Chemical Constituents and Biological Activities of Cassia Genus: Review

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**ABSTRACT**

A review of chemical constituents and pharmacological activities of genus *Cassia*, Family Leguminosae has been presented. There are about 600 species of this genus distributed all around the world. Many of these species are still not investigated. Hence, an attempt is made to present a review on the phytochemical and biological studies of *Cassia* species that remain a potential source for new natural pharmacologically active components.

**Keywords:** Cassia genus; chemical constituents; biological activities

**INTRODUCTION**

Since ancient times, several societies have resorted to nature, mainly to plants as medical and healthy sources. Today, a great percentage of the world population, particularly in developing countries, use plants for facing the primary needs of medical assistance [1].

**Taxonomy**

Family Leguminosae is one of the largest families of the flowering plants. It comprises about 650 genera and 18000 species [2]. The Fabaceae or Leguminosae, commonly known as the legume, pea or bean family, is a large and economically important family of flowering plants. Plants of this family are found throughout the world, growing in many different environments and climates. The plants range in habit from giant trees to small annual herbs, with the majority being herbaceous perennials. The plants have indeterminate inflorescences, which are sometimes reduced to a single flower. The flowers have a short hypanthium and a single carpel with a short gynophore, and after fertilization produces fruits that are legumes. The leaves are usually alternate compounds and are even - or odd-pinnately compound. The name "Cassia" means "Cinnamon-like bark". Besides,
the genus Cassia was for long ill-delimited with regards to the related Cassiinae - especially Senna (which has many medicinal important species) [3].

Leguminosae is divided into three subfamilies: Caesalpinioideae, Papilionoideae, and Mimosoideae. These sub-families are now treated as independent families due to their numerous species and named, Caesalpiniaceae, Papilionaceae, and Mimosaceae [4]. The name Caesalpinioideae is derived from the generic name Caesalpinia. The Caesalpinioideae are mainly trees distributed in the moist tropical area. Caesalpiniaceae represents approximately 11% of the known legume flora, with 152 genera and 2800 species [5]. Cassia is a major genus of the Caesalpiniaceae, comprising about 600 species [6].

3. Traditional uses of Genus Cassia

Some of them are used in traditional folk medicines as a laxative, purgative, antimalarial, ulcer healing, antidiabetic, hepatoprotective, nephroprotective, antitumor and also used in the treatment of skin infection and periodic fever throughout the tropical and subtropical region.

4. Chemical constituents of genus Cassia

Deep reviewing of literature concerning genus Cassia revealed the isolation and separation of different following classes of compounds: A number of authors isolated and identified several compounds from different Cassia species such as anthraquinones, anthracenes, polyphenols, fatty acids, sterols, polysaccharides and some other miscellaneous compounds from different Cassia species [7] summarized in table 1, 2, 3 and their chemical structure in Fig. 1 (Fig. 1.1-Fig. 1.21), Fig. 2 (Fig. 2.1-Fig. 2.5) and Fig. 3 (Fig. 3.1-

5. Reported biological activities of species belonging to genus Cassia

Previous evaluation of the pharmacological benefits of many Cassia species showed that most of them possess many biological activities of great importance made some of them be included in the pharmacopoeia like C. glauca C. angustifolia and C. acutifolia. Some of these important activities such as antioxidant activity, antidiabetic, hepatoprotective activity and cytotoxic activity; all are summarized in table 4.

The phytochemical constituents and biological activities of compounds isolated and identified from Cassia were searched through SciFinder that retrieves information in databases produced by Chemical Abstracts Service (CAS) as well as the MEDLINE database of the National Library of Medicine. The data was updated in March 2019, regarding chemical constituents or biological activities and Cassia keywords.

CONCLUSION

The Cassia species have been carefully studied for their phytoconstituents as well as for their biological activities. From collected data it was observed that many phytochemical constituents were isolated from different Cassia species; anthraquinones, anthracene and phenolic acids. Many biological activities were reported about Cassia species such as; antidiabetic, antioxidant hepatoprotective, cytotoxic and hypolipidemic effects. Emodin, chrysophanol, and rhein are widely distributed throughout this genus which recommends that these compounds may be chemotaxonomic markers of the genus Cassia.
Table 1. Reported anthraquinones, anthracenes and their derivatives in different *Cassia* species

| Species           | Compound name (compound number)                        | Investigated part | Reference |
|-------------------|--------------------------------------------------------|-------------------|-----------|
| *C. alata*        | Alatinone (1)                                          | Stem              | [8]       |
|                   | Rhein (2)                                              |                   |           |
|                   | Aloe-emodin (3)                                        |                   |           |
|                   | Emodin (4)                                             |                   |           |
|                   | Chrysophanol (5)                                       |                   |           |
|                   | Physcion (6)                                           |                   |           |
|                   | Sennoside A (7)                                        | Stem              | [9]       |
|                   | Sennidine A (8)                                        |                   |           |
|                   | Sennoside B (9)                                        | Leaves            | [10]      |
| *C. angustifolia* | Sennidine B (10)                                       | Leaves            |           |
|                   | Aloe-emodin 8-O-glucoside (11)                         |                   |           |
|                   | Torachrysone 8-O-glucoside (12)                        | Leaves            | [11]      |
|                   | Emodin 8-O-sophoroside (13)                            |                   |           |
|                   | Aloe-emodin anthrone 8,8’-di-O-glucoside (14)         |                   |           |
| *C. corymbosa*    | Emodin (4)                                             | Leaves            | [12]      |
|                   | Chrysophanol (5)                                       |                   |           |
|                   | Physcion (6)                                           |                   |           |
|                   | Floribundone-1 (15)                                   |                   |           |
| *C. idymobotrya*  | 5,10-dihydroxy-2-methyl-9-(physcion-7’-yl) 1,4-anthraquinone (16) | Pods              | [13]      |
|                   | Knipholone (17)                                        |                   |           |
| *C. floribunda*   | Floribundone-1 (15)                                   | Leaves            | [6]       |
|                   | Floribundone-2 (18)                                   |                   |           |
|                   | 1-Chrysophanol (5)                                     |                   |           |
| *C. glauca*       | 2-Physcion (6)                                         | Stem & Bark       | [14]      |
|                   | 3- Aloe-Emodin (3)                                     | Bark              | [6]       |
| *C. greggii*      | 5-hydroxy-1,4,6,7-tetramethoxy-2-methylanthraquinone (19) | Roots             | [16]      |
|                   | 1,5,7-trihydroxy-4,6-dimethoxy-2-methylanthraquinone (20) |                   |           |
|                   | 5,6-dihydroxy-1,4,7-trimethoxy-2-methylanthraquinone (21) |                   |           |
| *C. javanica*     | 1-hydroxy-4,7-dimethoxy-5,6-methylenedioxy-2-methylanthraquinone (22) | Roots             | [16]      |
|                   | 5,7-dihydroxy-1,4,6-trimethoxy-2-hydroxymethylanthraquinone (23) |                   |           |
|                   | 4,5-dihydroxy-1,6,7-trimethoxy-2-methylanthraquinone (24) |                   |           |
|                   | 5,6-dihydroxy-4,7dimethoxy-2-methylanthraquinone (25)  |                   |           |
|                   | 1,6-dihydroxy-3-methylanthraquinone 8-O-α-L-rhamno-pyranoside (26) | Root bark         | [6]       |
| *C. kleinii*      | 1,5,6-trihydroxy-3 methylanthraquinone 8-O-α-L- rhamnopiranoside (27) | Roots             | [17]      |
|                   | kleinioxanthrone-1 (28)                               |                   |           |
|                   | kleinioxanthrone-2 (29)                               |                   |           |
|                   | kleinioxanthrone-3 (30)                               |                   |           |
|                   | kleinioxanthrone-4 (31)                               |                   |           |
| *C. laevigata*    | 1-hydroxy-6-methoxy-3-methylanthraquinone 8-O-β-D-galactosyl-(1→6)-O-β-D-galactopyranoside (32) | Pods              | [6]       |
| Species          | Compound name (compound number)                                                                 | Investigated part | Reference |
|------------------|-------------------------------------------------------------------------------------------------|-------------------|-----------|
| *C. longiracemosa* | Chrysophanol (5)                                                                                   | Root, bark        | [18]      |
|                  | Physcion (6), Torosachrysone (33)                                                                 |                   |           |
|                  | 8-(chrysophanol-7-yl)-8-hydroxy-chrysophanol-9-anthrone (34)                                       |                   |           |
|                  | Nataloe- emodin (35)                                                                               |                   |           |
|                  | Chrysophanolbianthrone (36)                                                                       |                   |           |
|                  | Chrysophanol-physcionbianthrone (37)                                                                |                   |           |
|                  | Chrysophanol-isophyscionbianthrone (38)                                                              |                   |           |
|                  | Isophyscionbianthrone (39)                                                                         |                   |           |
|                  | 1,3-dihydroxy-6,8dimethoxy-2-methyl anthraquinone 3-O-α-L-rhamnosyl-(1→6)- O-β-D-glucopyranoside (40) |                   |           |
| *C. marginata*   | Root, bark                                                                                        |                   | [6]       |
|                  | Physcion (6)                                                                                       |                   |           |
|                  | Floribundone-1 (15)                                                                               |                   |           |
|                  | Torosachrysone (33)                                                                                |                   |           |
| *C. multiglandulosa* | Anhydrophlegmacin B2 (41)                                                                            |                   | [19]      |
|                  | Isosengulone (42)                                                                                  |                   |           |
|                  | Sengulone (43)                                                                                    |                   |           |
|                  | Emodin (4)                                                                                        | Seeds             |           |
|                  | Floribundone-1 (15)                                                                               |                   |           |
| *C. occidentalis* | Physcion (6)                                                                                       | Roots             | [6]       |
|                  | Emodin (4)                                                                                        |                   |           |
|                  | Chrysophanol (5)                                                                                   |                   |           |
|                  | Physcion (6)                                                                                       | Leaves            | [21]      |
|                  | Aloe-emodin (3)                                                                                   |                   |           |
|                  | Occidental- 1 (44)                                                                                 |                   |           |
|                  | Occidental- II (45)                                                                                |                   |           |
|                  | Torosachrysone (33)                                                                                |                   |           |
|                  | Isotoralactone (46)                                                                               |                   |           |
| *C. obtusifolia* | Toralactone (47)                                                                                  | Seeds             | [22]      |
|                  | *Cassia* lactone (48)                                                                              |                   |           |
|                  | 1,8-dihydroxy-3-methoxy-6-methylxanthine (49)                                                     | Leaves            | [23]      |
| *C. obtuse*      | 1,3-dihydroxy-6 methoxy-7-methyl anthraquinone (50)                                               | Root              | [24]      |
|                  | 1-hydroxy-3,7-di-formyl anthraquinone (51)                                                         |                   |           |
| *C. pudibunda*   | Emodin (4)                                                                                        | Roots             | [25]      |
|                  | Chrysophanol (5)                                                                                   |                   |           |
|                  | Physcion (6)                                                                                       |                   |           |
|                  | Chrysophanol dimethyl ether (52)                                                                   |                   |           |
|                  | Emodin (4)                                                                                         |                   |           |
| *C. roxburghii*  | Emodin 1-O-β-D-glucopyranosyl-(1→6)-O-β-D-glucopyranoside (53)                                     | Leaves            | [26]      |
|                  | Aloe-emodin 8-O-β-D-glucopyranosyl-(1→6)-O-β-D-glucopyranoside (54)                               |                   |           |
|                  | Roxburghinol (55)                                                                                  | Leaves            | [6]       |
| *C. reticulata*  | 1-hydroxyxanthone-6,8 dicarboxylic acid (56)                                                      | Leaves            | [27]      |
|                  | 1,2,6-trihydroxy-7,8-dimethoxy-3-methyl anthraquinone (57)                                         |                   |           |
| *C. sophera*     | 1,2,7-trihydroxy-6,8-dimethoxy-3-methyl anthraquinone (58)                                         | Heartwood         | [6]       |
|                  | 1,8-dihydroxy-2-methyl anthraquinone 3-neohesperidoside (59)                                       | Root, bark        | [6]       |
|                  |                                                                                                  |                   |           |
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| Species | Compound name (compound number) | Investigated part | Reference |
|---------|---------------------------------|-------------------|-----------|
| *C. siamea* | Chrysophanol (5) | Heartwood | [28] |
| | Physcion (6) | | |
| | 4,4′-bis(1,3-dihydroxy-2-methyl-6,8-dimethoxy anthraquinone) (60) | | |
| | Emodin (4) | | |
| | Chrysophanol (5) | | |
| | 1,1′,3,8,8′-Pentahydroxy-3′,6′-dimethyl[2,2′-bianthracene]-9,9′,10,10′-tetrone (61) | Root bark | [29] |
| | 7-Chloro-1,1′,6,8,8′-pentahydroxy-3,3′-dimethyl[2,2′-bianthracene]-9,9′,10,10′-tetrone (62) | | |
| | Cassiamin A (63) | | |
| | 5-chlorocassiamin A (64) | | |
| | 1-[β-D-glucopyranosyl-(1→3)-O-β-D-glucopyranosyl-(1→6)-O-β-D-glucopyranosyl]oxy]-8-hydroxy-3-methyl-9,10-anthraquinone (65) | | [30] |
| | 1-[β-D-glucopyranosyl-(1→6)-O-β-D-glucopyranosyl-(1→6)-O-β-D-glucopyranosyl]oxy]-8-hydroxy-3-methyl-9,10-anthraquinone (66) | Seeds | |
| | 2-([β-D-glucopyranosyloxy]-8-hydroxy-3-methyl-1-methoxy-9,10-anthraquinone (67) | | |
| *C. torosa* | 1-desmethylaurantio-obtusin (68) | | |
| | 1-desmethylichryso-obtusin (69) | | |
| | Aurantio-obtusin (70) | | [31] |
| | Chryso-obtusin (71) | | |
| | Obrusin (72) | | |
| | Torososide A (73) | Leaves | [32] |
| | Torosachrysone (33) | | |
| | Emodin (4) | | |
| | Chrysophanol (5) | Seedlings | [6] |
| | Physcion (6) | | |
| | Chrysophanol dimethyl ether (52) | | |
| | Physcion-9-anthrone (74) | | |
| | Phlegmacin A2 and B2 (75) | | |
| | Anhydrophlegmacin-9,10-quinones A2 and B2 (76) | | |
| | Anhydrophlegmacin B2 (41) | | |
| | Physcion-10,10′-bianthrone (77) | | |
| | Torosanin (78) | | |
| | Torosachrysone (33) | | |
| | Phlegmacin A2 and B2 (75) | Unripe seeds | [6] |
| | Anhydrophlegmacin-9,10-quinones A2 and B2 (76) | | |
| | Torosachrysone (33) | | |
| | Torosachrysone (33) | | |
| | Germitorosone (79) | | |
| | Methylgermitorosone (80) | unripe seeds | [34] |
Table 2. Phenolic compounds reported in different *Cassia* species

| Species          | Compound name (compound number)                  | Investigated part | Reference |
|------------------|--------------------------------------------------|--------------------|-----------|
| *C. alata*       | Chrysoeriol-7-O-(2'-O-β-D-mannopyranosyl)-β-D-allopyranoside (81) | Seeds              | [35]      |
|                  | Rhamnetin-3-O-(2'-O-β-D-mannopyranosyl)-β-D-allopyranoside (82) |                    |           |
|                  | Kampferol (83)                                    |                    |           |
| *C. auriculata*  | Quercetin (84)                                   | Aerial parts       | [36]      |
|                  | Kaempferol 3-O-rutinoside (85)                    |                    |           |
|                  | Luteolin (86)                                    |                    |           |
| *C. angustifolia*| Quercetine 3-O-gentiobioside (87)                | Leaves             | [37]      |
|                  | Kaempferol 3-O-gentiobioside (88)                |                    |           |
|                  | Isorhaminent 3-O-gentiobiosid (89)               |                    |           |
| *C. fistula*     | (2'S)-7-hydroxy-5-hydroxymethyl-2-(2'-hydroxypropyl) chromone (90) | Leaves             | [38]      |
|                  | Benzy1-2-O-β-D-glucopyranosyl-3,6-dimethoxybenzoate (91) |                    |           |
| *C. glauca*      | Apigenin (92)                                    | Leaves             | [39]      |
|                  | Luteolin (86)                                    |                    |           |
|                  | Quercetin (84)                                   |                    |           |
|                  | Quercetin-3-O-β-D-glucopyranoside (93)           |                    |           |
|                  | Kaempferol-3-O-rutinoside (85)                   |                    |           |
|                  | Rutin (94)                                       |                    |           |
|                  | Quercetin-3-O-glucoside-7-O-rhamnoside (95)      |                    | [40]      |
| *C. garrettiana* | Cassigarol A (96)                                | Heart wood         | [41]      |
|                  | Cassigarol A (96)                                |                    |           |
|                  | Cassigarol C (97)                                |                    |           |
|                  | Cassigarol B (98)                                |                    |           |
|                  | Cassigarol D (99)                                |                    |           |
|                  | Cassigarol E (100)                               |                    |           |
|                  | Cassigarol F (101)                               |                    |           |
|                  | Cassigarol G (102)                               |                    |           |
| *C. italic*      | Apigenin (92)                                    | Aerial parts       | [44]      |
|                  | Kampferol (83)                                   |                    |           |
|                  | Quercetin (84)                                   |                    |           |
|                  | Apaginin 7-O-β-D-glucoside (103)                 |                    |           |
|                  | Kampferol 7-O-β-D-glucoside (104)                |                    |           |
|                  | Quercetin 7-O-β-D-glucopyranoside (105)          |                    |           |
|                  | Tamarixetine 7-O-α-L-rhamnopyranoside, 3-rutinoside (106) |                    |           |
|                  | Isorhaminent 7-O-β-D-glucopyranoside, 3-rutinoside (107) |                    |           |
| *C. javanica*    | Dihydrothamnetin-3-O-β-D-glucopyranoside (108)   | Flowers            | [45]      |
|                  | Leucocyanidin- 6'-O-methyl ether-3-O-β-D-galactopyranoside (109) |                    |           |
| *C. nomame*      | Demethyktorosaflavone C (110)                    | Aerial parts       | [46]      |
|                  | Demethyktorosaflavone D (111)                    |                    |           |
|                  | Luteolin (86)                                    |                    |           |
|                  | Luteolin 7- O-β-D-glucopyranoside (112)          |                    |           |
|                  | Vitexin (113)                                    |                    |           |
### Table 3. Some miscellaneous compounds have been isolated from different Cassia species

| Species       | Compound name (compound number) | Investigated part | Reference |
|---------------|----------------------------------|-------------------|-----------|
| *C. auriculata* | Di-(2-ethyl)-hexylphthalate (121) | Leaves            | [48]      |
| *C. floribunda* | N₁,N⁸-dibenzoylspermidine (122) | Leaves            | [49]      |
| *C. glauca*    | Palmitic acid (123)               | Seeds oil         | [50]      |
|                | Stearic acid (124)                |                   |           |
|                | Oleic acid (125)                  |                   |           |
|                | Linoleic acid (126)               |                   |           |
|                | Linolenic acid (127)              |                   |           |
|                | Arachidic acids (128)             |                   |           |
|                | β-Sitosterol- β-D-glucoside (129) | Stem              | [15]      |
|                | Galactomannan (130)               |                   | [6]       |
| *C. italic*    | β-Sitosterol (131)                | Leaves            | [51]      |
|                | Stigmasterol (132)                |                   |           |
| *C. laevigata* | Calendin (133)                   | Leaves            | [52]      |
|                | Cinnamic acid (134)               |                   |           |
|                | 3-hydroxy-1-(4-hydroxy-3-methoxyphenyl)-propan-1-one (135) | | |
|                | 2,3-dihydroxy-1-(4-hydroxy-3-methoxyphenyl)-propan-1-one (136) | | |
|                | 3-hydroxy-1-(4-hydroxy-3,5-dimethoxyphenyl)-propan-1-one (137) | | |
|                | Syringic acid (138)               |                   |           |
|                | Vanillic acid (139)               |                   |           |
| *C. leptophylla* | (-)-spectalin (140)              | Leaves            | [53]      |
|                | (-)-spectalinin (141)             |                   |           |
|                | Canavalin (142)                  |                   |           |
|                | Leptophyllin A (143)             |                   |           |
|                | 3-acetylleptophyllin (144)        |                   |           |
|                | (+)-spectaline (145)              |                   |           |
|                | Iso-6-canavaline (146)            |                   |           |
|                | Leptophyllin B (147)              |                   |           |
| Species        | Compound name (compound number)                                                                 | Investigated part     | Reference |
|---------------|-------------------------------------------------------------------------------------------------|-----------------------|-----------|
| C. multijuga  | 5-acetonyl-7-hydroxy-2-methylchromone (148)                                                     | Leaves                | [54]      |
|               | 5 - Acetonyl - 2 - methylchromone - 7 -O - β - D-glucopyranoside (149)                          |                       |           |
| C. nodosa     | Nodolidate (150)                                                                                | Bark                  | [55]      |
| C. occidentalis| Phytosterol (151)                                                                               | Roots                 | [21]      |
| C. obtusifolia| (4R, 5S, 6E, 8Z)-ethyl-1-enyl]-5-hydroxypentadeca-6,8-dionate (152)                            | Leaves                | [22]      |
|               | Stigmasterol (132)                                                                              |                       |           |
|               | Lupeol (153)                                                                                    |                       |           |
|               | Buteolinic acid (154)                                                                            |                       |           |
|               | Friedelin (155)                                                                                  |                       |           |
| C. sophera    | β-Sitosterol (131)                                                                              | Leaves                | [56]      |
| C. tora       |                                                                                                 | Seeds                 | [57]      |
| C. siamea     |                                                                                                 | Leaves                | [58]      |
|               | Barakol (157)                                                                                   |                       |           |
|               | Chrobisiamone A (158)                                                                            | Flowers               | [60]      |
|               | Cassiarin A (159)                                                                               |                       |           |
|               | Cassiadiamine (160)                                                                             | Flowers               |           |
|               | 5-acetonyl-7-hydroxy-2-methylchromone (148)                                                     |                       |           |
|               | (+)-6-Hydroxymellein (161)                                                                       |                       |           |
|               | (+)-6-Hydroxymellein diacetate (162)                                                            |                       |           |
|               | Chaksine (163)                                                                                  |                       |           |

**Table 4. Biological activities of genus Cassia**

| Biological activities | Species        | Part or compound responsible for the activity                                                                 | Reference |
|-----------------------|----------------|---------------------------------------------------------------------------------------------------------------|-----------|
| Antacid activity      | C. garritiana  | Cassigarol A (Heartwood)                                                                                        | [41]      |
| Anxiolytic activity   | C. siamea      | Barakol (leaves)                                                                                               | [60]      |
|                       | C. abbreviata  | Root methanol extract, Kampferol, Quercetin, Kaempferol 3-O-rutinoside, Luteolin                                | [61]      |
|                       | C. auriculata  | (Aerial parts) Flowers extract, Different root fractions                                                        | [62]      |
|                       |                |                                                                                                               | [63]      |
|                       | C. angustifolia| Aqueous flower extract                                                                                          | [64]      |
| Antioxidant activity  | C. fistula     | Crude extracts from stem bark, leaves, flowers, and fruit pulp                                               | [65]      |
|                       |                | Flower butanol extract                                                                                         | [66]      |
|                       |                | Leave ethanol extract                                                                                         | [67]      |
|                       |                | Leaves methanol extract                                                                                        | [68]      |
|                       |                | Leaves ethanol extract                                                                                        | [69]      |
|                       |                | Flower methanol extract                                                                                        | [70], [71]|
|                       | C. glauca      | Leaves, flower, stem and pod methanol extracts, Seed extract, Acetone seed extract                             | [71]      |
|                       |                | Acetone seed extract                                                                                          | [72]      |
| Biological activities | Species          | Part or compound responsible for the activity                                                                 | Reference |
|-----------------------|------------------|-------------------------------------------------------------------------------------------------------------|-----------|
| C. italica            | Methanol leaves extract |                                                                                                           | [76]      |
|                       | The ethanolic extracts of aerial parts                                                                 |                                                                 | [77]      |
| C. javanica           | Ethanol leaves extract |                                                                                                           | [76]      |
| C. nodaosa            | Stem & bark methanolic extracts - Emodin - Emodin 1-O-β-D-glucopyranosyl-(1→6)-O-β-D-glucopyranoside.       |                                                                 | [26]      |
|                       | Aloe-emodin 8-O-β-D-glucopyranosyl-(1→6)-O-β-D-glucopyranoside. (leaves)                                 |                                                                 |           |
| C. roxburghii         | Methanol leaves & flowers extract                                                                       |                                                                 | [76]      |
|                       | Flower extract                                             |                                                                                                           | [78]      |
| C. semen              | Leaves aqueous extract                                     |                                                                                                           | [79]      |
| C. tora               | Leaves extract                                             |                                                                                                           | [80]      |
|                       | Methanol extract                                           |                                                                                                           | [81]      |
| C. alata              | Leaves aqueous extract                                     |                                                                                                           | [82]      |
| C. auriculata         | Polyphenolic extract                                       |                                                                                                           | [83]      |
|                       | Leaves acetone extract                                      |                                                                                                           | [85]      |
|                       | Leaves aqueous extract                                      |                                                                                                           | [86]      |
|                       | Bark aqueous extract                                        |                                                                                                           | [87]      |
| Antidiabetic          | C. glauca                                                  | Flower aqueous and methanol extracts                                                                    | [88]      |
|                       | Ethanol leaves extract                                     |                                                                                                           | [89]      |
|                       | Polyphenolic extract                                       |                                                                                                           | [69]      |
|                       | Leaves aqueous extract                                     |                                                                                                           | [70]      |
| Anti-ulcer activity   | C. semen                                                   | Leaves extract                                                                                                | [71]      |
|                       | C. siamea                                                  | Leaves extract                                                                                                | [72]      |
|                       | C. auriculata                                              | Leaf extract                                                                                                | [73]      |
|                       | C. alata                                                   | Kaempferol 3-O-sophoroside - Leaves extract                                                                | [74]      |
| Analgesic and anti-inflammatory activity | C. fistula                                                 | The ethanolic extract of the aerial part                                                                   | [67]      |
|                       | C. siamea                                                  | Stem bark extract                                                                                            | [93]      |
|                       | C. uniflora                                                | Leaves extract                                                                                                | [94]      |
| Antibacterial         | C. bakeriana                                               | Leaves and bark ethanol extracts                                                                          | [95]      |
|                       | Leaves and flower extracts                                 |                                                                                                           | [73]      |
|                       | Seed methanol and acetone extracts                          |                                                                                                           | [96]      |
|                       | Leaves methanol extract                                    |                                                                                                           | [69]      |
|                       | Flower methanol extract                                    |                                                                                                           | [97]      |
|                       | Seed extract                                                |                                                                                                           | [72]      |
|                       | C. glauca                                                  | Ethyl acetate leaves extract                                                                               | [76]      |
|                       | Ethyl acetate seed coat extract                             |                                                                                                           | [76]      |
|                       | Ethanolic leaves extract                                   |                                                                                                           | [76]      |
|                       | Leaves extract                                              |                                                                                                           | [99]      |
|                       | C. alata                                                   | Leaves extract                                                                                                |           |
| Antifungal            | C. glauca                                                  | Leaves acetone extract                                                                                      | [70]      |
|                       | Flower methanol extract                                    |                                                                                                           | [100]     |
|                       | Seed methanol and acetone extracts                          |                                                                                                           | [72]      |
|                       | C. spectabilis                                             | Flower methanol extract                                                                                     | [76]      |
|                       | Ethanolic leaves extract                                   |                                                                                                           | [76]      |
|                       | C. tora                                                    | Ethanolic leaves extract                                                                                   | [76]      |
| Biological activities       | Species          | Part or compound responsible for the activity                      | Reference |
|-----------------------------|------------------|---------------------------------------------------------------------|-----------|
| Cytotoxic activity          | *C. bakeriana*   | Leaves and bark ethanol extracts                                    | [95]      |
|                             | *C. fistula*     | Leaves extract                                                      | [101]     |
|                             | *C. glauca*      | Leaves ethanol extract                                               | [69]      |
|                             |                  | Leaves methanol extract                                             | [68]      |
|                             |                  | Hydro alcoholic extract of aerial part                              |           |
|                             | *C. tora*        | Leaves extract                                                      | [102]     |
|                             |                  | Flowers extract                                                     | [103]     |
|                             | *C. auriculata*  | Leaves aqueous extract                                              | [83]      |
|                             | *C. siamea*      | Leaves extract                                                      | [78]      |
|                             | *C. semen*       | Leaves aqueous extract                                              | [79]      |
|                             | *C. tora*        | Seed extract                                                        | [104]     |
|                             |                  | Flowers extract                                                     | [105]     |
|                             |                  | Root methanol extract                                               |           |
|                             | *C. abbreviata*  | Leaves methanol extract                                             | [108]     |
|                             |                  | Leaves extract                                                      | [107]     |
|                             | *C. auriculata*  | Leaves methanol extract                                             | [109]     |
|                             | *C. fistula*     | Leaves extract                                                      |           |
|                             | *C. occidentalis*| Leaves methanol extract                                             | [110]     |
|                             | *C. auriculata*  | Flower ethanol extract                                              |           |
|                             | *C. auriculata*  | Polyphenols derived from flowers extract                            |           |
|                             | *C. alata*       | Leaves extract                                                      | [111]     |
|                             | *C. podocarpa*   | Leaves extract                                                      |           |
|                             | *C. fistula*     | Leaves extract                                                      | [112]     |

![Fig.1.1. Structure of compound 1](image1)

![Fig.1.2. Structure of compounds 2 and 3](image2)

![Fig.1.3. Structure of compounds 4-6](image3)
Fig. 1.4. Structure of compounds 4-14
Fig. 1.5. Structure of compounds 15 - 18

|   | R<sub>1</sub> | R<sub>2</sub> | R<sub>3</sub> | R<sub>4</sub> | R<sub>5</sub> | R<sub>6</sub> |
|---|-------------|-------------|-------------|-------------|-------------|-------------|
| 19 | OMe | Me | OMe | OH | OMe | OMe |
| 20 | OH | Me | OMe | OH | OMe | OH |
| 21 | OMe | Me | OMe | OH | OH | OMe |
| 22 | OH | Me | OMe | OH | OMe | OH |
| 23 | CH<sub>3</sub>OH | OMe | OMe | OH | OMe | OH |
| 24 | OMe | Me | OH | OH | OMe | OMe |
| 25 | H | Me | OMe | OH | OH | OMe |

Fig. 1.6. Structure of compounds 19 - 25

|   | R<sub>1</sub> | R<sub>2</sub> | R<sub>3</sub> | R<sub>4</sub> |
|---|-------------|-------------|-------------|-------------|
| 26 | H | O-α-L-rhamnopyranoside | OH | H |
| 27 | H | O-α-L-rhamnopyranoside | OH | OH |

Fig. 1.7. Structure of compounds 26 and 27
Fig. 1.8. Structure of compounds 28 - 31

Fig. 1.9. Structure of compound 32

Fig. 1.10. Structure of compounds 33 and 34

Fig. 1.11. Structure of compound 35
**Fig. 1.12.** Structure of compounds 36 - 39

**Fig. 1.13.** Structure of compound 40

**Fig. 1.14.** Structure of compounds 41 and 44
Fig. 1.15. Structure of compounds 42 and 43

Fig. 1.16. Structure of compounds 45 – 49 and 60
Fig. 1.17. Structure of compounds 61 - 64

|   | R1 | R2 | R3 | R4 | R5 | R6 |
|---|----|----|----|----|----|----|
| 61 | H  | H  | Me | H  | OH |
| 62 | H  | Cl | OH | H  | Me |
| 63 | H  | H  | OH | H  | Me |
| 64 | H  | H  | OH | Cl | Me |

Fig. 1.18. Structure of compounds 50 – 54, 57- 59 and 68-72

|   | R1 | R2 | R3 | R4 | R5 | R6 |
|---|----|----|----|----|----|----|
| 50 | OH | H  | OMe| Me | H  | OH |
| 51 | OH | H  | H  | CHO| H  | CHO|
| 52 | R  | H  | OH | H  | OH | Me |
| 53 | R  | H  | H  | H  | OH | CH₂OH|
| 54 | OH | OH | OH | OMe| Me |
| 55 | OH | OH | OMe| OH | OMe| Me |
| 56 | OH | Me | H  | H  | OH | Neohesperidoside|
| 57 | OH | OH | Me |
| 58 | OH | OMe| OMe| Me |
| 59 | OH | Me |
| 60 | OH | OH | Me |
| 61 | OH | OMe| OMe| Me |
| 62 | OMe| OH | OMe| OH | Me |
| 63 | OMe| OH | OMe| OMe| Me |
| 64 | OMe| OH | OMe| OMe| Me |
(65) $R_1 = R_2 = H$

(66) $R_1 = R_2 = H$

(67) $R_1 = \text{OCH}_3$, $R_2 = \beta$-D-glucopyranoside

Fig. 1.19. Structure of compounds 65 - 67

(73)

(74)

Fig. 1.20. Structure of compounds 73 and 74
Fig. 1.21. Structure of compounds 75 - 80

Fig. 1. Chemical structure of reported anthraquinones, anthracenes and their derivatives in different *Cassia* species in Fig. 1 (Fig.1.1- Fig.1.21).
Fig. 2.1. Structure of compounds 81-82, 90-91 and 96-99

Fig. 2. Chemical structure of reported Phenolic compounds in different Cassia species in figure 2 (Fig.2.1 – Fig.2.5).
Fig. 2.2. Structure of compounds 100-102 and 108-116
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**Fig. 2.3.** Structure of compounds 83-89, 92-95, 103-107 and 112
Fig. 2.4. Structure of compounds 117-119

![Image of compounds 117-119]

| R₁ | R₂ | R₃ | R₄ |
|----|----|----|----|
| (117) | Ac | Ac | H  | H  |
| (118) | Ac | H  | Ac | H  |
| (119) | Ac | H  | H  | Ac |

Fig. 2.5. Structure of compound 120

![Image of compound 120]
Fig. 3.1. Structure of compounds 121-128
Fig. 3.2. Structure of compounds 129-133

Fig. 3.3. Structure of compounds 134-139
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Fig. 3.4. Structure of compounds 140-142

Fig. 3.5. Structure of compounds 143-145

Fig. 3.6. Structure of compounds 146 and 147
Fig. 3. The chemical structure of reported some miscellaneous compounds have been isolated from different Cassia species in Fig. 3 (Fig.3.1 – Fig.3.8).
Declarations

Ethics approval and consent to participate
Not applicable

Consent to publish
Not applicable

Consent to publish
Not applicable

Availability of data and materials
All data generated or analyzed during this study are included in this published article in the main manuscript.

Competing interests
The authors declare that no competing interests exist

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6. REFERENCES

1. Tene, V., Malagon, O., Finzi, P. V., Vidari, G., Armijos, C., and Zaragoza, T. An ethnobotanical survey of medicinal plants used in Loja and Zamora-Chinchipe, Ecuador. J. Ethnopharmacol. 2007; 111(1), 63–81.

2. Hu, J.-M., Lavin, M., Wojciechowski, M. F., and Sanderson, M. J. Phylogenetic systematics of the tribe Millettieae (Leguminosae) based on chloroplast trnK/matK sequences and its implications for evolutionary patterns in Papilionoideae. Am. J. Bot. 2000; 87(3), 418–430.

3. Awomukwu, D.A., Nyananyo, B.L., Ikpeama, A.I. and Adieze, C.U. Comparative chemical constituents of some Cassia species and their pharmacognostic importance in South-Eastern Nigeria. Sci. J. of Chemi. 2015; 3(3), pp.40-49.

4. Gledhill, D. (2008). The names of plants. Cambridge University Press.

5. Willis C., (1973). A dictionary of the flowering plants and frens. 8th ed., Cambridge University Press. The USA.

6. Dave, H., and Ledwani, L. A review on anthraquinones isolated from Cassia species and their applications. Ind. J. Nat. Prod. Resour. 2012; Vol. 3(3), pp. 291-319.

7. Caro, Y., Anamale, L., Fouillaud, M., Laurent, P., Petit, T. and Dufosse, L., Natural hydroxyanthraquinoid pigments as potent food-grade colorants: an overview. Natural Products and Bioprospecting. J. Nat. Prod. 2012; 2(5), pp.174-193.

8. Kalidhar, S. B., and others. Alatinone, an anthraquinone from Cassia alata. Phytochem. 1993; 32(6), 1616–1617.

9. Fernand, V. E., Dinh, D. T., Washington, S. J., Fakayode, S. O., Losso, J. N., van Ravenswaay, R. O., and Warner, I. M. Determination of pharmacologically active compounds in root extracts of Cassia alata L. by use of high-performance liquid chromatography. Talanta, 2008; 74(4), 896–902.

10. Verma, R. K., Uniyal, G. C., Singh, S. P., Sharma, J. R., and Gupta, M. M. Reverse-phase High-Performance Liquid Chromatography of Sennosides in Cassia angustifolia. Phytoch. Anal. 1996; 7(2), 73–75.

11. Kinjo, J., Ikeda, T., Watanabe, K., and Nohara, T. An anthraquinone glycoside from Cassia angustifolia leaves. Phytochem. 1994; 37(6), 1685–1687.
Barba, B., Di\'iaz, J. G., & Herz, W. Anthraquinones and other constituents of two Senna species. Phytochem. 1992; 31(12), 4374–4375. 
https://doi.org/10.1016/S0031-9422(92)80483-U

12. Alemayehu, G., Hailu, A., and Abegaz, B. M. Bianthraquinones from Senna didymobotrya. Phytochem. 1996a; 42(5), 1423–1425. 
https://doi.org/10.1016/S0031-9422(96)00102-1

13. Tiwari, H.P., and Misra, M., 1993. Phytochemical investigation of Cassia glauca bark. J. Ind. Chem. Soc. 1993; 70(7), pp.653-653.

14. Kalidhar, S. B., and others. Chemical components of Cassia glauca lam. Ind. J. of Pharma. Sci. 1994; 56(1).

15. Gonza, A. G., Barrera, J. B., Davila, B. B., Valencia, E., Domi, X. A., & others. Anthraquinones from Cassia greggii. Phytochem. 1992; 31(1), 255–258. 
https://doi.org/10.1016/S0031-9422(91)83048-P

16. Anu, S. J., & Rao, J. M. Oxanthrone esters from the roots of Cassia kleinii. Phytochem. 2002; 59(4), 425–427. 
https://doi.org/10.1016/S0031-9422(01)00439-3

17. Alemayehu, G., Abegaz, B., Snatzke, G., and Duddeck, H. Bianthrones from Senna longiracemosa. Phytochem. 1993; 32(5), 1273–1277. 
https://doi.org/10.1016/S0031-9422(00)95104-5

18. Alemayehu, G., and Abegaz, B. M. Bianthraquinones from the seeds of Senna multitiglandulosa. Phytochem. 1996b; 41(3), 919–921. 
https://doi.org/10.1016/S0031-9422(95)00645-1

19. Abegaz, B. M., Bezabeh, M., Alemayehu, G., & Duddeck, H. Anthraquinones from Sena multitiglandulosa. Phytochem. 1994; 35(2), 465–468. 
https://doi.org/10.1016/S0031-9422(00)94783-6

20. Yadav, J.P., Arya, V., Yadav, S., Panghal, M., Kumar, S. and Dhanakhar, S., Cassia occidentalis L.: A review on its ethnobotany, phytochemical and pharmacological profile. Fitoterapia, 2010; 81(4), pp.223-230. 
https://doi.org/10.1016/j.fitote.2009.09.008

21. Sui-Ming, W., Wong, M. M., Seligmann, O., and Wagner, H. Anthraquinone glycosides from the seeds of Cassia tora. Phytochem. 1989; 28(1),
Chemical Constituents and Biological Activities of Cassia Genus: Review

211–214.

https://doi.org/10.1016/0031-9422(89)85040-X

31. Zhu, L., Yu, S., Zeng, X., Fu, X., & Zhao, M. Preparative separation and purification of five anthraquinones from Cassia tora L. by high-speed counter-current chromatography. Sep. Purif. Tech. 2008; 63(3), 665–669.

https://doi.org/10.1016/j.seppur.2008.07.011

32. Kitanaka, S., & Takido, M. (S)-5, 7′-biphyscion 8-glucoside from Cassia torosa. Phytochem. 1995; 39(3), 717–718.

https://doi.org/10.1016/0031-9422(94)00955-S

33. Takahashi, S., Kitanaka, S., Takido, M., Sankawa, U., and Shibata, S. Phlegmacins and anhydrophlegmacinquinones: Dimeric hydroanthracenes from seedlings of Cassia torosa. Phytochem. (UK) 1977; 16(7), 999–1002.

https://doi.org/10.1016/S0031-9422(00)86709-6

34. Takido, M., Kitanaka, S., Takahashi, S., and Tanaka, T. Germitorosone and methylgermitorosone, two hydroanthracene derivatives from seedlings of Cassia torosa. Phytochem. 1982; 21(2), 425–427.

https://doi.org/10.1016/S0031-9422(00)95281-6

35. Gupta, D., and Singh, J. Flavonoid glycosides from Cassia alata. Phytochem. 1991; 30(8), 2761–2763.

https://doi.org/10.1016/0031-9422(91)85140-U

36. Juan-Badaturuge, M., Habtemariam, S., and Thomas, M. J. K. Antioxidant compounds from a South Asian beverage and medicinal plant, Cassia auriculata. Food Chem. 2011; 125(1), 221–225.

https://doi.org/10.1016/j.foodchem.2010.08.065

37. Ganapaty, S., Thomas, P.S., Ramana, K.V., Vidyadhari, K.N. and Chakradas, V., A review of phytochemical studies of Cassia species. J. of Nat. Remedies. 2002; 2(2), pp.102-120.

38. Nagpal, M. A., Nagpal, N., Rahar, S., Shah, G., Swami, G., Kapoor, R., and others. Phytochemical investigation of methanolic extract of Cassia fistula leaves. J. Pharmacog. 2011; 3(26), 61–69.

https://doi.org/10.5530/pj.2011.26.11

39. El-Sayed, M. M., Abdel-Aziz, M. M., Abdel-Gawad, M. M., Abdel-Hameed, E. S., Ahmed, W. S., and Abdel-Lateef, E. E. Chemical constituents and cytotoxic activity of Cassia glauca Lan. Leaves. Life. Sci. 2013; 10(3), 1617–1625.

40. El-Sawi, S. A., Sleem, A. A., and others. Flavonoids and hepatoprotective activity of leaves of Senna surattensis (Burm. f.) in CCl4 induced hepatotoxicity in rats. Aust. J. Basic Appl. Sci. 2010; 4(6), 1326–1333.

http://www.insipub.com/ajbas/2010/1326-1333.pdf

41. Murakami, S., Arai, I., Muramatsu, M., Otomo, S., Baba, K., Kido, T., and Kozawa, M. Inhibition of gastric H+, K+-ATPase and acid secretion by cassigrol A, a polyphenol from Cassia garrettiana Craib. Biochem. Pharmacol. 1992; 44(1), 33–37.

https://doi.org/10.1016/0006-2952(92)90034-G

42. Baba, K., Kido, T., Maeda, K., Taniguchi, M., & Kozawa, M. Two stilbenoids from Cassia garrettiana. Phytochem. 1992; 31(9), 3215–3218.

https://doi.org/10.1016/0031-9422(92)83478-H

43. Baba, K., Kido, T., Taniguchi, M., and Kozawaq, M. Stilbenoids from Cassia garrettiana. Phytochem. 1994; 36(6), 1509–1513.

https://doi.org/10.1016/S0031-9422(00)89752-6

44. Mohamed, G. A. New cytotoxic cycloartan triterpenes from Cassia italica aerial parts. Nat. Prod. Res. 2014; 28(13), 976–983.

https://doi.org/10.1080/14786419.2014.902820

45. Sharma, A., Ahmad, S. and Harikumar, S.L., Pharmacognosy, Phytochemistry and Pharmacology of Cassia javanica Linn: A Review. J. Pharma Res. Rev. 2014; 3(4), pp.101-105.

Aditi Sharma et al., IJPRR 2014; 3(4)

46. Kitanaka, S., and Takido, M. Demethyltorosaflavones C and D from Cassia nomame. Phytochem. 1992; 31(8), 2927–2929.

https://doi.org/10.1016/0031-9422(92)83671-K

47. Wu, X., Ruan, J., Yang, V. C., Wu, Z., Lou, J., Duan, H., Guo, D. Three new acetylated benzyl-β-resorcylate glycosides from Cassia obtusifolia. Fitoterapia. 2012; 83(1), 166–169.

https://doi.org/10.1016/j.fitote.2011.10.009

48. Rao, G. N., Kumar, P. M., Dhandapani, V. S., Krishna, T. R., and Hayashi, T. Constituents of Cassia auriculata. Fitoterapia. 2000; 71(1), 82–83.

https://doi.org/10.1016/S0367-326X(99)00108-2
49. Singh, S., Singh, S.K. and Yadav, A., A review on Cassia species: Pharmacological, traditional and medicinal aspects in various countries. J. American. Phytomed. Clinical Therap. 2013; 1(3), pp.291-312.

50. Dixit, a. k., and tiwari, h. p. Fatty acid composition and characteristics of Cassia glauca seed oil. J. Indian Chem. Soc. 1990; 67(10).

51. Kazmi, M. H., Malik, A., Hameed, S., Akhtar, N., and Ali, S. N. An anthraquinone derivative from Cassia italica. Phytochem. 1994; 36(3), 761–763.

https://doi.org/10.1016/S0031-9422(00)89812-X

52. Jones, L., Bartholomew, B., Latif, Z., Sarker, S. D., & Nash, R. J. Constituents of Cassia laevigata. Fitoterapia. 2000; 71(5), 580–583.

https://doi.org/10.1016/S0367-326X(00)00155-6

53. Bolzani, V. da S., Gunatilaka, A. A. L., and Kingston, D. G. I. Bioactive and other piperidine alkaloids from Cassia leptophylla. Tetrahedron. 1995; 51(21), 5929–5934.

https://doi.org/10.1016/0040-4020(95)00254-6

54. Zhao, Y., Zhao, K., Jiang, K., Tao, S., Li, Y., Chen, W., Kou, S., Gu, C., Li, Z., Guo, L. and L. White, W., A review of flavonoids from Cassia species and their biological activity. Current Pharm. Biotechno. 2016; 17(13), pp.1134–1146.

https://doi.org/10.2174/13892010176661608191511153

55. Jain, R., Agrawal, O.P., Jain, N.K. and Jain, S.C., Phytochemical and biological evaluation of Cassia nodosa root bark. J. Indian Chem. Soc. 2013; 90(12), pp.2287-2290.

56. Rahman, M.M., Sultana, T., Ali, M.Y., Rahman, M.M., Al-Reza, S.M. and Rahman, A., Chemical composition and antibacterial activity of the essential oil and various extracts from Cassia sophora L. against Bacillus sp. from soil. Arabian J. Chem. 2017; 10, pp.S2132-S2137.

https://doi.org/10.1016/j.arabjc.2013.07.045

57. Choi, J. S., Jung, J. H., Lee, H. J., Lee, J. H., and Kang, S. S. A naphthalene glycoside from Cassia tora. Phytochem. 1995; 40(3), 997–999.

https://doi.org/10.1016/0031-9422(95)00318-2

58. Oshimi, S., Tomizawa, Y., Hirasawa, Y., Honda, T., Ekasari, W., Widyawaruyanti, A.Morita, H. Chrobisiamone A, a new bischromone from Cassia siamea and a biomimetic transformation of 5-acetonyl-7-hydroxy-2-methylchromone into cassiarin A. Bioorg. Med. Chem. Lett. 2008; 18(13), 3761–3763.

https://doi.org/10.1016/j.bmcl.2008.05.041

59. Ravi, K.J., Ganga, R.B., Lakshmi, N.M. and Mallikarjun, R.T., Evaluation of antidiabetic activity of Cassia siamea leaves in alloxan induced diabetic rats. J. Phytopharm. 2013; 4, pp.237-40.

60. Thongsard, W., Deachapunya, C., Pongsakorn, S., Boyd, E. A., Bennett, G. W., and Marsden, C. A. Barakol: a potential anxiolytic extracted from Cassia siamea. Pharmacol. Biochem. Behav. 1996; 53(3), 753–758.

https://doi.org/10.1016/0091-3952(95)00318-6

61. Sobeh, M., Mahmoud, M.F., Abdelfattah, M.A., Cheng, H., El-Shazly, A.M. and Wink, M., A proanthocyanidin-rich extract from Cassia abbreviata exhibits antioxidant and hepatoprotective activities in vivo. J. Ethnopharmacol. 2018; 213(1), pp.38–47.

https://doi.org/10.1016/j.eph.2017.11.007

62. Kumaran, A., and Karunakaran, R. J. Antioxidant activity of Cassia auriculata flowers. Fitoterapia. 2007; 78(1), 46–47.

https://doi.org/10.1016/j.fitote.2006.09.031

63. Deshpande, S., Kewatkar, S. M., and Paithankar, V. V. In-vitro antioxidant activity of different fraction of roots of Cassia auriculata Linn. Drug Inven. Tod. 2013; 5(2), 164–168.

https://doi.org/10.1016/j.dit.2013.05.006

64. Bharathi, D. and Bhuvaneshwari, V., Evaluation of the Cytotoxic and Antioxidant Activity of Phyto-synthesized Silver Nanoparticles Using Cassia angustifolia Flowers. J. BionanoSci. 2019; 9(1), pp.155-163.

https://doi.org/10.1007/s12668-018-0577-5

65. Siddhuraju, P., Mohan, P. S., and Becker, K. Studies on the antioxidant activity of Indian Laburnum (Cassia fistula L.): a preliminary assessment of crude extracts from stem bark, leaves, flowers and fruit pulp. Food Chem. 2002; 79(1), 61–67.

https://doi.org/10.1016/S0308-8146(02)00179-6

66. Limtrakul, P., Yokdeeree, S., Thippaphan, P., Punfa, W. and Srisomboon, J., Anti-aging and tyrosinase inhibition effects of Cassia fistula flower butanolic extract. BMC Compl. Altern. med. 2016; 16(1), p.497.
Chemical Constituents and Biological Activities of Cassia Genus: Review

67. Sritidhya, M., Hridya, H., Shanthi, V. and Ramanathan, K., Bioactive Amento flavone isolated from Cassia fistula L. Leaves exhibits therapeutic efficacy. 3 Biotech. 2017; 7(1), p.33.

68. Sharma, D.K., Enumerations on phytochemical, pharmacological and ethnobotanical properties of Cassia fistula Linn: yellow shower. Seeds. 2017; 6(7), p.8.

69. El-hashash, M., Abdel-Gawad, M., El-Sayed, M., Sabry, W., Abdel-Hameed, E.-S., and Abdel-Lateef, E. Antioxidant properties of methanolic extracts of the leaves of seven Egyptian Cassia species. Acta Pharmaceutica. 2010; 60(3), 361–367.

70. Affify, A. E.-M. M. R., and Hassan, H. M. M. Free radical scavenging activity of three different flowers-Hibiscus rosa-sinensis, Quisqualis indica and Senna surattensis. Asi. Pacif. J. Trop. Biomed. 2016; 6(9), 771–777.

71. Veerapur, V. P., Prapat, V., Thippeswamy, B. S., Marietta, P., Bansal, P., Kulkarni, P. V, and Kulkarni, V. H. Polyphenolic enriched extract of Cassia glauca Lamk, improves streptozotocin-induced type-1 diabetes linked with partial insulin resistance in rats. J. Ethnopharmacol. 2017; 198(23), 489–498.

72. Kumar, D., Singh, A., Sanghi, A., Chandra, R., and Arora, S. Individual and combined effects of leaves and flowers extracts of Cassia glauca on membrane stabilization, antimicrobial and antioxidant activities. J. Pharma. Sci. 2017b; 8(2), 129–134.

73. Sangetha, S., Sasidharan, S., Zuraini, Z., and Suryani, S. Antioxidant activity of methanolic extracts of Cassia surattensis. Pharmacol. online. 2008b; 2, 829–838.

74. Kumar, U., Seeta, U., Chen, Y., Kanwar, J. R., and Sasidharan, S. Redox Control of Antioxidant and Antihepatotoxic Activities of Cassia surattensis Seed Extract against Paracetamol Intoxication in Mice: In Vitro and In Vivo Studies of Herbal Green Antioxidant. Oxid. Med. Cell. Longevity. 2016; 2016. 13 pages.

75. Chew, Y.-L., Goh, J.-K., and Lim, Y.-Y. Assessment of in vitro antioxidant capacity and polyphenolic composition of selected medicinal herbs from Leguminosae family in Peninsular Malaysia. Food Chem. 2009; 116(1), 13–18.

76. Sundaramoorthy, S., Gunasekaran, S., Arunachalam, S. and Sathivelu, M., A phytopharmacological review on Cassia species. J. Pharma. Sci. and Res. 2016; 8(5), p.260.

77. Mehta, J.P., Parmar, P.H., Vadia, S.H., Patel, M.K. and Tripathi, C.B., In-vitro antioxidant and in-vivo anti-inflammatory activities of aerial parts of Cassia species. Arabian J. Chem. 2017; 10(2), pp.S1654-S1662.

78. Kaur, G., Alam, M. S., Jabbar, Z., Javed, K., and Athar, M. Evaluation of antioxidant activity of Cassia siamea flowers. J. Ethnopharmacol. 2006; 108(3), 340–348.

79. Dong, X., Fu, J., Yin, X., Yang, C., Zhang, X., Wang, W., Du, X., Wang, Q. and Ni, J., Cassiae semen: A review of its phytochemistry and pharmacology. Mol. Med. Rep. 2017; 16(3), pp.2331-2346.

80. Zhenbao, J., Fei, T., Ling, G., Guanjun, T., and Xiaolin, D. Antioxidant properties of extracts from juemingzi (Cassia tora L.) evaluated in vitro. LWT-Food Sci. Tech. 2007; 40(6), 1072–1077.

81. Chethana, K.R., Senol, F.S., Orhan, I.E., Anilakumar, K.R. and Keri, R.S., Cassia tora Linn: A boon to Alzheimer's disease for its anti-amyloidogenic and cholinergic activities. Phytomed. 2017; 33(15), pp.43-52.

82. Palanichamy, S., Nagarajan, S., and Devasagayam, M. Effect of Cassia alata leaf extract on hyperglycemic rats. J. Ethnopharmacol. 1988;
22(1), 81–90.
https://doi.org/10.1016/j.molecules.2017.05.091
83. Gupta, S., Sharma, S. B., Bansal, S. K., and Prabhu, K. M. Antihyperglycemic and hypolipidemic activity of aqueous extract of Cassia auriculata L. leaves in experimental diabetes. J. Ethnopharmacol. 2009; 123(3), 499–503.
https://doi.org/10.1016/j.jep.2009.02.019
84. Fauzi, F.M., John, C.M., Karunanidhi, A., Mussa, H.Y., Ramasamy, R., Adam, A. and Bender, A., Understanding the mode-of-action of Cassia auriculata via in silico and in vivo studies towards validating it as a long term therapy for type II diabetes. J. Ethnopharmacol. 2017; 197(2), pp.61-72.
https://doi.org/10.1016/j.jep.2016.07.058
85. Farswan, M., Mazumder, P. M., and Percha, V. Protective effect of Cassia glauca Linn. On the serum glucose and hepatic enzymes level in streptozotocin induced NIDDM in rats. J. Ind. Pharmacol. 2009; 41(1), 19.
https://doi.org/10.4103/0253-743X.48887
86. Salahuddin, M., and Jalalpure, S. S. Evaluation of antidiabetic activity of Cassia glauca Lam. leaf in streptozotocin induced diabetic rats. Iran. J. Pharmacol. Therap. 2010b; 9(1), 20–29.
http://ijpt.iiums.ac.ir/article-1-197-en.html
87. Salahuddin, M. D., Jalalpure, S. S., and Gadge, N. B. Antidiabetic activity of aqueous bark extract of Cassia glauca in streptozotocin-induced diabetic rats. Can. J. Physiol. Pharmacol. 2010a; 88(2), 153–160.
https://doi.org/10.1139/Y09-121
88. Petchi, R. R. Evaluation of anti-diabetic activity of Cassia surattensis burm. F. Flower in streptozotocin induced diabetic rats. J. Res. Pharma. Sci. 2016; 2(2), 200–205.
89. Thilagam, E., Parimaladevi, B., Kumarapappan, C., and Mandal, S. C. $\alpha$-$\alpha$-Glucosidase and $\alpha$-$\alpha$-amylase inhibitory activity of Senna surattensis. J. Acupun. Merid. Stud. 2013; 6(1), 24-30.
https://doi.org/10.1016/j.jams.2012.10.005
90. Kumar, D., Jain, A., and Verma, A. Phytochemical and Pharmacological Investigation of Cassia Siamea Lamk: An Insight. J. Nat. Prod. 2017a; 7(4), 255–266.
https://doi.org/10.2174/2210315507666170509125800
91. Adikay, S., and Santhoshini, T. Pharmacological evaluation of anti-ulcer activity of Cymbopogon flexuosus. J. Basic and Clin. Pharmacol. 2017; 4(2), 208–212.
92. Palanichamy, S., Nagarajan, S., and others. Antifungal activity of Cassia alata leaf extract. J. Ethnopharmacol. 1990b; 29(3), 337–340.
https://doi.org/10.1016/0378-8741(90)90043-s
93. Ntandou, G. F. N., Banzouzi, J. T., Mbatchi, B., Elion-Itou, R. D. G., Etou-Ossibi, A. W., Ramos, S., … Ouamba, J. M. Analgesic and anti-inflammatory effects of Cassia siamea Lam. stem bark extracts. J. Ethnopharmacol. 2010; 127(1), 108–111.
https://doi.org/10.1016/j.jep.2009.09.040
94. Chaudhari, S. S., Chaudhari, S. R., & Chavan, M. J. Analgesic, anti-inflammatory and anti-arithmetic activity of Cassia uniflora Mill. Asian Pac. J. Trop. Biomed. 2012; 2(1), S181–S186.
95. Cunha, L.C., de Morais, S.A., de Aquino, F.J., Chang, R., de Oliveira, A., Martins, M.M., Martins, C.H., Sousa, L.C., Barros, T.T., da Silva, C.V. and do Nascimento, E.A., Bioassay-guided fractionation and antimicrobial and cytotoxic activities of Cassia bakeriana extracts. Revista Brasileira de Farmacognosia. 2017; 27(1), pp.91-98.
https://doi.org/10.3390/molecules18044588
96. Deepak, K., Shefali, A., and Ankit, V. Fatty acid composition and antimicrobial and antioxidant activity of Cassia glauca seed extracts. J. Phytopharmacol. 2013; 4(2), 113–118.
97. Voon, H. C., Bhat, R., and Rusul, G. Flower extracts and their essential oils as potential antimicrobial agents for food uses and pharmaceutical applications. Compr. Rev. Food Sci. Food Saf. 2012; 11(1), 34–55.
https://doi.org/10.1002/ptr.6101
98. Chukwujekwu, J. C., Coombes, P. H., Mulholland, D. A., and Van Staden, J. Emodin, an antibacterial anthraquinone from the roots of Cassia occidentalis. S.Afr. J. Bot. 2006; 72(2), 295–297.
https://doi.org/10.1016/j.sajb.2005.08.003
99. Palanichamy, S., Nagarajan, S., and others. Antifungal activity of Cassia alata leaf extract. J. Ethnopharmacol.1990b; 29(3), 337–340.
100. Sumathy, V., Zakaria, Z., Jothy, S. L., Gothai, S., Vijayarathna, S., Latha, L. Y., Sasidharan, S. In vitro and in vivo antifungal activity of Cassia surattensis flower against Aspergillus niger. Microb. Pathogen. 2014; 77, 7–12.
https://doi.org/10.1016/j.micpath.2014.10.004

101. Bhakta, T., Banerjee, S., Mandal, S. C., Maity, T. K., Saha, B. P., and Pal, M. Hepatoprotective activity of Cassia fistula leaf extract. Phytomed. 2001; 8(3), 220–224.
https://doi.org/10.1016/s0378-8741(98)00220-7

102. Ansari Asba, Bhot Meeta, Evaluation of Phytochemicals of Cassia tora Linn. And its cytotoxicity assay using Brine Shrimp. J. Pharmacog. Phytoc. Res. 2017; 9(4); 587-595.
DOI number: 10.25258/phyto.v9i2.8132

103. Vijayaraj, P., Muthukumar, K., Sabarirajan, J., and Nachiappan, V. Antihyperlipidemic activity of Cassia auriculata flowers in triton WR 1339 induced hyperlipidemic rats. Exp. Toxicol. Patho. 2013; 65(1–2), 135–141.
https://doi.org/10.1016/j.etp.2011.07.001

104. Tzeng, T.-F., Lu, H.-J., Liou, S.-S., Chang, C. J., and Liu, I.-M. Reduction of lipid accumulation in white adipose tissues by Cassia tora (Leguminosae) seed extract is associated with AMPK activation. Food Chem. 2013; 136(2), 1086–1094.
https://doi.org/10.1016/j.foodchem.2012.09.017

105. Patil, U. K., Saraf, S., and Dixit, V. K. Hypolipidemic activity of seeds of Cassia tora Linn. J. Ethnopharmacol. 2004; 90(2–3), 249–252.
https://doi.org/10.1016/j.jep.2003.10.007

106. Aye, M.M., Aung, H.T., Sein, M.M. and Armijos, C., A Review on the Phytochemistry, Medicinal Properties and Pharmacological Activities of 15 Selected Myanmar Medicinal Plants. Molecules. 2019; 24(2), p.293.
https://doi.org/10.3390/molecules24020293

107. Bhakta, T., Banerjee, S., Mandal, S. C., Maity, T. K., Saha, B. P., and Pal, M. Hepatoprotective activity of Cassia fistula leaf extract. Phytomed. 2001; 8(3), 220–224.