World Journal of Advanced Research and Reviews, 2020, 07(03), 291–303

World Journal of Advanced Research and Reviews

e-ISSN: 2581-9615, Cross Ref DOI: 10.30574/wjarr

Journal homepage: https://www.wjarr.com

(REVIEW ARTICLE)

Hibiscus herbs - a comprehensive botanical, chemical and biological overview

Rajesh Kowti [1,*], Pulak Majumder [2], Harshitha HS [1], Vedamurthy Joshi [3], Rupesh Kumar M [1] and Syed Sagheer Ahmed [1]

[1] *Dept. of Pharmacology, Sri Adichunchanagiri College of Pharmacy, Adichunchanagiri University, B.G. Nagara, Mandya, Karnataka.*
[2] *Dept. of Pharmacognosy, Sri Adichunchanagiri College of Pharmacy, Adichunchanagiri University, B.G. Nagara, Mandya, Karnataka.*
[3] *Dept. of Pharmaceutics, Sri Adichunchanagiri College of Pharmacy, Adichunchanagiri University, B.G .Nagara, Mandya, Karnataka.*

Publication history**:** Received on 18 September 2020; revised on 27 September 2020; accepted on 29 September 2020

Article DOI: https://doi.org/10.30574/wjarr.2020.7.3.0351

Abstract

Hibiscus cannabinus and *Hibiscus sabdariffa* are the most multidimensional plants in the Genus Hibiscus. Current overview is an updated comprehensive reported outcome of these plants, for its botanical, chemical and biological activities. It provides mainly botanical features of the plants for identification. It also includes the ethno-traditional medicinal practices of those plants. Till date, the presence of various reported phytochemicals like volatile compounds i.e. E-phytol, linolenic acid, trisiloxane-1,1,1,5,5,5-hexamethyl-3,3-bis[(trimethylsilyl)oxy], linoleic acid, caffeic acid, kaempferitrin, vanillic acid etc. are embrace the key of biological activities in these plants which reflects in the traditional uses. The aerial view of *In vivo* and *In vitro* reported biological activities like Anti-anemic, Antihyperlipidemic, Antidiabetic, Anthelmintic, Hepatoprotective, Antiulcer, Anti–hypercholesterolemic, Antibacterial, Glycosylation Inhibition etc. make this herb a multidimensional in its domain as pharmacologically active herbs. On the other hand the exploration of metabolic profiles, nanoparticulated activities, Cytotoxicity, Anti-oxidant profile etc. indicated the vast usefulness of these herbs. Alteration of fiber by unite copolymerization is a scientific update from *Hibiscus cannabinus* and Toxicological Studies concluded with safety of these plants were described. The correlation with phytochemicals and related pharmacological actions in these plants were well indicated in this review. Various scopes of biological activities in both the species were clearly visualized and well defined. This review will leads the researches to obtain all aspects of information under one umbrella and help them to explore more scientific date by refereeing this bulk upto date data base of these two plant species. All such information's in one not been reported till date.

Keywords: *Hibiscus cannabinus; Hibiscus sabdariffa*; Botanical features; Phytochemicals; Biological activities

1. Introduction

The art of utilizing the medicinal plants is known since ages by the man and Medicinal plants found to play crucial role for the creating a healthy society. About 75% of world's population consumes plant for prevention, therapy and strengthening the immune systems. Art of isolation, formulation and evaluation of active herbal constituents enable to validate the pharmacological activity and to set standards for bulk production as plants tend to vary their constituents periodically. Prior to the presentation of chemical medications, man depended on the recuperating properties of therapeutic plants. It is pondered 80% of the 5.2 billion individuals of the world live in the less evolved nations and the World Health Organization gauges that about 80% of these individuals depend only on customary drug for their essential medicinal service needs. Presently, majority part of the world start respecting and believing the Indian practices in lieu with medicinal plants use. Identified parts of the plants were harvested in a given period, isolated and

* Corresponding author: Rajesh Kowti
Dept. of Pharmacology, Sri Adichunchanagiri College of Pharmacy, Adichunchanagiri University, B.G. Nagara, Mandya, Karnataka.

made to the suitable formulation and utilized to treat ailments. These formulations manifest actions with no side effects hence; the plants need of Indian medication framework shows recipient effects [1].

2. Plant descriptions

Kenaf (*Hibiscus cannabinus*), (Figure.1) having a place with the Malvaceae family, is a tall, herbaceous, yearly, woody, tropical plant. It is a normally single-stemmed, erect, and annual to perennial plant growing around 1.8 meters tall. The stems can become more or less woody and persistent its leaves are devoured as a vegetable in specific pieces of the world and have erythrocyte defensive action against medicate incited oxidative pressure [2].

The perennial herb Hibiscus sabdariffa has (Figure,2) grown up to 2–2.5 m height. Alternately arranged 3- to 5 -lobed leave of 8–15 cm long. The flowers are 8–10 cm (3–4 in) in diameter, white to pale yellow with a dark red spot at the base of each petal, and have a stout fleshy calyxat the base, 1–2 cm wide. Mature fruits are enlarging about 3–3.5 cm, with fleshy and bright red colour. They take about six months to mature.

3. Origin, geographic distributions, taxonomical status and vernacular name

*Hibiscus cannabinus*is ,is a common wild plant in most African countries south of the Sahara. It's been domesticated as a fiber plant already 6000 years ago in Sudan. Kenaf is now widespread in the tropics and subtropics. As a vegetable it is widely grown in Africa, where it is grown on a much smaller scale as a fibre crop. In the past it has been of some importance as a commercial fibre crop in Côte d'Ivoire, Burkina Faso, Togo, Benin, Niger, Kenya, Tanzania and Malawi. India has long been the largest producer of kenaffibre[3].

H. sabdariffa originated from Africa. Roselle is now found throughout the tropics. In tropical Africa it is especially common in the savanna region of West and Central Africa.

The taxonomical status [4] and vernacular names of both the plants are describe in table 1 and 2.

Table 1 Taxonomic classification of *Hibiscus cannabinus* and *Hibiscus sabdariffa* L.

Kingdom: Planate	**Kingdom:** Plantae
Subkingdom: Viridiplantae	**Subkingdom:** Tracheobionta
Super division: Embryophyta	**Super division:** Spermatophyta
Division: Tracheophyta	**Division:** Magnoliophyta
Subdivision: Spermatophytina	**Class:** Magnoliopsida
Class: Magnoliopsida	**Subclass:** Dilleniidae
Superorder: Rosanae	**Order:** Malvales
Family: Malvaceae	**Family :** Malvaceae
Genus: Hibiscus	**Genus:** Hibiscus L.
Species: *Hibiscus cannabinus*	**Species:** *Hibiscus sabdariffa* L.

Figure 1 *Hibiscus cannabinus*

Figure 2 *Hibiscus sabdariffa L*

Table 2 Vernacular names:

Hibiscus cannabinus	***Hibiscus sabdariffa***
Sanskrit: Ambalika, ambashtha, ambastha English: Kenaf, vegetable Kenaf, Guinea hemp, Deccan hemp, Brown Indian Hemp Hindi: Patsan Tamil: Palungu, Pulimanji Malayalam: Kanjaru Telugu: Pimdikura, Gonkura Kannada: Dirindarani	English: Roselle, Hibiscus, Jamaica sorrel, Red sorrel Hindi: LalAmbari Tamil: Simaikkasuru Malayalam: Polechi, puli-cheera Telugu: Erragomgura, erragonkaya, ettagomgura Kannada: Kempupundrike, plachakiri

4. Botanical review

Identifications of plant species is the prime objectives of plant research**.** Descriptions of vegetative parts of plants play a great role for their species identifications. *H*. *cannabinus* and *H. sabdariffa* also can be identified preliminarily with its organ descriptions like stem, leaves, flowers, fruit and seeds. The comparative descriptions are described in table 3.

Table 3 Botanical descriptions of *Hibiscus cannabinus and Hibiscus sabdariffa*

Botanical descriptions of *Hibiscus cannabinus*	**Botanical descriptions of *Hibiscus sabdariffa***
Stem Stems aculeate with minor sparse prickles typically directing uphill, otherwise closely glabrous or with a longitudinal line of crisped pubescence changing its radial place at every node **Leaves** Leaves narrowly ovate, ovate or sub orbicular in outline, 3–17 × 3–20 cm, un lobed to 3–7-palmatisect to palmatilobed, apex acute, base broadly cuneate to shallowly cordate, margin serrate or dentate, rarely subentire, scaberulous or almost glabrous with a few minute prickles on the veins, usually with a prominent gland on the under surface near the base of the midrib; petiole 6–22 cm long, prickly with a line of pubescence, like the stem; stipules narrowly linear to filiform, 4–5 mm long, caduceus	**Stem** Stems are smooth or nearly smooth, cylindrical, typically red stems. **Leaves** The petioles are 1 to 6 cm long. Leaves are simple, alternate and narrowly lanceolate to linear stipules. Lamina portions are in variable shape and size. Basal leaves are entire, orbicular, with 3 to 5 palmate veins. Upper leaves slightly to deeply 3-5-palmatilobed with oblong-lanceolate lobes, 5 to 10 cm with lanceolate and serrated margin. The apex is acute, the base is wedged. On the underside, at the birth of the midrib is an elliptical nectar gland, 2 to 3 mm long

Flower Flowers solitary in the leaf axils, pedicel 2-6 mm long, articulated at base, aculeate or hispid; epicalyx of 7–8 linear bracts 5–10 × 1–1.5 mm, joined to calyx for about 2 mm at base; calyx lobes 10–20 × 3–5 mm, long-acuminate (sometimes sub caudate) joined for up to a third of their length from the base, aculeate or hispid outside especially nearby the margin with a woolly tomentum, typically with a protuberant gland 1.5–2 mm width on midrib. Deep purple, pale yellow or white, 3–8 cm long Corolla with whitish or greyish pubescent outside, with glabrous Staminal tube at 2–4 cm long; filaments 13 mm long; exerted part of style 3–6 mm long, glabrous. **Fruit** Capsule ovoid-acuminate, 13–18 mm long, 9–12 mm in diameter, appressedsetose. **Seed** Seeds irregularly subreniform, 3–3.5 × 1.5–2.5 mm, sparsely to densely cover with truncate scales.	**Flower** The flowers are bisexual, regular, pentamerous, with pedicel 1 to 4 cm long, articulated. Epicalyxes consist of about 10 acute lobes, 8 to 10 mm in length, shorter than the calyx. Reddish calyx is 2 cm long, deeply divided into 10 long acuminate, glabrescent or slightly hispid and roughly accrescent lobes, becoming more or less fleshy during fruiting. Corolla is yellow, large, with 5 obovate petals, 4 to 5 cm long, veined and spotted with purple at the base. The staminal column measures half the length of the corolla and has numerous stamens on most of its length. A larger ovary contains 5 loculus topped with 5 branches of style. **Fruit** Spherical-conical capsule, shorter than the calyx, 1.5 to 2 cm long, apiculate at the top and covered with stiff and applied bristles. It remains included in the accrescent calyx, and contains many seeds. **Seed** Kidney-shaped seeds with dark brown colour up to 7 mm long.

5. Phytochemical review

Numerous phytochemicals are being isolated and identified from *Hibiscus cannabinus* and *Hibiscus sabdariffa* (Table 4-6). Some of the phytochemicals are also been quantified with modern quantification techniques (table 4). Principle phytochemicals of both the species are been illustrated in figure. 3 and 4.

Table 4 Major chemicals and quantity in *Hibiscus cannabinus* plant

Chemicals	mg /100gm	References
E-phytol	32.4mg	[5]
Linolenic acid	47.3mg	
Trisiloxane-1,1,1,5,5,5-hexamethyl-3,3-Bis[(trimethylsilyl)oxy]	16.4mg	
Linoleic acid	46.4mg	
Caffeic acid	5.2 mg	
Kaempferitrin	17.5	
Vanillic acid	2.1 mg	
Caffeic acid isomer	1.5 mg	
p-hydroxybenzoic acid	1.0 mg	
Afzelin	4.9 mg	
Kaempferol glycoside	2.9 mg	
Isoquercitrin	2.8 mg	
Gallic acid	1.5 mg	
Stem bark:		
Kaempferitrin	24.1 mg	
Afzelin	4.5 mg	
Kaempferol glycoside isoquercitrin	4.2 mg	

leaf		
3,7,11,15-Tetramethyl-2-hexadecen	4.4	
Tetradecanoic acid	0.8	
6,10,14-trimethyl-pentadecan-2-ol 6,10,14-Trimethyl-2-pentadecanone	0.9 3.4	
Hexadecanoic acid	14.3	
9-Octadecenoic n=6, 0.7acid Phytol acetic acid derivation	2.9 2.3	
9,12-Octadecadienoic acid	6.8	
Phytol	32.4	
9,12,15-Octadecatrienoic acid	27.6	
2-5-oxohexyl-cyclopentanone	1.4	
2,6,10,14,18,22-Tetracosahexaene	2.1	

The volatile compounds found in most abundant. Other major components in different parts of *Hibiscus cannabinus* are kaemperitrin, caffeic acid, myricetin glycoside, and p-hydroxybenzoic acid in leaves, bark, blossoms, and seeds.

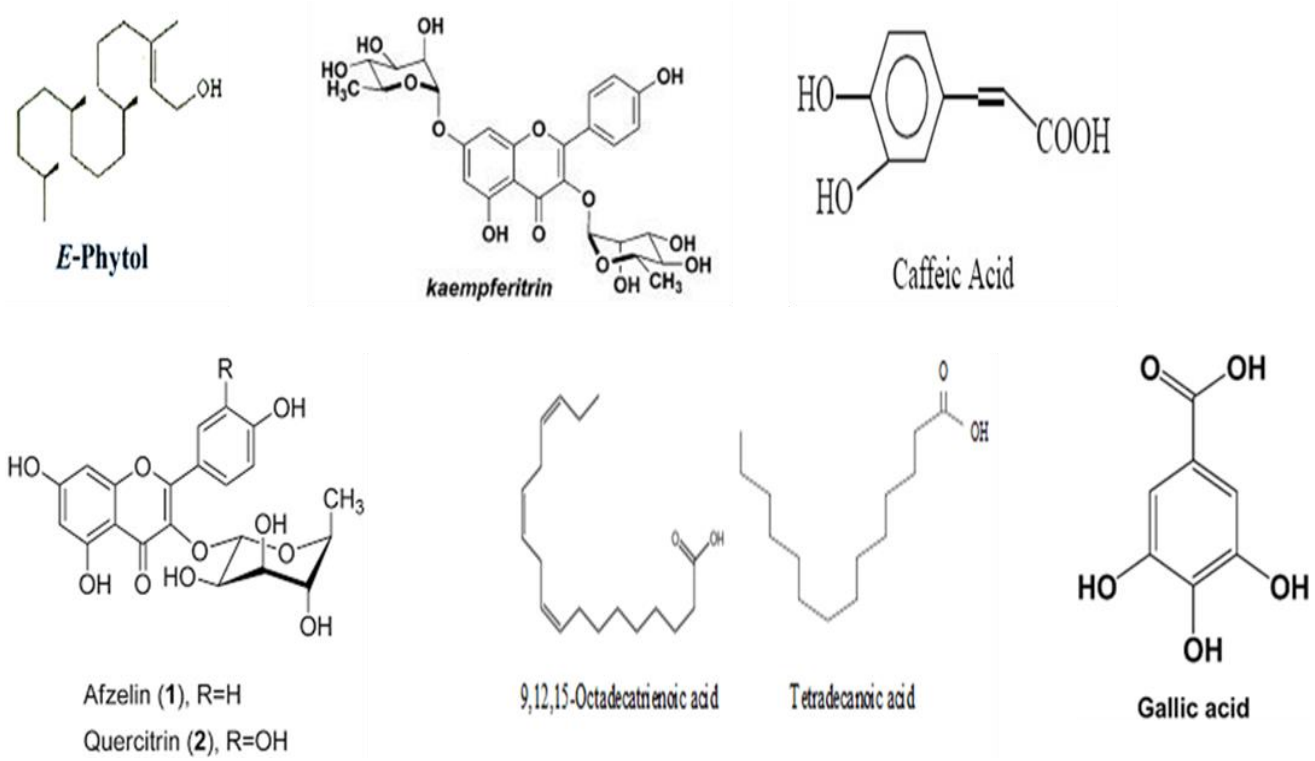

Figure 3 Major Chemical structures *Hibiscus cannabinus*

Table 5 Phytochemicals from different parts of *Hibiscus cannabinus*

Phytochemicals	**mg /100gm**	**Reference**
Leaf		
3,7,11,15 tetramethyl-2 hexadecen-1-ol (Z-phytol)	4.4	
13.9 Tetradecanoic acid	0.8	
15.1 6,10,14-Trimethyl-pentadecan-2-ol	0.9	
15.3 2-Pentadecanone, 6,10,14-trimethyl	3.4	[5]
15.5 Hexadecanoic acid	14.3	
18.2 9-Octadecenoic acid	2.9	
18.8 Phytol, acetate	2.3	
19.4 9,12-Octadecadienoic acid	6.8	
E-Phytol	32.4	
10 20.7 9,12,15-Octadecatrienoic acid	0.7	
11 21.0 9,12,15-Octadecatrienoic acid	27.6	
12 22.4 Cyclopentanone, 2-(5-oxohexyl)	1.4	
13 26.2 2,6,10,14,18,22-Tetracosahexaene	2.1	
Bark		
Hexadecanoic acid	25.4	
9-Hexadecenoic acid	3.0	
Octadecanoic acid	3.1	
9-Octadecenoic acid	1.2	
Phytol	0.7	
9,12-Octadecadienoic acid	10.7	
E-Phytol	8.7	
9,12,15-Octadecatrienoic acid	47.3	
Flower		
Trisiloxane,1,1,1,5,5,5-hexamethyl-3,3-bis[(trimethylsilyl)oxy]	16.4	
3-Isopropoxy-1,1,1,7,7,7-hexamethyl-3,5,5-Tris(trimethylsiloxy)tetrasiloxane	10.3	
Hexadecanoic acid	16.1	
15-methylhexadecanoic acid	1.6	
Octadecanoic acid	5.3	
Octasiloxane1,1,3,3,5,5,7,7,9,9,11,11,13,13,15,15-Hexadecamethyl	8.6	
9-Octadecenoic acid	12.5	
9,12-Octadecadienoic acid	4.5	
9,12,15-Octadecatrienoic acid	7.2	
Hexasiloxane, tetradecamethyl	8.9	
Heptasiloxane, hexadecamethyl	8.6	
Seed		
Tetradecanoic acid	0.1	
Hexadecanoic acid	20.9	
9-Hexadecenoic acid	0.6	
cis-10-Heptadecenoic acid	0.3	
Octadecanoic acid	2.2	

9-Octadecadienoic acid (trans)	1.2
9-Octadecenoic acid (cis)	27.4
9,12-Octadecadienoic acid	46.4
Nonadecanoic acid	0.3
9,12,15-Octadecatrienoic acid	0.6

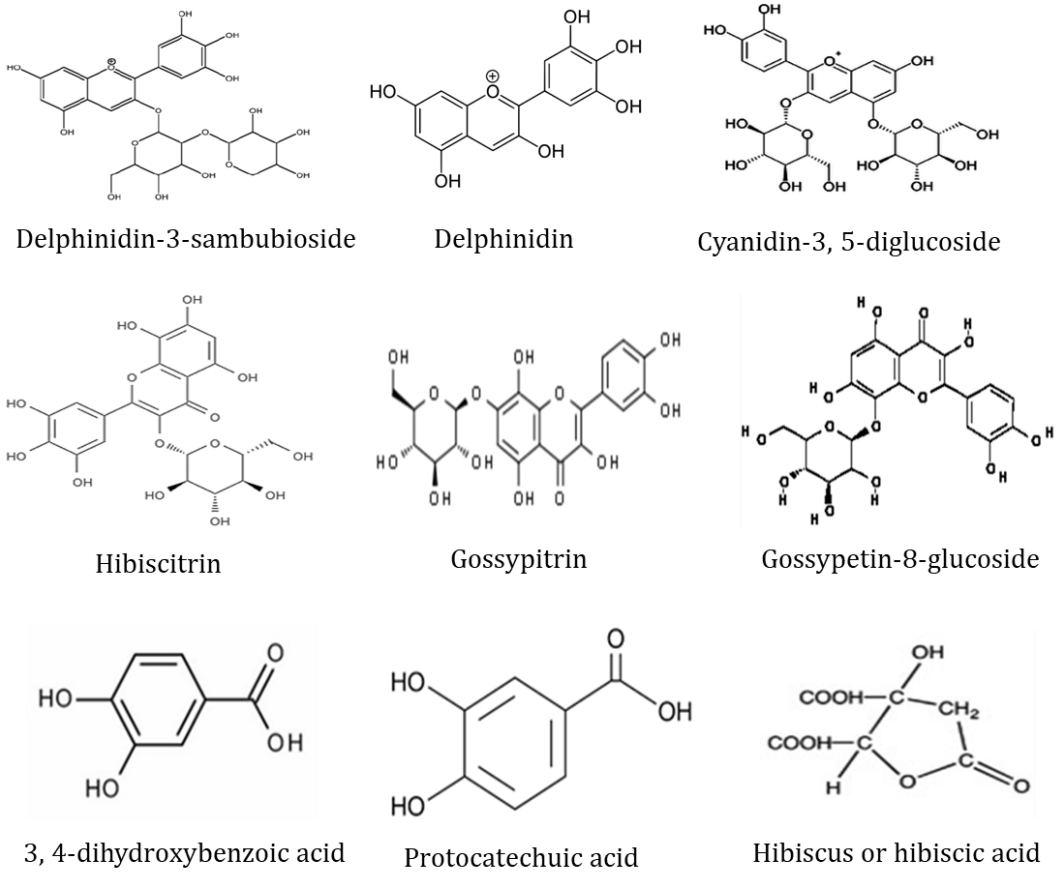

Figure 4 Major chemical structures of *Hibiscus sabdariffa*

Table 6 Major Phytochemicals from *Hibiscus sabdariffa L*

Phytochemicals	**Reference**
Delphinidin-pentoside-glucoside	[6]
Delphinidin-3-sambubioside, delphinidin-3-monoglucoside, cyanidin-3-monoglucoside, delphinidin	[6]
Delphinidin-3-sambubioside	[7]
Cyanidin-3, 5-diglucoside, cyanidin-3-2Gglucosylrutinoside	[8]
Flavonolglycoside, hibiscitrin, hibiscetin, Gossypitrin, sabdaritrin. hibiscitrin, gossypitrin and sabdaritrin.	[9]
Gossypetin-8-glucoside, gossypetin-7-glucoside, gossypetin-3-glucoside, 8-glucoside, gossypin, anthocyanins	[9]
8-glucoside, gossypin, gossypitrin, sabdaritrin.	
hibiscin, gossypetin, gossypetrin, quercetin, probably myricetin, hibiscetin, hibiscetrin, sabdaritrin, possibly sabdaretin	[10]

Quercetin, luteolin, a luteolin glycoside	[8]
Protocatechuicacid	[9]
Eugenol	[9]
Sterols β-sitosterol, ergosterol	[11]
Quercetin	[12]
Hibiscus protocatechuic acid (3, 4-dihydroxybenzoic acid	[13]

6. Biological overview

The biological activities of *Hibiscus cannabinus* and *Hibiscus sabdariffa* are reported by various researchers. The *in vitro* and *in vivo* biological activities of *H. cannabinus* and *H. sabdariffa* have been tabulated in Table 7 - 9.

Table 7 *In vitro* activities of *Hibiscus cannabinus*

Part of the plant	Activity	Extract used	Reference
Leaves	Anti-diabetic	Methanolic extract	[14] [15]
	Inhibition of glycosylation	Methanolic leaf concentrate	[16]
	Anti-oxidant activity	Methanolic and dichloromethane extracts	[17]
	Anti-inflammatory activity	Methanolic and dichloromethane extracts	[17]
	Antimicrobial activity	Union of mono dispersed silver nanoparticles	[18]
Seed concentrate and seed oil	Cytotoxic effect on human breast cancer	3-(4,5-dimethylthiazol-2-yl)- 2,5-diphenyltetrazolium bromide and sulforhodamine B	[19]
	Cytotoxic effect on human colon cancer	3-(4,5-dimethylthiazol-2-yl)- 2,5-diphenyltetrazolium bromide and sulforhodamine B	
	Cytotoxic effect on human lung cancer	3-(4,5-dimethylthiazol-2-yl)- 2,5-diphenyltetrazolium bromide and sulforhodamine B	
	Cytotoxic effect on human cervical cancer	3-(4,5-dimethylthiazol-2-yl)- 2,5-diphenyltetrazolium bromide and sulforhodamine B	
Seed	Anti-oxidant activity	Kenaf phenolic fraction	[20]
Seed	Antibacterial activity	*Hibiscus cannabinus stem*-assisted silver and gold nanoparticles	[21]
Stem	Dye removal activity	graft copolymerization	[22]
Fiber	Cytotoxic activity	acetone extraction	[23]
Core and bark	Cytotoxic effect	Supercritical carbon dioxide extraction fluid	[24]

Table 8 *In vitro* activities of *Hibiscus sabdariffa*

Part of the plant	Activity	Extract used	Reference
Whole plant	Antibacterial and Cytotoxic activity	Aqueous methanolic extract	[25]
Whole plant	Inhibitory activity against porcine pancreatic α-amylase	50% methanol and acetone extracts	[26]
Seed and plant calyx	Anti-oxidant	Methanolic extract	[27]
Whole plant	Diuretic	Aqueous extract	[28]
leaves	Phytochemistry	Leaf extract	[29]
leaves	Antioxidant capacity	Leaf extract	
leaves	Total phenolic content	Leaf extract	
leaves	Anti-inflammatory activity	Leaf extract	

Table 9 *In vivo* activities of *Hibiscus cannabinus*

Parts used	Activity	Animal	Extraction	Significant dose	Reference
Leaf	Anti-anemic	Male albino rats	Aqueous extract	400 mg/kg	[30]
	Antihyperlipidemic	Rats	Hydro alcoholic extract	400 mg/kg p.o	[31]
	Antidiabetic Properties	Albino rats	Methanolic concentrate	400mg/kg	[32]
	Antidiabetic activity	Albino rats	Ethanolic extract	400mg/kg	[33]
	Anthelmintic activity	Earthworm Pheritimaposthuma	Methanolic leaf extract	10,20,30,and40mg/ml	[34]
	Hepatoprotective	Albino rats	Aqueous leaf extract	1.6mg/kg BW	[35]
Seeds	Anti-ulcer	Rats	Seed separate	600 mg/kg	[36]
	Antihypercholesterolemic effect	Male Sprague dawley	Phenolic extract	500 mg/ kg	[37]

Table 10 *In vivo* biological actions of *Hibiscus sabdariffa*

Parts used	Activity	Animal	Extraction	Significant dose	Reference
Flower	Hepatoprotective	Rat	Crude extract	0.20mg/ml	[38]
Whole plant	Anti-inflammatory	------	Aqueous extract	500mg/kg orally	[39]
Whole plant	Action on obesity and its problems	Mice	Phenolic extract	1 mg/kg	[40]
Whole plant	Antimicrobial	Staphylococcus aureus	Aqueous extract	10-160 mg/ml	[41]
Whole plant	Obesity	MSG mice	Aqueous concentrate	120 mg/kg	[42]
Whole plant	Atherosclerosis	Rabbit	Aqueous concentrate	30 mg/kg i.v.	[43]
Whole plant	Hepatoprotective	Wistar rats	---------	200 mg/kg body weight, orally	[44]
Hibiscus sabdariffa – human clinical trials					
Whole plant	Essential hypertension	-------	-------	150 g of sour or ordinary tea	[45]
Whole plant	Blood pressure lowering	-------	-------	720 mL/dl	[46]
Whole plant	Reduced serum cholesterol	-------	----------	15.8- 8.1 mg/dl	[47]

7. Conclusion

This review evaluates data regarding the botanical, phyto-pharmaceutical and biological potential of *H. cannabins* and (figure, 1) and *H. sabdariffa* (figure, 2). This review will facilitate the researcher for its potential identification and further more exploration of these herbs in terms of biological activities guided phytochemical identification and finding out the drug mechanism of action of phytochemicals in treatment of several diseases. These hibiscus groups of plats need of more investigation on the pharmacological properties and phytochemical compositions for futuristic use.

Compliance with ethical standards

Acknowledgments

The Authors would like to express their hearty gratitude to Adichunchanagiri University and SAC Pharmacy College for supporting this work.

Disclosure of conflict of interest

There is no conflict of interest.

Author's contribution statement

Rajesh Kowti, conceptualized and gathered the data of this work, Pulak Majumder, analyzed the data and put necessary inputs towards the designing of the manuscript, Harshitha HS, gathered the data with regard to this work, Vedamurthy Joshi, Rupesh Kumar M & Syed Sagheer Ahmed given necessary inputs for designing of the manuscript. All authors discussed the methodology and results and contributed to the final manuscript.

References

[1] Webster E. Webster's third new international dictionary Merriam-Webster. Inc., Springfield, Massachusetts. 2000.

[2] Mariod AA, Ibrahim RM, Ismail M, Ismail N. Antioxidant activity of phenolic extracts from kenaf (*Hibiscus cannabinus*) seedcake. grasas y aceites. 2012 Jun 30; 63(2): 167-74.

[3] Edmonds JM. The distribution of Hibiscus L. section Furcaria in tropical East Africa. International Board for Plant Genetic Resources.1991.

[4] Al-Snafi AE. Medical benefit of Malvaneglecta-A review. IOSR Journal of Pharmacy. 2019; 9(6): 60-7.

[5] Ryu J, Kwon SJ, Ahn JW, Jo YD, Kim SH, Jeong SW, Lee MK, Kim JB, Kang SY. Phytochemicals and antioxidant activity in the kenaf plant (*Hibiscus cannabinus* L.). Journal of Plant Biotechnology. 30 Jun 2017; 44(2): 191-202.

[6] Ryu J, Kwon SJ, Ahn JW, Jo YD, Kim SH, Jeong SW, Lee MK, Kim JB, Kang SY. Phytochemicals and antioxidant activity in the kenaf plant (*Hibiscus cannabinus* L.). Journal of Plant Biotechnology. 2017 Jun 30; 44(2): 191-202.

[7] Yamamoto R, Osima Y. On the colouring matter of "*Hibiscus sabdariffa*" L. (Hiviscin) II, The Institute of Physical and Chemical Research. 1936; 30.

[8] Du CT, Francis FJ. Anthocyanins of roselle (*Hibiscus sabdariffa*, L.). Journal of Food Science. Jul 1973; 38(5): 810-2.

[9] Subramanian SS, AGR Nair. Flavonoids of four malvaceous plants Phytochemistry. 1972; 11(4): 1518-1519.

[10] Rao RP, Seshadri TR. Pigments of the flowers of *Hibiscus sabdariffa* isolation of sabdaretin, a new hydroxyflavone. Proceedings of the Indian Academy of Sciences. 1942; 16A (5): 323-327.

[11] Khafaga ER, Koch H, El Afry MM, Prinz D. Stage of maturity and quality of karkadeh (*Hibiscus sabdariffa* L. var. sabdariffa). 1. Organic acids. 2. Anthocyanins. 3. Mucilage, pectin and carbohydrates. 4. Improved drying and harvesting systems. Angewandte Botanik. 1980; 54(5/6): 287-318.

[12] Salah AM, Gathumbi J, Vierling W. Inhibition of intestinal motility by methanol extracts of *Hibiscus sabdariffa* L.(Malvaceae) in rats. Phytotherapy Research. May 2002; 16(3): 283-5.

[13] Tseng TH, Wang CJ, Kao ES. Hibiscus protocatechuic acid protects against oxidative damage induced by tert-butylhydroperoxide in rat primary hepatocytes. Chemico-Biological Interactions. 14 Aug 1996; 101(2): 137-48.

[14] Takeda N, Yasui Y. Identification of mutagenic substances in roselle color, elderberry color and safflower yellow. Agricultural and biological chemistry. 1985; 49(6): 1851-2.

[15] James SA, Omwirhiren EM, Ladan Z, Alhassan N, Mohammed SN. Spectroscopic characterization of the antidiabetic properties of partially purified ethanolic extract of *Hibiscus cannabinus*, Vernonia Amygdalina, Murraya Koenigii and Telfairia Occidentalis. Journal of Pharmacognosy and Phytochemistry. 2018; 7(2): 1508-19.

[16] Kumar TR, Kumar EU, Sekar M, Kumar MK. Antidiabetic activity of methanolic extract of *Hibiscuscannabinus*instreptozotocin induced diabetic rats. International Journal of Pharma and Bio Sciences. 2011; 2(1): P125-30.

[17] James SA, Auta R, Goje DJ. *In vitro* study on inhibition of glycosylation of methanolic leaf extract of *Hibiscuscannabinus*. Science World Journal. 2011; 6(3): 7-9.

[18] Kapepula PM, Kabamba Ngombe N, Tshisekedi Tshibangu P, Tsumbu C, Franck T, Mouithys-Mickalad A, Mumba D, Tshala-Katumbay D, Serteyn D, Tits M, Angenot L. Comparison of metabolic profiles and bioactivities of the leaves of three edible Congolese Hibiscus species. Natural product research. 17 Dec 2017; 31(24): 2885-92.

[19] Bindhu MR, Umadevi M. Synthesis of monodispersed silver nanoparticles using *Hibiscus cannabinus* leaf extract and its antimicrobial activity. SpectrochimicaActa Part A: Molecular and Biomolecular Spectroscopy. 15 jan 2013; 101: 184-90.

[20] Wong YH, Tan WY, Tan CP, Long K, Nyam KL. Cytotoxic activity of kenaf (*Hibiscus cannabinus* L.) seed extract and oil against human cancer cell lines. Asian Pacific journal of tropical biomedicine. 1 May 2014; 4: S510-5.

[21] Mariod AA, Ibrahim RM, Ismail M, Ismail N. Antioxidant activity of phenolic extracts from kenaf (*Hibiscus cannabinus*) seedcake. grasas y aceites. 30 jun 2012; 63(2): 167-74.

[22] Bindhu MR, Rekha PV, Umamaheswari T, Umadevi M. Antibacterial activities of *Hibiscus cannabinus* stem-assisted silver and gold nanoparticles. Materials Letters. 15 sep 2014; 131: 194-7.

[23] Sharma G, Naushad M, Pathania D, Mittal A, El-Desoky GE. Modification of *Hibiscus cannabinus* fiber by graft copolymerization: application for dye removal. Desalination and Water Treatment. 12 jun 2015; 54(11): 3114-21.

[24] Moujir L, Seca AM, Silva AM, López MR, Padilla N, Cavaleiro JA, Neto CP. Cytotoxic activity of lignans from *Hibiscus cannabinus*. Fitoterapia. 1 jul 2007; 78(5): 385-7.

[25] AbdGhafar SA, Ismail M, SaifulYazan L, Fakurazi S, Ismail N, Chan KW, MdTahir P. Cytotoxic activity of kenaf seed oils from supercritical carbon dioxide fluid extraction towards human colorectal cancer (HT29) cell lines. Evidence-Based Complementary and Alternative Medicine. 1 jan 2013.

[26] Tolulope M. Cytotoxicity and antibacterial activity of methanolic extract of *Hibiscus sabdariffa*. Journal of Medicinal Plants Research. 31 Aug 2007; 1(1): 009-13.

[27] Hansawasdi C, Kawabata J, Kasai T. α-Amylase inhibitors from roselle (*Hibiscus sabdariffa* Linn.) tea. Bioscience, biotechnology, and biochemistry. 1 Jan 2000; 64(5): 1041-3.

[28] Mohd-Esa N, Hern FS, Ismail A, Yee CL. Antioxidant activity in different parts of roselle (*Hibiscus sabdariffa* L.) extracts and potential exploitation of the seeds. Food chemistry. 15 Oct 2010; 122(4): 1055-60.

[29] Alarcón-Alonso J, Zamilpa A, Aguilar FA, Herrera-Ruiz M, Tortoriello J, Jimenez-Ferrer E. Pharmacological characterization of the diuretic effect of *Hibiscus sabdariffa* Linn (Malvaceae) extract. Journal of Ethnopharmacology. 15 Feb 2012; 139(3): 751-6.

[30] Zhen J, Villani TS, Guo Y, Qi Y, Chin K, Pan MH, Ho CT, Simon JE, Wu Q. Phytochemistry, antioxidant capacity, total phenolic content and anti-inflammatory activity of *Hibiscus sabdariffa* leaves. Food chemistry. 1 Jan 2016; 190: 673-80.

[31] Gabor GA, Oben JE, Ngogang JY .Haematinic activity of *Hibiscus cannabinus*. African journal of Biotechnology. 2005; 4(8): 833-7.

[32] Pradeep K, Gagandeep K, Nanjaian M. Antihyperlipidemic effect of hydro alcoholic extract of Kenaf (*Hibiscus cannabinus* L.) leaves in high fat diet fed rats. Annals of biological research. 2010; 1(3): 174-81.

[33] James SA, Omwirhiren EM, Ladan Z, Alhassan N, Mohammed SN. Spectroscopic characterization of the antidiabetic properties of partially purified ethanolic extract of *Hibiscus cannabinus*, VernoniaAmygdalina, MurrayaKoenigii and Telfairia Occidentalis. Journal of Pharmacognosy and Phytochemistry. 2018; 7(2): 1508-19.

[34] Elias W. The Anti-Diabetic Effect of *Hibiscus cannabinus* Extract on the Submandibular Salivary Gland of Alloxan-Induced Diabetic Albino Rats. International Journal of Pharmaceutical Research & Allied Sciences. 2020; 9(2): 195-202.

[35] Sravanthi KC, Sarvani M and Srilakshmi S. Anthelmintic activity of *Hibiscuscannabinus* leaf extract. International Journal of Research in Ayurveda and Pharmacy. 2011; 2(1): 244-246.

[36] Agbor GA, Oben JE, Nkegoum B, Takala JP and Ngogang JY. Hepatoprotective activity of Hibiscus*cannabinus* [Linn.] against carbon tetrachloride and paracetamol induced liver damage in rats. Pakistan Journal of Biological Sciences. 2005; 8(10): 1397-1401.

[37] Nyam KL, Tang JLK, Long K. Anti-ulcer activity of *Hibiscuscannabinus* and *Hibiscussabdariffa* seeds in ulcer-induced rats. International Food Research Journal. 2016; 23(3): 1164-1172.

[38] Kai NS, Nee TA, Ling EL, Ping TC, Kamariah L, Lin NK. Anti–hypercholesterolemic effect of kenaf (*Hibiscus cannabinus* L.) seed on high–fat diet Sprague dawley rats. Asian Pacific journal of tropical medicine. 1 Jan 2015; 8(1): 6-13.

[39] Tseng TH, Kao ES, Chu CY, Chou FP, Wu HW, Wang CJ. Protective effects of dried flower extracts of *Hibiscus sabdariffa* L. against oxidative stress in rat primary hepatocytes. Food and Chemical Toxicology. 1 Dec 1997; 35(12): 1159-64.

[40] Dafallah AA, Al-Mustafa Z. Investigation of the anti-inflammatory activity of Acacia nilotica and *Hibiscus sabdariffa*. The American journal of Chinese medicine. 1996; 24(03n04): 263-9.

[41] Diez-Echave P, Vezza T, Rodríguez-Nogales A, Ruiz-Malagón AJ, Hidalgo-García L, Garrido-Mesa J, Molina-Tijeras JA, Romero M, Robles-Vera I, Pimentel-Moral S, Borras-Linares I. The prebiotic properties of *Hibiscus sabdariffa* extract contribute to the beneficial effects in diet-induced obesity in mice. Food Research International. 1 Jan2020; 127: 108722.

[42] Timothy S, Anaegbu J, Yakubu N, Adamu S, Sugun M, David BN, Wazis H, Zakama SG, Igbokwe IO, Gamaniel KS. Phytochemical and antimicrobial activity of aqueous extract of *Hibiscus sabdariffa*. Journal of Pharmacy & Bioresources. 2008; 5(1).

[43] Alarcon-Aguilar FJ, Zamilpa A, Perez-Garcia MD, Almanza-Perez JC, Romero-Nunez E, Campos-Sepulveda EA, Vazquez-Carrillo LI, Roman-Ramos R. Effect of *Hibiscus sabdariffa* on obesity in MSG mice. Journal of ethnopharmacology. 8 Oct 2007; 114(1): 66-71.

[44] Chen CC, Hsu JD, Wang SF, Chiang HC, Yang MY, Kao ES, Ho YC, Wang CJ. *Hibiscus sabdariffa* extract inhibits the development of atherosclerosis in cholesterol-fed rabbits. Journal of agricultural and food chemistry. 27 Aug 2003; 51(18): 5472-7.

[45] Liu JY, Chen CC, Wang WH, Hsu JD, Yang MY, Wang CJ. The protective effects of *Hibiscus sabdariffa* extract on CCl4-induced liver fibrosis in rats. Food and Chemical Toxicology. 1 Mar 2006; 44(3): 336-43.

[46] Faraji MH, Tarkhani AH. The effect of sour tea (*Hibiscus sabdariffa*) on essential hypertension. Journal of Ethnopharmacology. 1999 Jun 1; 65(3): 231-6.

[47] McKay DL, Chen CO, Saltzman E, Blumberg JB. *Hibiscus sabdariffa* L. tea (tisane) lowers blood pressure in prehypertensive and mildly hypertensive adults. The Journal of nutrition. 1 Feb 2010; 140(2): 298-303.

[48] Lin TL, Lin HH, Chen CC, Lin MC, Chou MC, Wang CJ. *Hibiscus sabdariffa* extract reduces serum cholesterol in men and women. Nutrition research. 1 Mar 2007; 27(3): 140-5.