vectors and Hela cancer cells. Mater Sci Eng C Mater Biol Appl 2014; 39: 203-12.
[7] Xia P, Song S, Feng Z, Zhang P. [Chemical constituents from leaves of Sterculia foetida]. Zhongguo Zhong Yao Za Zhi 2009; 34(20): 2604-6. Chinese.
[8] Ding X, Li E, Shi C. Studies on the constituents of the petals of Firmiana planifolia (L. F.) M. arsill. Nanjing Yaeyuan Xueba 1986; 6(4): 251.

[9] Xia P. Study on the chemical constituents and bioactivities of Sterculia foetida L. [dissertation]. China: Peking Union Medical College; 2009.

[10] Lin L, Song ZJ, Xu H H. A new phenylpropanoid galactoside and other constituents from Petrygota alata (Roxb.) R. Brown. Biochem Syst Ecol 2010; 38(6): 1238-41.

[11] Farag MA, A bou Zed HA, Hamed MA, Kandeel Z, El-Rafie HM, El-Akad RH. Metabolic fingerprint classification of Brachychiton acerifolius organs via UPLC-qTOF-PDA-MS analysis and chemometrics. Nat Prod Res 2015; 29(2): 116-24.

[12] Shamsundar SG, Paramyothi S. Preliminary pharmacognostical and phytochemical investigation on Sterculia foetida Linn. seeds. Afr J Biotechnol 2010; 9(13): 1978-89.

[13] Shi GZ, inventors; Beijing Beixin-Zhicheng Intellectual Property Agent Co., Ltd., assignee. The use of isoscutellarin for the manufacture of medicine. WIPO Patent WO/2006/089478A1. 2006 Aug 31.

[14] De Laurentis N, Armenise D, Milillo MA, Matrella R. Chemical investigation on Sterculia acerifolia leaves. Rev Ital EPPOS 2003; 36: 21–30.

[15] Hossain MK, Prodhan MA, Even ASM H, Marshd H, Hossain MM. Anti-inflammatory and antidiabetic activity of ethanolic extracts of Sterculia villosa barks on Albino Wistar rats. J Appl Pharm Sci 2012; 2(8): 96-100.

[16] Xia PF, Feng ZM, Yang YN, Zhang PC. Two flavonoid glycosides and a phenylpropanoid glucose ester from the leaves of Sterculia foetida. J Asian Nat Prod Res 2009; 11(8): 766-71.

[17] Desoky EK, Youssef SA. Hypoglycemic effect of Sterculia repens and a comparable study of its flavonoids with a phenylpropanoid glycoside ester from the leaves of Sterculia foetida. J Assoc Pharm Sci 2011; 2(8): 257-61.

[18] Wang RF, Yang YX, Ma CM, Shang MY, Liang JY, Wang X, et al. Alkaloids from the seeds of Sterculia fiscifera. Phytochemistry 2003; 63: 475-8.

[19] Petchlert C, Boonsala P, Payon V, Kitcharoen K, Promsopa S. Antioxidative and antimutagenic effect of malva nut (Sterculia foetida (Pangdahai). Pharm Biocatal Chem 2007; 4(1): 207-12.

[20] Li Z, Tang X, Chen Y, Wei L, Wang Y. Activation of Firmiana simplex leaf and the enhanced Pb (II) adsorption performance: equilibrium and kinetic studies. J Hazard Mater 2009; 169(1-3): 386-94.

[21] Khadavilhavil NS, Gogilavilhavil LN, Yaroah ES, Kemertelidze EP. Lipids from Sterculia planifolia and Hamamelis virginiana seeds. Chem Nat Comp 2007; 43(3): 315-6.

[22] Katade S, Deshmukh M, Phalgun U, Biswas S, Deshpande N. Isolation of straight chain alcohol and ester from Sterculia gutta. Asian J Chem 2008; 20(1): 308-12.

[23] Kumbhare V, Bhargava A. Studies on the nutritional composition of Sterculia species. J Food Sci Technol 1999; 36(6): 542-4.

[24] Petrocini C, Bazan E, Averna V. On the composition of the aril fat of Firmiana hispanica. J Ethnopharmacol 2006; 108(1): 53-56.

[25] Dhage P, Kasture SB, Mohan M. Analgesic, anti-inflammatory, antioxidant and antiulcer activity of ethanolic extract of Sterculia scaphigera Hance (Sterculiaceae) seeds in mice and rats. Int J Biol Pharm Res 2013; 4: 35-45.

[26] Kassem HA, EID HH, Abdel-Latif HA. Chemical constituents of Firmiana hainanensis Kosterm. Bull Fac Pharm Cairo Univ 2002; 40(2): 85-91.

[27] Kassem HA. Study of further phytocconstituents of Brachychiton discolor F.J. Muell. cultivated in Egypt. Bull Fac Pharm Cairo Univ 2007; 45: 155-60.

[28] Dubey P, Tiwari JS. Flavonoids and other constituents of Sterculia genus. J Indian Chem Soc 1991; 68: 426-7.

[29] Ogihara Y, Ogawa M, Aoyama T. The constituents of the barks of Firmiana planifolia Scott et Endl. Nagoya-shiritsu Daigaku Yakugakubu Kenkyu Nempo 1975; 23: 52-32.

[30] Pan JY, Chen SL, Yang MH, Wu J, Sinkkonen J, Zhou K. An update on lignans: natural products and synthesis. Nat Prod Rep 2009; 26(10): 1251-92.

[31] Kim JW, Yang H, Cho N, Kim B, Kim YC, Sung SH. Hepatoprotective constituents of Firmiana simplex stem bark against ethanol insult to primary rat hepatocytes. Pharmacogn Mag 2015; 11(41): 55-60.
Chemical characterization of the oil of Sterculia striata Str. HIL. et NAUD. Nuts. Quin Nova 2004; 23(7): 404-8.

Chaves MH, Barbosa AS, Neto JMM, Aued-Pimentel S, Lago JHG. Characteristics and fatty acid composition of Brachychiton species seeds and the oils (Sterculiaceae). J Agric Food Chem 1991; 39(5): 881-2.

Herrera-Meza S, Martínez AJ, Sánchez-Otero MG, Mendoza-López MR, García-Barradas O, Ortiz-Viveros GR, et al. Fatty acid composition and some physicochemical characteristics of Sterculia apetala seed oils. Grasas y Aceites 2014; doi:10.3989/gya.0223141.

Rao KS. Chinese pharmaceutical formulations for scalp and head. Faming Zhuanli Shenqing Gongkai Shuomingshu 2010; 8 pp. [Chem. Abs. 153: 242285]

Saules M, Klijn J, Ball G, van der Wal A, van Leeuwenhoek A, et al. Antiplasmodial activity of extracts from seven medicinal plants used in malaria treatment in Cameroon. J Ethnopharmacol 2009; 123(3): 483-8.

Yousif F, Hifnawy MS, Soliman G, Boulos L, Labib T, Mahmoud S, et al. Large-scale in vitro Screening of Egyptian native and cultivated plants for schistosomicidal activity. J Ethnopharmacol 2010; 127(4): 543-52.

Keskin C, Kacar S. Fatty acid composition of root and shoot samples of some Astragalus L. (Fabaceae) taxa growing in the east and southeast of Turkey. Turk J Biol 2013; 37(1): 122-8.

Patra AK, Saxena J. Dietary phytochemicals as rumen modifiers: a review of the effects on microbial populations. Antonie Van Leeuwenhoek 2009; 96(4): 363-75.

Kawada I. Food and cosmetics containing removers of active oxygen. Chemical characterization of the oil of Sterculia diversifolius as a source of natural products: antibacterial and antioxidant activities. BioResources 2014; 9(3): 3835-45.

Boyom FF, Kemege EM, Tepongning R, Ngouama V, Mbacham WF, Orisakeye OT, Olugbade TA. Epicatechin and procyanidin B2 in the air-dried wood, bark, and leaves of Brachychiton diversifolius R. BR: antibacterial, antifungal, and antioxidant activities. BioResources 2014; 9(3): 3835-45.

Chinsembu KC, Hedimbi M. Ethnomedicinal plants and other natural products with anti-HIV active compounds and their putative modes of action. Int J Biotechnol Mol Biol Res 2007; 4(3): 1843-50.

Yousif F, Hifnawy MS, Soliman G, Boulos L, Labib T, Mahmoud S, et al. Large-scale in vitro Screening of Egyptian native and cultivated plants for schistosomicidal activity. J Ethnopharmacol 2010; 127(4): 543-52.

Keskin C, Kacar S. Fatty acid composition of root and shoot samples of some Astragalus L. (Fabaceae) taxa growing in the east and southeast of Turkey. Turk J Biol 2013; 37(1): 122-8.

Chinsembu KC, Hedimbi M. Ethnomedicinal plants and other natural products with anti-HIV active compounds and their putative modes of action. Int J Biotechnol Mol Biol Res 2007; 4(3): 1843-50.

Yousif F, Hifnawy MS, Soliman G, Boulos L, Labib T, Mahmoud S, et al. Large-scale in vitro Screening of Egyptian native and cultivated plants for schistosomicidal activity. J Ethnopharmacol 2010; 127(4): 543-52.

Keskin C, Kacar S. Fatty acid composition of root and shoot samples of some Astragalus L. (Fabaceae) taxa growing in the east and southeast of Turkey. Turk J Biol 2013; 37(1): 122-8.

Patra AK, Saxena J. Dietary phytochemicals as rumen modifiers: a review of the effects on microbial populations. Antonie Van Leeuwenhoek 2009; 96(4): 363-75.

Keskin C, Kacar S. Fatty acid composition of root and shoot samples of some Astragalus L. (Fabaceae) taxa growing in the east and southeast of Turkey. Turk J Biol 2013; 37(1): 122-8.

Patra AK, Saxena J. Dietary phytochemicals as rumen modifiers: a review of the effects on microbial populations. Antonie Van Leeuwenhoek 2009; 96(4): 363-75.

Keskin C, Kacar S. Fatty acid composition of root and shoot samples of some Astragalus L. (Fabaceae) taxa growing in the east and southeast of Turkey. Turk J Biol 2013; 37(1): 122-8.

Patra AK, Saxena J. Dietary phytochemicals as rumen modifiers: a review of the effects on microbial populations. Antonie Van Leeuwenhoek 2009; 96(4): 363-75.

Keskin C, Kacar S. Fatty acid composition of root and shoot samples of some Astragalus L. (Fabaceae) taxa growing in the east and southeast of Turkey. Turk J Biol 2013; 37(1): 122-8.

Patra AK, Saxena J. Dietary phytochemicals as rumen modifiers: a review of the effects on microbial populations. Antonie Van Leeuwenhoek 2009; 96(4): 363-75.
