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Review Article

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*

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1. 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]**.

2. 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. Caesalpinacae 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-Fig. 3.8)**.

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 pharmacopeia 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)** Rhein **(2)** Aloe-emodin **(3)** Emodin **(4)** Chrysophanol **(5)** Physcion **(6)**	Stem Root	**[8]** **[9]**
C. angustifolia	Sennoside A **(7)** Sennidine A **(8)** Sennoside B **(9)** Sennidine B **(10)** Aloe-emodin 8-*O*-glucoside **(11)** Torachrysone 8-*O*-glucoside **(12)** Emodin 8-*O*-sophoroside **(13)** Aloe-emodin anthrone 8,8'-di-*O*-glucoside **(14)**	Leaves Leaves	**[10]** **[11]**
C. corymbosa	Emodin **(4)** Chrysophanol **(5)** Physcion **(6)** Floribundone-1 **(15)**	Leaves	**[12]**
C. idymobotrya	5,10- dihydroxy- 2 - methyl- 9 - (physcion - 7` - yl) - 1,4 –anthraquinone **(16)** Knipholone **(17)**	Pods	**[13]**
C. floribunda	Floribundone-1 **(15)** Floribundone-2 **(18)**	Leaves	**[6]**
C. glauca	1- Chrysophanol **(5)** 2- Physcion **(6)** 3- Aloe-Emodin **(3)**	Stem & Bark Bark	**[14]** **[15]** **[6]**
C. greggii	5-hydroxy-1,4,6,7-tetramethoxy-2-methylanthraquinone **(19)** 1,5,7-trihydroxy-4,6-dimethoxy-2-methylanthraquinone **(20)** 5,6-dihydroxy-1,4,7-trimethoxy-2-methylanthraquinone **(21)** 1-hydroxy-4,7-dimethoxy-5,6-methylenedioxy-2-methylanthraquinone **(22)** 5,7-dihydroxy-l,4,6-trimethoxy-2-hydroxymethylantraquinone **(23)** 4,5-dihydroxy-l,6,7-trimethoxy-2-methylanthraquinone **(24)**	Roots	**[16]**
C. javanica	5,6-dihydroxy-4,7dimethoxy-2-methylanthraquinone **(25)** 1,6-dihydroxy-3-methylanthraquinone 8-*O*-α-L-rhamno-pyranoside **(26)** 1,5,6-trihydroxy-3 methylanthraquinone 8-O-α-L-rhamnopyranoside **(27)**	Root bark	**[6]**
C. kleinii	kleinioxanthrone-1 **(28)** kleinioxanthrone-2 **(29)** kleinioxanthrone-3 **(30)** kleinioxanthrone-4 **(31)**	Roots	**[17]**
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)** Physcion **(6),** Torosachrysone **(33)** l0-(chrysophanol-7`-yl)-l0-hydroxy-chrysophanol-9-anthrone **(34)** Nataloe- emodin **(35)** Chrysophanolbianthrone **(36)** Chrysophanol-physcionbianthrone **(37)** Chrysophanol-isophyscionbianthrone **(38)** Isophyscionbianthrone **(39)**	Root, bark	**[18]**
C. marginata	1,3-dihydroxy-6,8dimethoxy-2-methyl anthraquinone 3-0-*α*-L-rhamnosyl-(1→6)- O-*β*-D-glucopyranoside **(40)**	Roots	**[6]**
C. multiglandulosa	Physcion **(6)** Floribundone-1 **(15)** Torosachrysone **(33)** Anhydrophlegmacin B2 **(41)** Isosengulone **(42)** Sengulone **(43)**	Seeds	**[19]**
C. occidentalis	Emodin **(4)** Floribundone-1 **(15)**	Leaves	**[20]**
C. obtusifolia	Physcion **(6)**	Roots	**[6]**
	Emodin **(4)** Chrysophanol **(5)** Physcion **(6)** Aloe-emodin **(3)** Occidental- I **(44)** Occidental- II **(45)**	Leaves	**[21]**
	Torosachrysone **(33)** Isotoralactone **(46)** Toralactone **(47)** *Cassia* lactone **(48)**	Seeds	**[22]**
	1,8- dihydroxy-3- methoxy-6- methylxanthine **(49)**	Leaves	**[23]**
C. obtuse	1,3-dihydroxy-6 methoxy-7-methyl anthraquinone **(50)** 1-hydroxy-3,7-di-formyl anthraquinone **(51)**	Root	**[24]**
C. pudibunda	Emodin **(4)** Chrysophanol **(5)** Physcion **(6)** Chrysophanol dimethyl ether **(52)**	Roots	**[25]**
C. roxburghii	Emodin **(4)** Emodin 1-O-*β*-D- glucopyranosyl-(1→6)-O-*β*-D-glucopyranoside **(53)** Aloe-emodin 8-O-*β*-D- glucopyranosyl-(1→6)-O-*β*-D- glucopyranoside **(54)**	Leaves	**[26]**
	Roxburghinol **(55)**	Leaves	**[6]**
C. reticulata	l-hydroxyxanthone-6,8 dicarboxylic acid **(56)**	Leaves	**[27]**
C. sophera	1,2,6-trihydroxy-7,8-dimethoxy-3-methyl anthraquinone **(57)** 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]**

Species	Compound name (compound number)	Investigated part	Reference
C. siamea	Chrysophanol **(5)** Physcion **(6)** 4,4`-bis(l,3-dihydroxy-2-methyl-6,8-dimethoxy anthraquinone) **(60)** Emodin **(4)**	Heartwood	**[28]**
	Chrysophanol **(5)** 1,1`,3,8,8`-Pentahydroxy-3`,6-dimethyl[2,2`bianthracene]-9,9`,10,10`-tetrone **(61)** 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)**	Root bark	**[29]**
C. tora	l-[(*β*-D-glucopyranosyl-(1→3)-O-*β*-D-glucopyranosyl-(1→6)-O-*β*-D-glucopyranosyl)oxy]-8-hydroxy-3-methyl-9,10-anthraquinone **(65)** l-[(*β*-D-glucopyranosyl-(1→6)-*O*-*β*-D-glucopyranosyl-(1→6)-O-β-D-glucopyranosyl-(1→6)-*O*-*β*-D-glucopyranosyl)oxy]-8-hydroxy-3-methyl-9,l0-anthraquinone **(66)** 2-(*β*-D-glucopyranosyloxy)-8-hydroxy-3-methyl-l-methoxy-9,10-anthraquinone **(67)**	Seeds	**[30]**
	1-desmethylaurantio-obtusin **(68)** 1-desmethylchryso-obtusin **(69)** Aurantio-obtusin **(70)** Chryso-obtusin **(71)** Obtusin **(72)**		**[31]**
	Torososide A **(73)**	Leaves	**[32]**
	Torosachyrsone **(33)** Emodin **(4)** Chrysophanol **(5)** Physcion **(6)** Chrysophanol dimethyl ether **(52)**	Seedlings	**[6]**
C. torosa	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)**	Unripe seeds	**[6]**
	Phlegmacin A2 and B2 **(75)** Anhydrophlegmacin-9,10-quinones A2 and B2 **(76)** Torosachrysone **(33)**	Seedlings	**[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-7-0-(2``-*O*-*β*-D-mannopyranosyl)-*β*-D-allopyranoside **(81)** Rhamnetin-3-0-(2``-*O*-*β*-D-mannopyranosyl)-*β*-D-allopyranoside **(82)**	Seeds	**[35]**
	Kampferol **(83)**	Root	**[9]**
C. auriculata	Kampferol **(83)** Quercetin **(84)** Kaempferol 3-*O*-rutinoside **(85)** Luteolin **(86)**	Aerial parts	**[36]**
C. angustifolia	Quercetine 3-*O*-gentiobioside **(87)** Kaempferol 3-*O*- gentiobioside **(88)** Isorhamentin 3-*O*- gentiobiosid **(89)**	Leaves	**[37]**
C. fistula	(2`S)-7-hydroxy-5-hydroxymethyl-2-(2`-hydroxypropyl) chromone **(90)** Benzyl-2-O-*β*-D-glucopyranosyl-3,6-dimethoxybenzoate **(91)**	Leaves	**[38]**
C. glauca	Apigenin **(92)** Luteolin **(86)** Quercetin **(84)** Quercetin-3-*O*-*β*-D-glucopyranoside **(93)** Kaempferol-3-*O*-rutinoside **(85)** Rutin **(94)**	Leaves	**[39]**
	Quercetin-3-*O*-glucoside-7-*O*-rahmnoside **(95)**		**[40]**
C. garrettiana	Cassigarol A **(96)**	Heart wood	**[41]**
	Cassigarol A **(96)** Cassigarol C **(97)** Cassigarol B **(98)** Cassigarol D **(99)**		**[42]**
	Cassigarol E **(100)** Cassigarol F **(101)** Cassigarol G **(102)**		**[43]**
C. italic	Apigenin **(92)** Kampferol **(83)** Quercetin **(84)** Apeginin 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)** Isorhamentin 7-*O*-*β*-D-glucopyranoside, 3-rutinoside **(107)**	Aerial parts	**[44]**
C. javanica	Dihydrorhamnetin-3-O-*β*-D-glucopyranoside **(108)** Leucocyanidin- 4`-O-methyl ether-3-*O*-*β*-D-galactopyranoside **(109)**	Flowers	**[45]**
C. nomame	Demethyltorosaflavone C **(110)** Demethyltorosaflavone D **(111)** Luteolin **(86)** Luteolin 7- *O*-*β*-D-glucopyranoside **(112)** Vitexin **(113)**	Aerial parts	**[46]**

Species	Compound name (compound number)	Investigated part	Reference
C. obtusifolia	2-benzyl-4,6-dihydroxy benzoic acid **(114)** 2-benzyl-4,6-dihydroxy benzoic acid-6-O-*β*-D-glucopyranoside **(115)** 2-benzyl-4,6-dihydroxy benzoic acid-4-O-*β*-D-glucopyranoside **(116)** 2-benzyl-4,6-dihydroxy benzoic acid-6-*O*-[2`,6`-*O*-diacetyl]-*β*-D-glucopyranoside **(117)** 2-benzyl-4,6-dihydroxy benzoic acid-6-*O*-[3`,6`-*O*-diacetyl]-*β*-D-glucopyranoside **(118)** 2-benzyl-4,6-dihydroxy benzoic acid-6-*O*-[4`,6`-*O*-diacetyl]-*β*-D-glucopyranoside **(119)**	Seeds	**[47]**
C. torosa	2,3-dihydro-8,10-dihydtoxy-2,5-dimethyl-4H-naphtho[l,2-b]pyran-4-one **(120)**	Unripe seeds	**[34]**

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	N^1,N^8-dibenzoylspermidine **(122)**	Leaves	**[49]**
C. glauca	Palmitic acid **(123)** Stearic acid **(124)** Oleic acid **(125)** Linoleic acid **(126)** Linolenic acid **(127)** Arachidic acids **(128)**	Seeds oil	**[50]**
	β -Sitosterol- *β* –D- glucoside **(129)**	Stem	**[15]**
	Galactomannan **(130)**		**[6]**
C. italic	*β*-Sitosterol **(131)** Stigmasterol **(132)**	Leaves	**[51]**
C. laevigata	Calendin **(133)** 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)**	Leaves	**[52]**
C. leptophylla	(-)-spectalin **(140)** (-)-spectalinin **(141)** Canavalin **(142)** Leptophyllin A **(143)** 3-acetylleptophyllin **(144)** (+)-spectaline **(145)** Iso-6-canavaline **(146)** Leptophyllin B **(147)**	Leaves	**[53]**

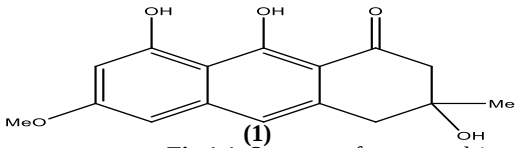
Species	Compound name (compound number)	Investigated part	Reference
C. multijuga	5-acetonyl-7- hydroxy-2-methylchromone **(148)** 5 - Acetonyl - 2 - methylchromone - 7 -*O* - *β* - D-glucopyranoside **(149)**	Leaves	**[54]**
C. nodosa	Nodolidate **(150)**	Bark	**[55]**
C. occidentalis	Phytosterol **(151)**	Roots	**[21]**
C. obtusifolia	(4R, 5S, 6E, 8Z)-ethyl-4-[(E)-but-1-enyl]-5-hydroxypentadeca-6,8- dionate **(152)** Stigmasterol **(132)** Lupeol **(153)** Buteolinic acid **(154)** Friedelin **(155)**	Leaves	**[22]**
C. sophera	*β*-Sitosterol **(131)**	Leaves	**[56]**
C. tora	Cassitoroside **(156)**	Seeds	**[57]**
C. siamea	Barakol **(157)**	Leaves	**[58]**
	Chrobisiamone A **(158)** Cassiarin A **(159)**		**[59]**
	Cassiadinine **(160)** 5-acetonyl-7- hydroxy-2-methylchromone **(148)** (+)-6-Hydroxymellein **(161)** (+)-6-Hydroxymellein diacetate **(162)** Chaksine **(163)**	Flowers	**[60]**

Table 4. Biological activities of genus *Cassia*

Biological activities	Species	Part or compound responsible for the activity	Reference
Antacid activity	***C. garrttiana***	Cassigarol A (Heartwood)	[**41]**
Anxiolytic activity	***C. siamea***	Barakol (leaves)	**[60]**
	C. abbreviata	Root methanol extract	**[61]**
	C. auriculata	Kampferol Quercetin Kaempferol 3-*O*-rutinoside Luteolin (Aerial parts)	**[36]**
		Flowers extract	**[62]**
		Different root fractions	**[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]** **[68]**
		Leaves methanol extract	**[69]**
		Leaves ethanol extract	**[70] , [71]**
		Flower methanol extract	**[72]**
	C. glauca	Leaves, flower, stem and pod methanol extracts	**[73]**
		Seed extract	**[74]**
		Acetone seed extract	**[75]**
		Acetone seed extract	**[71]**

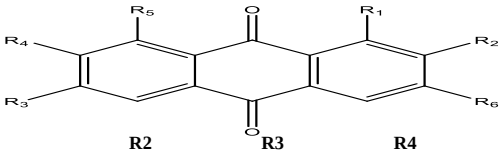
Biological activities	Species	Part or compound responsible for the activity	Reference
	C. italica	Methanol leaves extract	**[76]**
	C.javanica	The ethanolic extracts of aerial parts	**[77]**
		Ethanol leaves extract	**[76]**
	C.nodosa	Stem & bark methanolic extracts	**[76]**
	C. roxburghii	- Emodin - Emodin 1-*O*-*β*-D- glucopyranosyl-(1→6)-*O*-*β*-D- glucopyranoside. - Aloe-emodin 8-*O*-*β*-D-glucopyranosyl-(1→6)-*O*-*β*-D-glucopyranoside. (leaves)	**[26]**
	C.siamea	Methanol leaves & flowers extract	**[76]**
		Flower extract	**[78]**
	C. semen	Leaves aqueous extract	**[79]**
	C. tora	Leaves extract	**[80]**
		Methanol exrtact	**[81]**
	C. alata	Leaves extract	**[82]**
	C. auriculata	Leaves aqueous extract	**[83]**
		Polyphenolic extract	**[84]**
		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]**
	C. semen	Leaves aqueous extract	**[79]**
	C. siamea	Leaves extract	**[90]**
Anti-ulcer activity	***C. auriculata***	Leaf extract	**[91]**
	C. alata	Kaempferol 3-*O*-sophoroside Leaves extract	**[92]**
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]**
	C. bakeriana	Leaves and bark ethanol extracts	**[95]**
	C. glauca	Leaves and flower extracts	**[73]**
		Seed methanol and acetone extracts	**[96]**
		Leaves methanol extract	**[69]**
		Flower methanol extract	**[97]**
Antibacterial		Seed extract	**[72]**
	C.nigricans	Ethyll acetate leaves extract	**[76]**
	C. occidentalis	Emodin (Root extract)	**[98]**
	C.reningera	Methanol flower extract	**[76]**
	C.sophera	Ethyl acetate seed coat extract	**[76]**
	C. alata	Ethanolic leaves extract	**[76]**
		Leaves extract	**[99]**
	C. glauca	Leaves acetone extract	**[70]**
		Flower methanol extract	**[100]**
Antifungal		Seed methanol and acetone extracts	**[72]**
	C. spectabilis	Flower methanol 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]**
	C. tora	Hydro alcoholic extract of aerial part	**[102]**
Hypolipidemic	***C. auriculata***	Leaves aqueous extract	**[83]**
		Flowers extract	**[103]**
	C. siamea	Leaves extract	**[78]**
	C. semen	Leaves aqueous extract	**[79]**
	C. tora	Seed extract	**[104]** **[105]**
Hepatoprotective activity	***C. abbreviata***	Root methanol extract	**[61]**
	C. auriculata	Flower ethanol extract	**[106]**
	C. fistula	Leaves extract	**[107]**
	C. glauca	Leaves methanol extract	**[108]**
		Leaves extract	**[68]**
	C. occidentalis	Leaves methanol extract	**[109]**
	C. auriculata	Flower ethanol extract	**[105]**
Immunomodulatory activity	***C. auriculata***	Polyphenols derived from flowers extract	**[110]**
Laxative activity	***C. alata*** ***C. podocarpa***	Leaves extract	**[111]**
Wound healing	***C. fistula***	Leaves extract	**[112]**



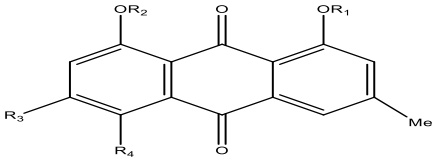
(1)

Fig.1.1. Structure of compound 1



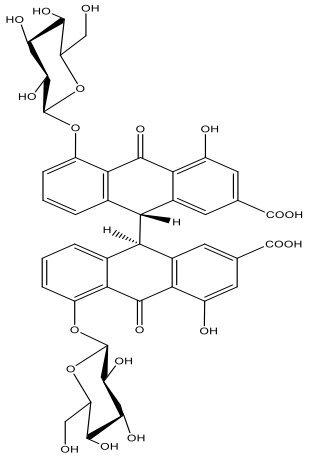
	R1	R2	R3	R4	R5	R6
(2)	OH	H	H	H	OH	COOH
(3)	OH	H	H	H	OH	CH_2OH

Fig.1.2. Structure of compounds 2 and 3

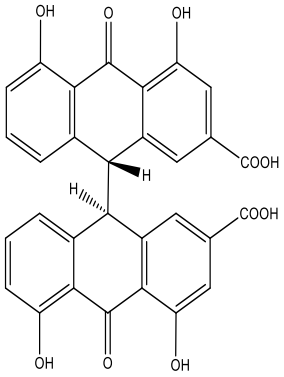


	R_1	R_2	R_3	R_4
(4)	H	H	OH	H
(5)	H	H	H	H
(6)	H	H	OMe	H

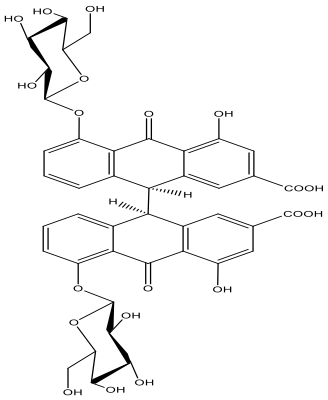
Fig. 1.3. Structure of compounds 4 -6



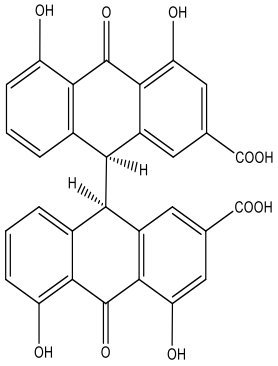
(7)



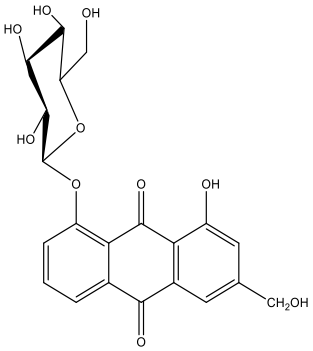
(8)



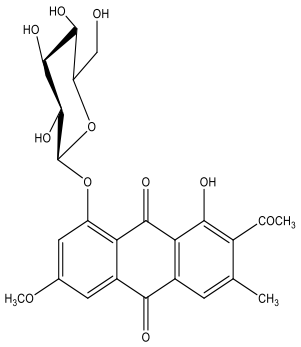
(9)



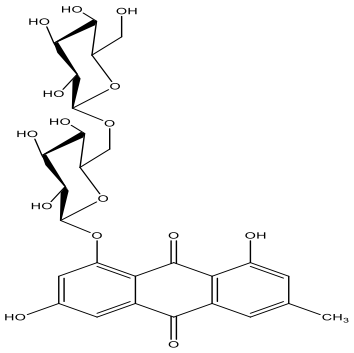
(10)



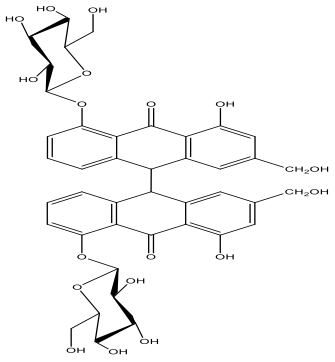
(11)



(12)

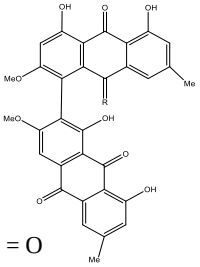


(13)

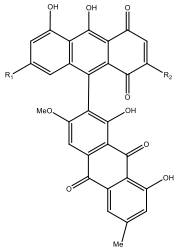


(14)

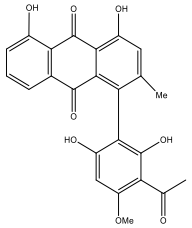
Fig. 1.4. Structure of compounds 4-14



(15) R = O
(18) R = H

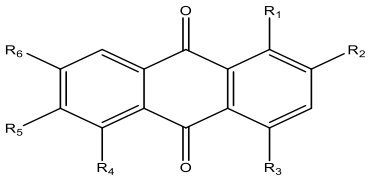


(16) R1= Me, R2= OMe



(17)

Fig. 1.5. Structure of compounds 15 - 18



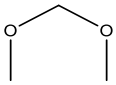
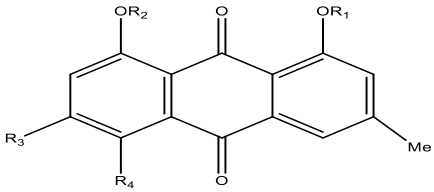
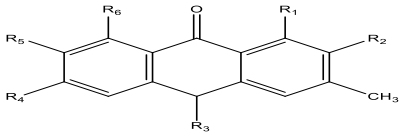
	R_1	R_2	R_3	R_4	R_5	R_6
(19)	OMe	Me	OMe	OH	OMe	OMe
(20)	OH	Me	OMe	OH	OMe	OH
(21)	OMe	Me	OMe	OH	OH	OMe
(22)	OH	Me	OMe			OMe
(23)	CH_2OH	OMe	OMe	OH	OMe	OH
(24)	OMe	Me	OH	OH	OMe	OMe
(25)	H	Me	OMe	OH	OH	OMe

Fig. 1.6. Structure of compounds 19 - 25



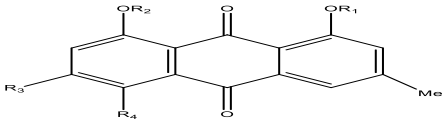
	R_1	R_2	R_3	R_4
(26)	H	O-α-L-rhamnopyranoside	OH	H
(27)	H	O-α-L-rhamnopyranoside	OH	OH

Fig. 1.7. Structure of compounds 26 and 27



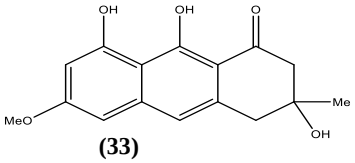
	R_1	R_2	R_3	R_4	R_5	R_6
(28)	OH	H	$OCO(CH_2)_8CH_3$	OMe	H	OH
(29)	OH	H	$OCO(CH_2)_{12}CH_3$	H	H	OH
(30)	OH	H	$OCO(CH_2)_{14}CH_3$	H	H	OH
(31)	OMe	OH	$OCO(CH_2)_8CH_3$	OH	OH	OMe

Fig. 1.8. Structure of compounds 28 - 31



	R_1	R_2	R_3	R_4
(32)	H	O-*β*-D-galactosyl-(1-4)-O-*β*-D-galactopyranoside.	OMe	H

Fig. 1.9. Structure of compound 32



(33)

(34) R = H

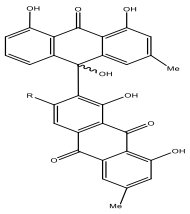
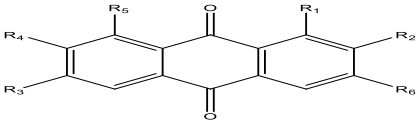
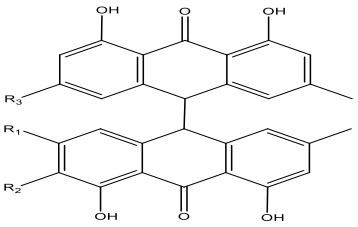


Fig. 1.10. Structure of compounds 33 and 34



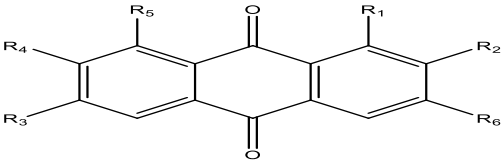
	R1	R2	R3	R4	R5	R6
(35)	OH	H	H	OH	OH	Me

Fig. 1.11. Structure of compound 35



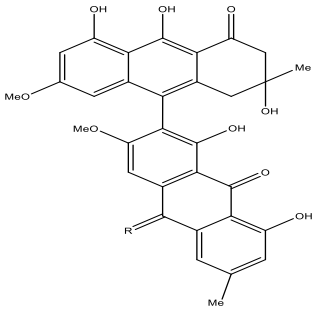
	R_1	R_2	R_3
(36)	H	H	H
(37)	OMe	H	H
(38)	H	OMe	H
(39)	H	OMe	OMe

Fig. 1.12. Structure of compounds 36 - 39

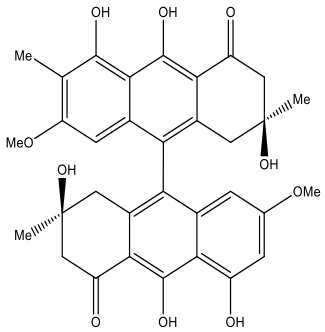


	R1	R2	R3	R4	R5	R6
(40)	OH	Me	OMe	H	OMe	R

Fig. 1.13. Structure of compound 40

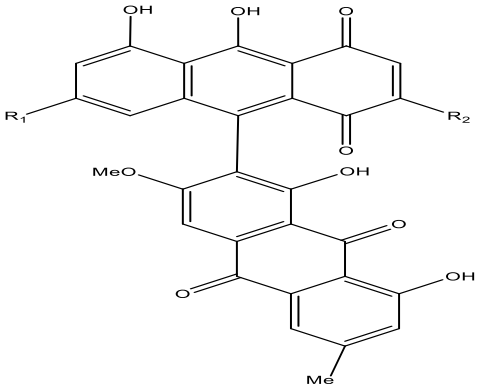


(41) R = H



(44)

Fig. 1.14. Structure of compounds 41 and 44



	R_1	R_2
(42)	OMe	Me
(43)	H	Me

Fig. 1.15. Structure of compounds 42 and 43

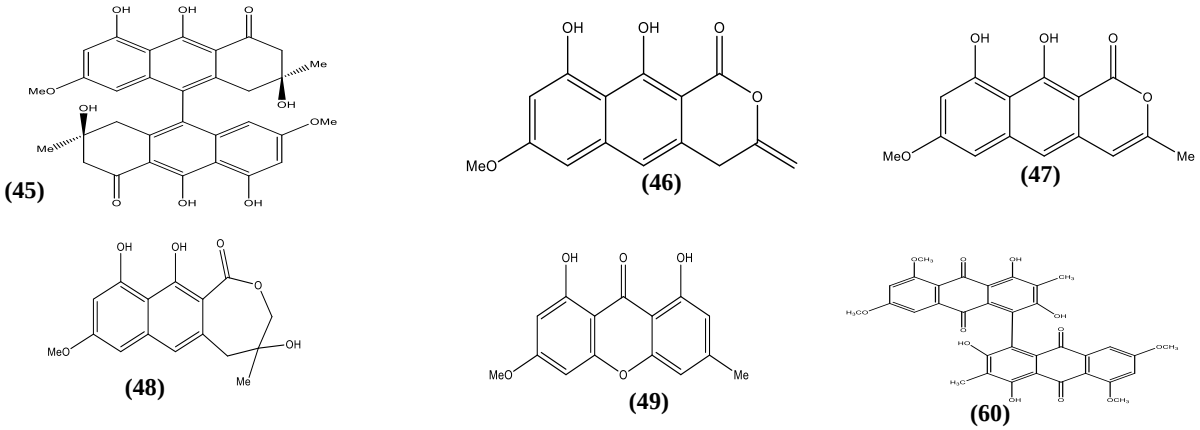
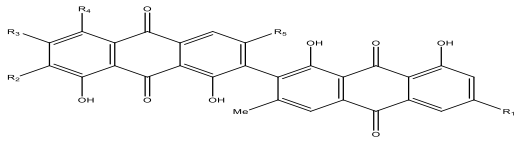
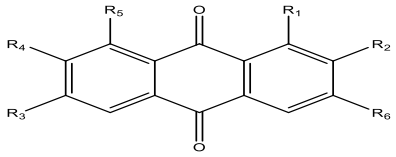


Fig. 1.16. Structure of compounds 45 – 49 and 60



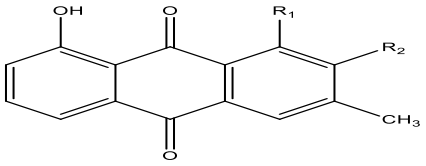
	R_1	R_2	R_3	R_4	R_5
(61)	H	H	Me	H	OH
(62)	H	Cl	OH	H	Me
(63)	H	H	OH	H	Me
(64)	H	H	OH	Cl	Me

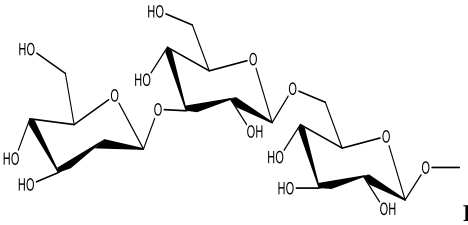
Fig. 1.17. Structure of compounds 61 - 64



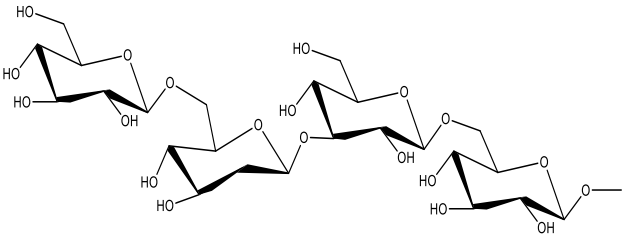
	R1	R2	R3	R4	R5	R6
(50)	OH	H	OMe	Me	H	OH
(51)	OH	H	H	CHO	H	CHO
(53)	R	H	OH	H	OH	Me
(54)	R	H	H	H	OH	CH_2OH
(57)	OH	OH	OH	OMe	OMe	Me
(58)	OH	OH	OMe	OH	OMe	Me
(59)	OH	Me	H	H	OH	Neohesperidoside
(68)	OH	OH	OH	OMe	OH	Me
(69)	OH	OH	OMe	OMe	OMe	Me
(70)	OMe	OH	OH	OMe	OH	Me
(71)	OMe	OH	OMe	OMe	OMe	Me
(72)	OMe	OH	OMe	OMe	OH	Me

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





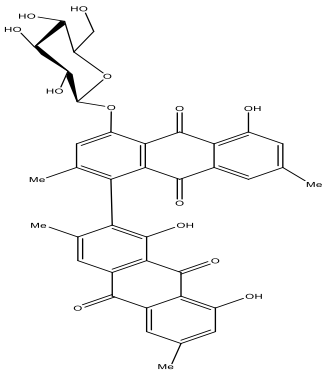
(65) R_1= **R_2**= H



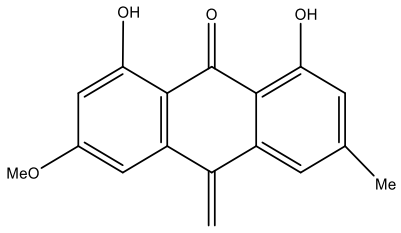
(66) R_1= **R_2**= H

(67) R_1= OCH_3 **R_2**= *β*-D-glucopyranoside

Fig. 1.19. Structure of compounds 65 - 67

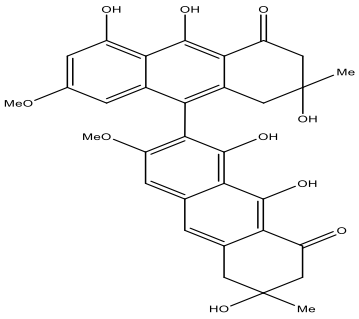


(73)

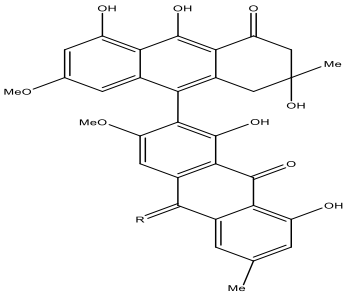


(74)

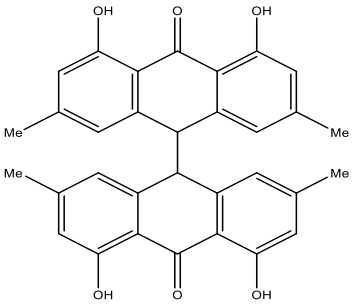
Fig. 1.20. Structure of compounds 73 and 74



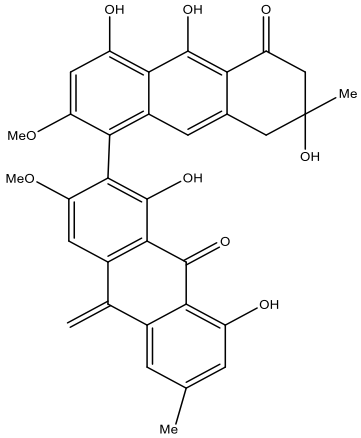
(75)



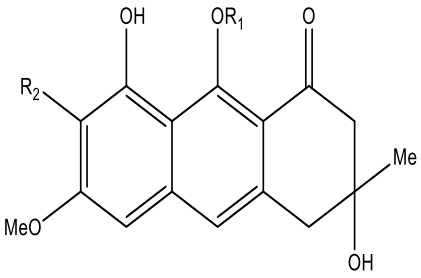
(76) R = O



(77)



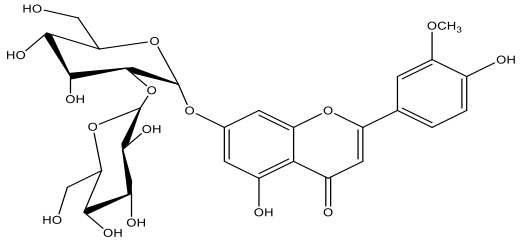
(78)



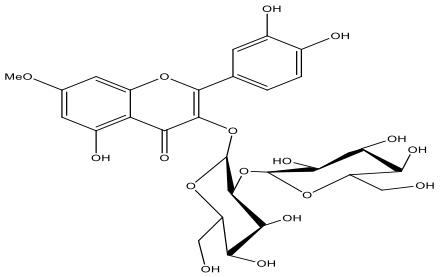
	R_1	R_2
(79)	H	Me
(80)	Me	Me

Fig. 1.21. Structure of compounds 75 - 80

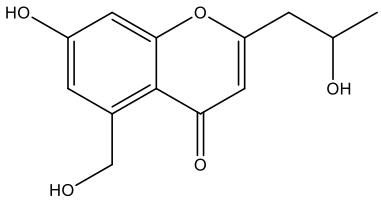
Fig. 1. Chemical structure of reported anthraquinones, anthracenes and their derivatives in different *Cassia* species in Fig. 1 (Fig.1.1- Fig.1.21).



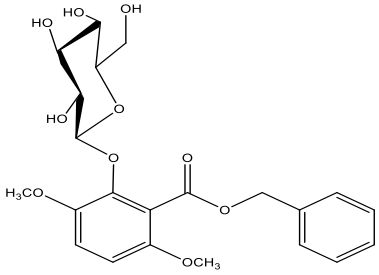
(81)



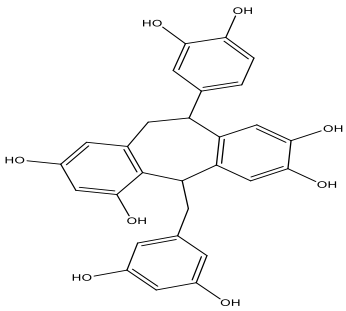
(82)



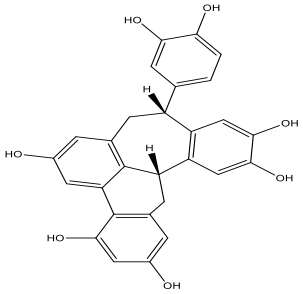
(90)



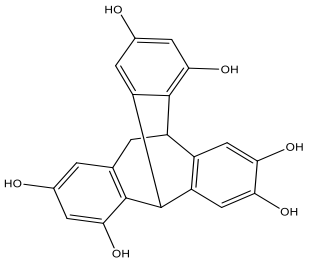
(91)



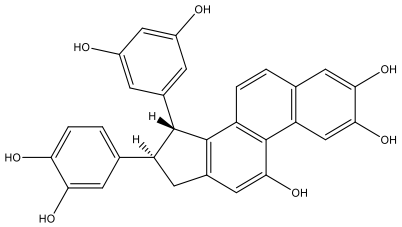
(96)



(97)



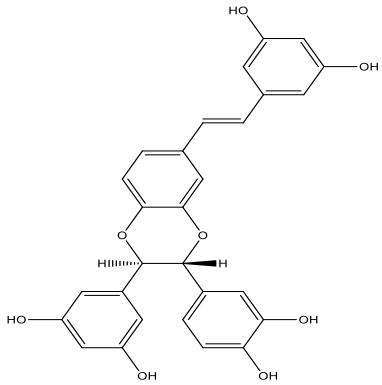
(98)



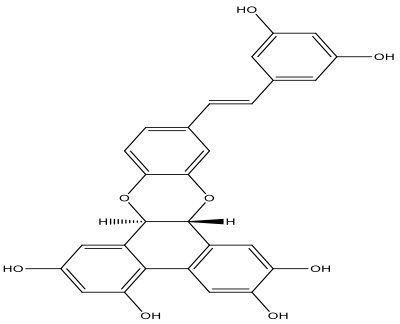
(99)

Fig. 2.1. Structure of compounds 81-82, 90-91 and 96-99

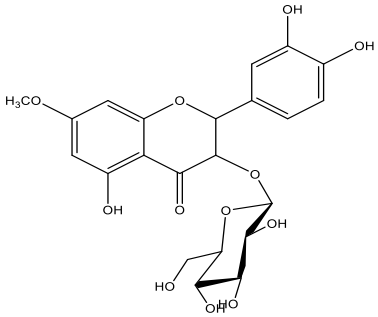
Fig. 2. Chemical structure of reported Phenolic compounds in different *Cassia* species in figure 2 (Fig.2.1 – Fig.2.5).



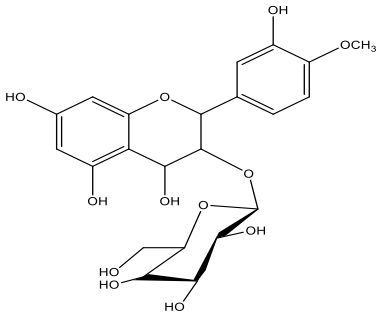
(100) E, (101) Z



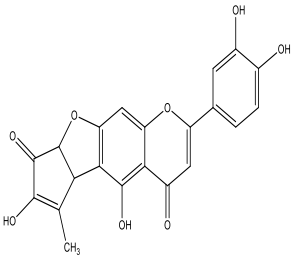
(102)



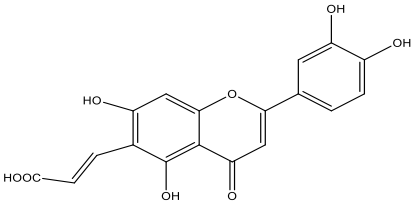
(108)



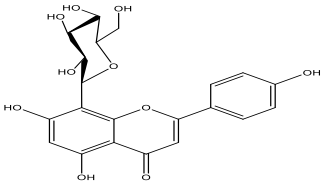
(109)



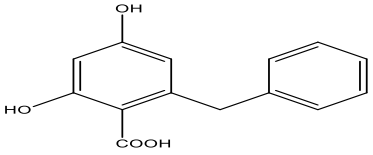
(110)



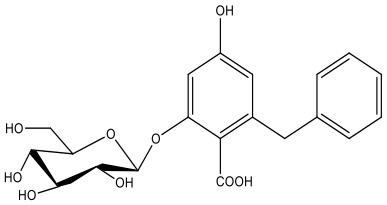
(111)



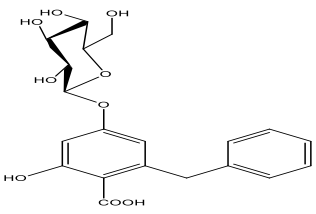
(113)



(114)

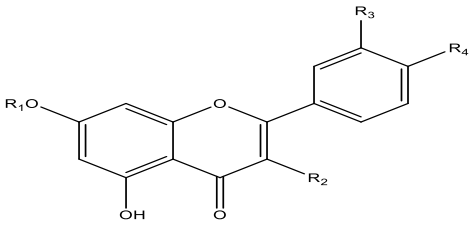


(115)



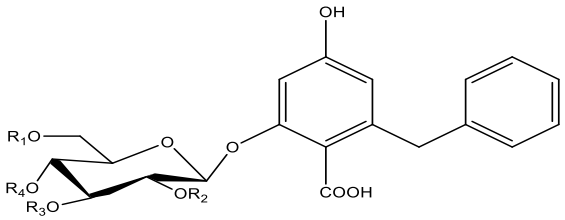
(116)

Fig. 2.2. Structure of compounds 100-102 and 108-116



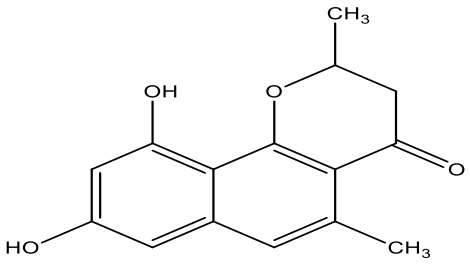
	R1	R2	R3	R4
(83)	H	OH	H	OH
(84)	H	OH	OH	OH
(85)	H	rutinose	H	OH
(86)	H	H	OH	OH
(87)	H	gentiobioside	OH	OH
(88)	H	gentiobioside	H	OH
(89)	H	gentiobioside	OH	OMe
(92)	H	H	H	OH
(93)	H	*β*-D-glucoside	OH	OH
(94)	H	rutinoside	OH	OH
(95)	α-L-rhamnopyranoside	*β*-D-glucoside	OH	OH
(103)	*β*-D-glucoside	H	H	OH
(104)	*β*-D-glucoside	OH	H	OH
(105)	*β*-D-glucoside	OH	OH	OH
(106)	α-L-rhamnopyranoside	rutinoside	OMe	OH
(107)	*β*-D-glucopyranoside	rutinoside	OH	OMe
(112)	*β*-D-glucoside	H	OH	OH

Fig. 2.3. Structure of compounds 83-89, 92-95, 103-107 and 112



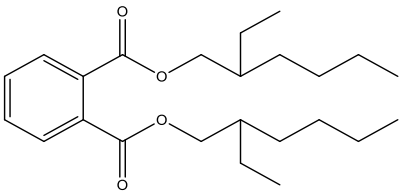
	R_1	R_2	R_3	R_4
(117)	Ac	Ac	H	H
(118)	Ac	H	Ac	H
(119)	Ac	H	H	Ac

Fig. 2.4. Structure of compounds 117-119

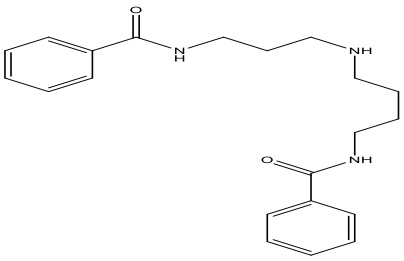


(120)

Fig. 2.5. Structure of compound 120

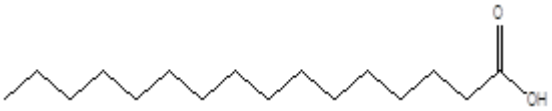


(121)



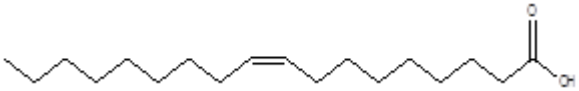
(122)

(123)

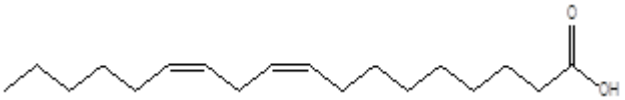


(124)

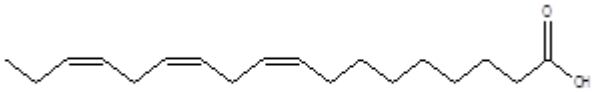
(125)



(126)



(127)



(128)

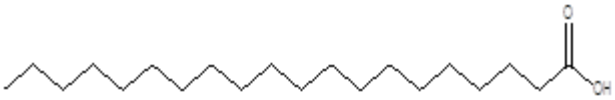


Fig. 3.1. Structure of compounds 121- 128

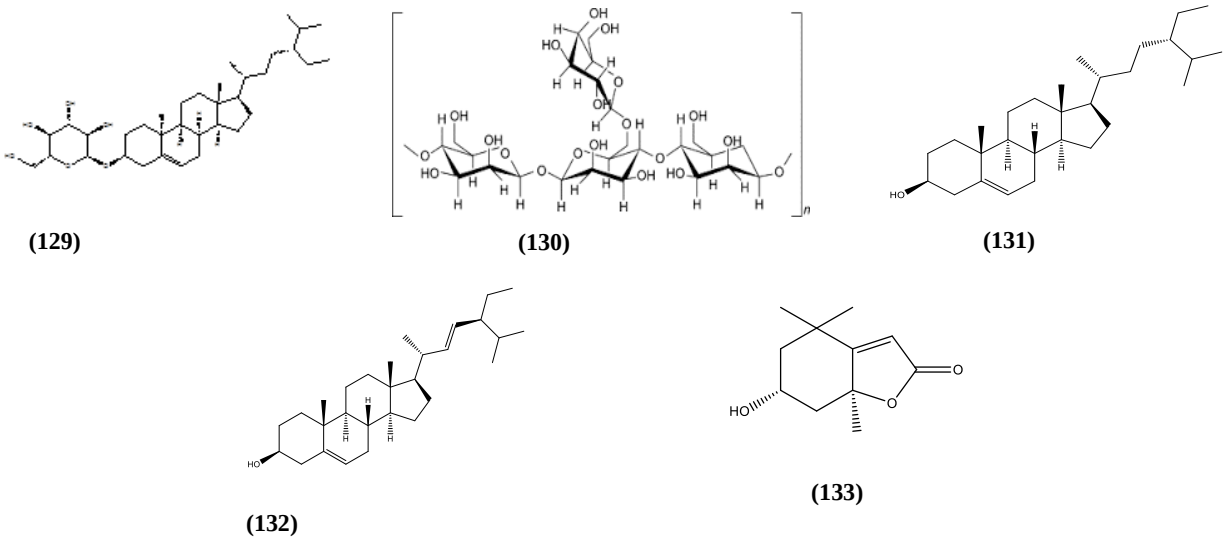
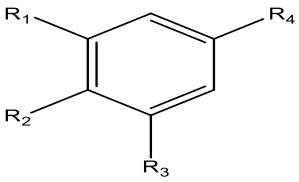


Fig. 3.2. Structure of compounds 129- 133



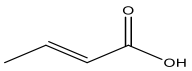
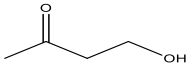
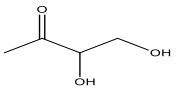
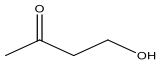
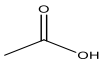
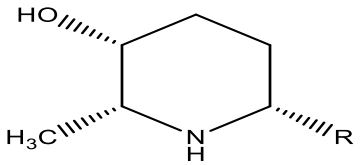
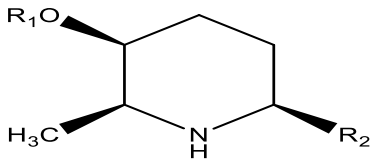
	R_1	R_2	R_3	R_4
(134)	H	H	H	
(135)	OMe	OH	H	
(136)	OMe	OH	H	
(137)	OMe	OH	OMe	
(138)	OMe	OH	OMe	
(139)	OMe	OH	H	

Fig. 3.3. Structure of compounds 134- 139



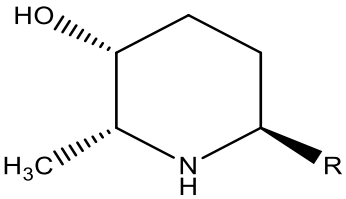
	R
(140)	-$(CH_2)_{12}$COCH3
(141)	-$(CH_2)_{12}$CO(OH)CH_3
(142)	-$(CH_2)_{10}$CO(OH)CH_3

Fig. 3.4. Structure of compounds 140- 142



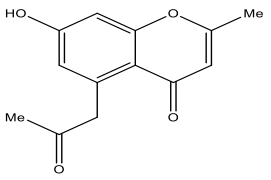
	R_1	**R_2**
(143)	H	-$(CH_2)_{10}$CO(OH)CH_2OH
(144)	Ac	-$(CH_2)_{10}$CO(OH)CH_2OH
(145)	H	-$(CH_2)_{10}$COCH3

Fig. 3.5. Structure of compounds143- 145

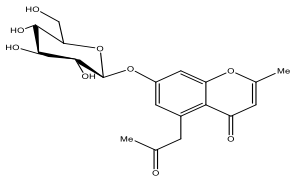


	R
(146)	-$(CH_2)_{10}$CO(OH)CH_3
(147)	-$(CH_2)_{10}CO_2H$

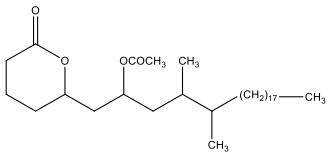
Fig. 3.6. Structure of compounds 146 and 147



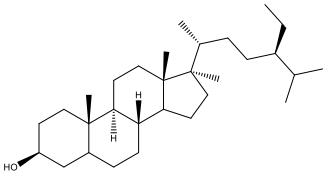
(148)



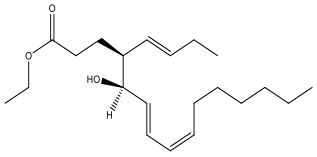
(149)



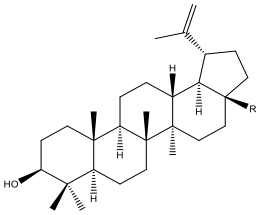
(150)



(151)



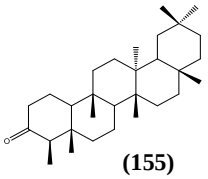
(152)



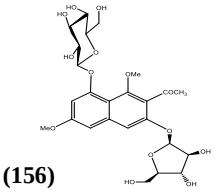
(153) R = CH_3

(154) R = COOH

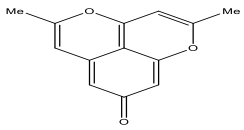
Fig. 3.7. Structure of compounds 148 - 154



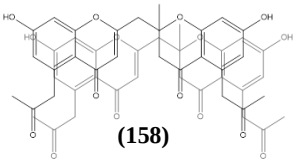
(155)



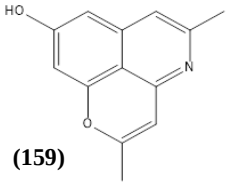
(156)



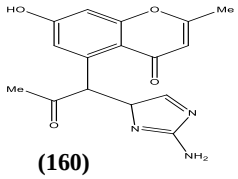
(157)



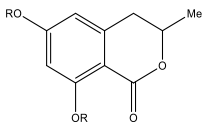
(158)



(159)

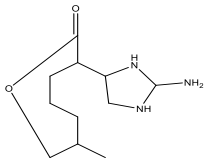


(160)



(161) R = H

(162) R = Ac



(163)

Fig. 3.8. Structure of compounds 155- 163

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

Funding Statement

No funding source was received.

Authors' contributions

The manuscript was drafted and written by all authors. All authors have read and approved the final manuscript.

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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.

https://doi.org/10.1016/j.jep.2006.10.032

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.

https://doi.org/10.2307/2656638

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.

http://hdl.handle.net/123456789/14810

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.

https://doi.org/10.1016/j.copbio.2013.09.007

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

https://doi.org/10.1016/0031-9422(93)85192-T

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.

https://doi.org/10.1016/j.talanta.2007.07.033

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.

https://doi.org/10.1080/14786419.2016.1258562

11. Kinjo, J., Ikeda, T., Watanabe, K., and Nohara, T. An anthraquinone glycoside from *Cassia angustifolia* leaves. *Phytochem*. 1994; 37(6), 1685–1687.

https://doi.org/10.1016/S0031-9422(00)89592-8

12. Barba, B., D\'\iaz, J. G., & Herz, W. Anthraquinones and other constituents of two *Senna* species. *Phytochem*. 1992; 31(12), 4374–4375.

https://doi.org/10.1016/0031-9422(92)80483-U

13. Alemayehu, G., Hailu, A., and Abegaz, B. M. Bianthraquinones from *Senna didymobotrya*. *Phytochem*. 1996a; 42(5), 1423–1425.

https://doi.org/10.1016/0031-9422(96)00102-1

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

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

16. 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/10.1016/0031-9422(91)83048-P

17. 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

18. 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

19. Alemayehu, G., and Abegaz, B. M. Bianthraquinones from the seeds of *Senna multiglandulosa*. *Phytochem*. 1996b; 41(3), 919–921.

https://doi.org/10.1016/0031-9422(95)00645-1

20. Abegaz, B. M., Bezabeh, M., Alemayehu, G., & Duddeck, H. Anthraquinones from *Senna multiglandulosa*. *Phytochem*. 1994; 35(2), 465–468.

https://doi.org/10.1016/S0031-9422(00)94783-6

21. Yadav, J.P., Arya, V., Yadav, S., Panghal, M., Kumar, S. and Dhankhar, 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

22. Sob, S. V. T., Wabo, H. K., Tchinda, A. T., Tane, P., Ngadjui, B. T., Ye, Y., & others. (2010). Anthraquinones, sterols, triterpenoids, and xanthones from *Cassia obtusifolia*. *Biochem. Syst. Ecol*. 2010; 38(3), 342–345.

http://dx.doi.org/10.1016/j.bse.2010.02.002

23. Sob, S. V. T., Wabo, H. K., Tane, P., Ngadjui, B. T., and Ma, D. A xanthone and a polyketide derivative from the leaves of *Cassia obtusifolia* (Leguminosae). *Tetrahedron*, 2008; 64(34), 7999–8002.

https://doi.org/10.1016/j.tet.2008.05.125

24. Sekar, M., Prasad, K. J. R., Sidduraju, P., and Janardhanan, K. New anthraquinones from *Cassia obtusa*. *Fitoterapia*, 1999; 70(3), 330–332.

https://doi.org/10.1016/S0367-326X(99)00041-6

25. Messana, I., Ferrari, F., Cavalcanti, M. S. B., and Morace, G. An anthraquinone and three naphthopyrone derivatives from *Cassia pudibunda*. *Phytochem*. 1991; 30(2), 708–710.

https://doi.org/10.1016/0031-9422(91)83762-A

26. El-Toumy, S. A., El Souda, S. S., Mohamed, T. K., Brouard, I., and Bermejo, J. Anthraquinone glycosides from *Cassia roxburghii* and evaluation of its free radical scavenging activity. *Carbohydr. Res*. 2012; 360, 47–51.

https://doi.org/10.1016/j.carres.2012.07.020

27. Nair, M. S. R., McMorris, T. C., and Anchel, M. Cassiaxanthone, a hydroxyxanthone dicarboxylic acid from *Cassia* species. *Phytochem*. 1970; 9(5), 1153–1155.

https://doi.org/10.1016/S0031-9422(00)85246-2

28. Singh, V., Singh, J., and Sharma, J. P. Anthraquinones from heartwood of *Cassia siamea*. *Phytochem*. 1992; 31(6), 2176–2177.

https://doi.org/10.1016/0031-9422(92)80395-U

29. Koyama, J., Morita, I., Tagahara, K., and Aqil, M. Bianthraquinones from *Cassia siamea*. *Phytochem*. 2001; 56(8), 849–851.

https://doi.org/10.1016/S0031-9422(01)00025-5

30. Sui-Ming, W., Wong, M. M., Seligmann, O., and Wagner, H. Anthraquinone glycosides from the seeds of *Cassia tora*. *Phytochem*. 1989; 28(1),

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., Vidyadhar, K.N. and Chakradhar, 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. J.* 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 cassigarol 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 Kozawaqa, 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 cycloartane triterpene 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.

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/10.2174/1389201017666160819151153

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 sophera* 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. Thongsaard, 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/10.1016/0091-3057(95)02088-8

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.jep.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., Yodkeeree, S., Thippraphan, P., Punfa, W. and Srisomboon, J., Anti-aging and tyrosinase inhibition effects of *Cassia fistula* flower butanolic extract. *BMC Complem. Altern. med*. 2016; 16(1), p.497.

https://doi.org/10.1186/s12906-016-1484-3

67. Srividhya, 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.

http://creativecommons.org/licenses/by/4.0/

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.

https://doi.org/10.2478/v10007-010-0030-y

70. Afify, 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.

https://doi.org/10.1016/j.apjtb.2016.07.006

71. Veerapur, V. P., Pratap, 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.

https://doi.org/10.1016/j.jep.2017.01.025

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.

https://www.researchgate.net/journal/0975-7538_International_Journal_of_Research_in_Pharmaceutical_Sciences

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.

http://dx.doi.org/10.1155/2016/6841348

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.

https://doi.org/10.1016/j.foodchem.2009.01.091

76. Sundaramoorthy, S.,Gunasekaran, S., Arunachalam, S. and Sathiavelu, 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.

https://doi.org/10.1016/j.arabjc.2013.06.010

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.

https://doi.org/10.1016/j.jep.2006.05.021

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.

https://doi.org/10.3892/mmr.2017.6880

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.

https://doi.org/10.1016/j.lwt.2006.05.010

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.

https://doi.org/10.1016/j.phymed.2017.06.002

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/10.1016/0378-8741(88)90233-4

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/10.4103/0253-7613.48887

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.iums.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., Kumarappan, C., and Mandal, S. C. $α$-Glucosidase and $α$-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-arthritic 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.

https://doi.org/10.1016/0378-8741(90)90043-s

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. Phytoch. 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.

https://doi.org/10.1016/s0378-8741(98)00220-7

108. Maity, T. K., Mandal, S. C., Mukherjee, P. K., Saha, K., Das, J., Saha, B. P., and Pal, M. Evaluation of hepatoprotective potential of *Cassia tora* leaf extract. *Nat. Prod. Sci*. 1997; 3(2), 122–126.

109. Jafri, M. A., Subhani, M. J., Javed, K., and Singh, S. Hepatoprotective activity of leaves of *Cassia occidentalis* against paracetamol and ethyl alcohol intoxication in rats. *J. Ethnopharmacol*. 1999; 66(3), 355–361.

https://doi.org/10.1016/s0378-8741(99)00037-9

110. John, C. M., Sandrasaigaran, P., Tong, C. K., Adam, A., and Ramasamy, R. Immunomodulatory activity of polyphenols derived from *Cassia auriculata* flowers in aged rats. *Cell. Immunol*. 2011; 271(2), 474–479.

https://doi.org/10.1016/j.cellimm.2011.08.017

111. Elujoba, A. A., Ajulo, O. O., and Iweibo, G. O. Chemical and biological analyses of Nigerian *Cassia* species for laxative activity. *J. Pharma. Biomed. Anal*. 1989; 7(12), 1453–1457.

https://doi.org/10.1016/0731-7085(89)80150-5