



The Traditional Uses, Phytochemistry and Pharmacology of Genus Hibiscus: A Review

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MK and DS designed the study and analysed. Authors GK, NK, CS and KB interpreted and prepared the manuscript. All authors read and approved the final manuscript.

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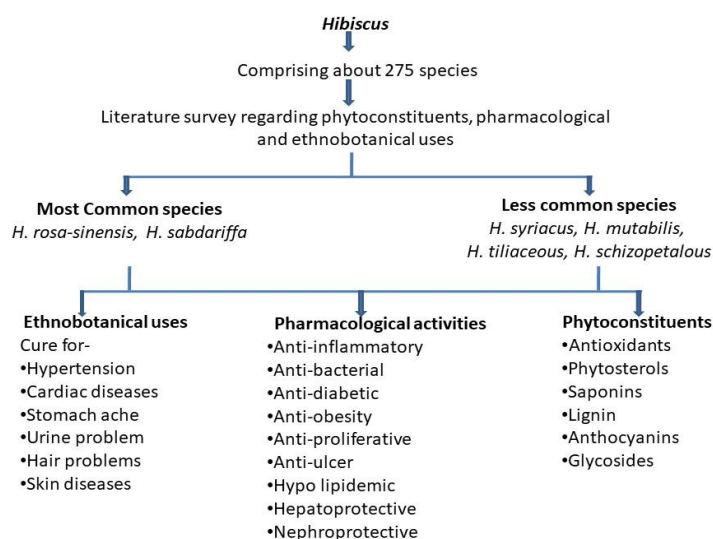
ABSTRACT

The genus Hibiscus belongs to the mallow family, Malvaceae comprising of about 275 species growing in tropical and sub tropical areas. The various species of genus Hibiscus have been used as traditional medicine all over the world. There are numerous reports of their traditional medicinal uses in various countries like India, Nigeria, China, and Srilanka etc. to cure various ailments such as hypertension, cardiac diseases, stomach-ache, urine problems, skin diseases and many more. Based on the historical knowledge, various pharmacological and phytochemical studies on some species of the genus Hibiscus have been done. Nevertheless, there are no up-to-date articles published which can provide an overview of pharmacological effects of the genus Hibiscus. Therefore, the main objective of the review article is to provide a systematic comprehensive summary of traditional uses, phytochemistry and pharmacology of the genus Hibiscus and to build up a correlation between its traditional ethano-botanical uses and pharmacological activities so as to find some advanced research opportunities in this field. The given information on the ethano-botanical uses, phytoconstituents and various medicinal properties of the genus Hibiscus was gathered from the online scientific databases through search in Google, Google Scholar, Science Direct, NCBI, Pubmed, Springer Link, Research Gate by using some keywords as. Besides these

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websites other published literature and unpublished Ph.D. thesis and M.Sc. dissertation were also consulted. Previously conducted research revealed that the genus contains good amount of phytoconstituents such as antioxidants, phytosterols, saponins, lignin, essential oils, glycosides, and anthocyanins etc. Presence of these bioactive compounds in the crude extracts of the plants make it suitable for various medicinal properties like anti-inflammatory, anti-diabetic, anti-obesity, anti-proliferative, anti-ulcer, hypersensitive, hypolipidemic, hepatoprotective, nephroprotective and many more. Additionally, this review article showed that mainly two species of the genus i.e. *H. rosa-sinensis* and *H. sabdariffa* have been explored for their pharmacological activities. There are few reports on some other species like *H. tiliaceus*, *H. microanthus*, *H. asper*, *H. acetosella*. This review highlights the medicinal potential of the plant Hibiscus due to its unique blend of phytochemicals. These phytoconstituents can be further assessed and subjected to clinical trials for their proper validations. Although large amount of the data regarding pharmacological effects has already been added to the existing reservoir but still potential of certain species like *H. radiatus*, *H. hirtus*, *H. moschetous*, *H. trionum* and many more is not yet unveiled and can be considered as future prospects that need to be worked out.

Graphical Abstract:



Keywords: *Hibiscus*; phytoconstituents; pharmacognosy; pharmacology; traditional uses; ethnobotany; anti-bacterial; antioxidant; anti-fungal; anti-canceractivity; *Hibiscus schizopetalous*; *Hibiscus rosa-sinensis*; *Hibiscus radiates*; *Hibiscus sabdariffa*; *Hibiscus syriacus*; *Hibiscus mutabilis*.

ABBREVIATIONS

DPPH : α , α -diphenyl- β -picrylhydrazyl.
 FRAP : Ferric reducing antioxidant power
 ABTS : 2, 2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid)
 H_2O_2 : Hydrogen peroxide
 NO : Nitric oxide
 SOD : Superoxide dismutase
 GPx : Glutathione Peroxidase
 CAT : Chloramphenicol acetyltransferase
 MIC : Minimum inhibitory concentration
 TBARS : Thiobarbituric acid reactive substance assay

TG : Triglycerides
 VLDL : Very low density lipids
 LDL : Low density lipids
 HDL : High density lipids
 AST : Aspartate amino transferase
 ALT : Alanine transaminase
 SGOT : Serum glutamic oxaloacetic transaminase
 SGPT : Serum glutamic pyruvic transaminase
 WBC : White blood cells
 RBC : Red blood cells
 IC50 : Inhibitory concentration 50.

1. INTRODUCTION

Hibiscus is a genus of flowering plants with numerous medicinal properties belongs to mallow family, Malvaceae. The genus is quite large, comprising several hundred species that is native to warm-temperate, sub-tropical and tropical regions throughout the world. There are about 275 species of *Hibiscus* in the tropical and sub-tropical regions [1]. Out of them *H. rosa-sinensis*, *H. syriacus*, *H. cannabinus*, *H. radiatus*, *H. vitifolius*, *H. sabdariffa*, *H. schizopetalus* etc. are commonly found in India. Along with a flowering plant it also has various medicinal properties. Plants with medicinal properties have a bright future because over 50% of all modern clinical drugs used today are of natural origin [2]. More than 7500 species out of 17000 species of higher plants are used in the various traditional systems of medicine like Ayurveda, Siddha and Unani [3]. Because plant-based medicines are organic in origin and have less or no side effects as compared to all opathicmedicine, their use has increased, which monetarily stands about US\$120 billion, and is expected to reach US\$7 trillion by 2050 [4]. The primary benefits of using the plant-derived medicines are more beneficial because they are readily affordable and accessible [5]. For the discovery of new more effective bio-therapeutic agents, the interest is increasing to find the chemical composition of plants [6]. The various parts of this plant have been known to contain numerous medicinal properties like antihypolipidemic, antiproliferative, antioxidant, antimicrobial, anti-inflammatory and other pharmacological properties [7]. This review will focus on the phytochemistry and pharmacological properties of *Hibiscus* in detail.

2. MORPHOLOGICAL CHARACTERISTICS

The genus includes both annual and perennial herbaceous plants, as well as woody shrubs and small trees. The leaves are alternate, ovate to lanceolate, often with a toothed or lobed margin. The flowers are complete, large, conspicuous, and trumpet-shaped, with five or more petals, colour from white to pink, red, orange, peach, yellow or purple and from 4 to 18 cm broad. Flower colour in certain species, such as *H. mutabilis* and *H. tiliaceus* changes with age. The fruit is a dry five-lobed capsule, containing several seeds in each lobe, which are released when the capsule dehisces (splits open) at maturity [Fig.1].

2.1 Phytochemical Analysis

Secondary metabolites are the important compounds present in the plants possessing major role in defence. Phytochemical studies on genus *Hibiscus* has been started million years ago and is being explored till date. These studies reveal that the plant is perfect blend of various phytoconstituents like flavonoids, tannins, saponins, carbohydrates, steroids, phenols, glycosides, quinones, terpenoids etc. The extraction of such economical phytochemicals has been done from various plant parts such as leaves, stem, flower and roots using different solvents viz. water, methanol, ethanol, ethylacetate, chloroform and petroleum ether for extract preparation. Table 1 illustrates presence of diverse phytoconstituents in different species of *Hibiscus* where it is clearly observed that *H. sabdariffa* and *H. rosa-sinensis* has been well explored in this regard but still little is known about *H. acetosella*, *H. cannabinus*, *H. syriacus* and many more.

Chart 1. Taxonomic classification

Botanical name	<i>Hibiscus</i>
Domain	Eukaryota
Kingdom	Plantae
Subkingdom	Tracheobionta
Phylum	Tracheophyta
Subphylum	Spermatophytina
Class	Magnoliopsida
Sub class	Dilleniidae
Super order	Rosanae
Order	Malvales
Family	Malvaceae
Sub family	Malvoideae
Tribe	Hibisceae
Genus	<i>Hibiscus</i> L.



Fig. 1. A) *Hibiscus schizopetalus*; B) *H. rosa-sinensis*; C) *H. radiates*; D) *H. sabdariffa*; E) *H. syriacus*; F) *H. mutabilis*

2.2 Pharmacological Activities

Besides being eye-catching morphologically, pharmacological activities of *Hibiscus* are also great source of attraction. The plant shows anti-bacterial, anti-fungal, anti-inflammatory, anti-cancerous, anti-hyperepidemic, anti-glycaemic activities along with various other health related benefits like effect on lipid metabolism, anti-hypertensive effects, effects on hairgrowth and anti-analgesic activities.

2.2.1 Anti-bacterial activity

Hibiscus exhibits anti-bacterial activity against different gram-positive and gram-negative bacteria like *Bacillus cereus*, *Streptococcus faecalis*, *Streptococcus aureus*, *Clostridium sporogenes*, *Micrococcus luteus*, *E.coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumonia*, *Serratia marcescens*, *Proteus*

vulgaris, *Proteus rettgeri*, *Aeromonas hydrophila*, *Bacillus subtilis* and many more. Studies have been conducted on different plant parts like leaves, flowers, fruits in different plant extracts like methanol, ethanol, ethyl acetate and aqueous and almost all the plant parts were found to show anti-bacterial activity, however these extracts did not display same results for all the bacterial strains used for different studies. The results obtained by different researchers have been included in Table 2 along with plant part and bacterial strain used.

2.2.2 Antioxidant activity

Exploration of antioxidant potential of biological forms like plants has always been of greater interest to the pharmacologist. Higher the antioxidant potential, greater benefits can be drawn out of various medicinal plants like hibiscus. Various parts of plant like leaves, bark,

Chart 2. Synonyms

Species	Synonyms
<i>Hibiscus acetosella</i> Welw. ex Hiern	<i>Hibiscus eetveldeanus</i> De Wild. & T. Durand
<i>Hibiscus adoensis</i> Hochst. ex A. Rich.	<i>Kosteletzkyia adoensis</i> (Hochst. ex A. Rich.) Mast.
<i>Hibiscus calycinus</i> Willd.	<i>Hibiscus calyphyllus</i> Cav.
<i>Hibiscus calyphyllus</i> Cav.	<i>Hibiscus calycinus</i> Willd.
<i>Hibiscus cuneiformis</i> DC.	<i>Alyogyne cuneiformis</i> (DC.) Lewton
	<i>Cienfuegosia cuneiformis</i> (DC.) Hochr.
	<i>Fugosia cuneiformis</i> (DC.) Benth.
<i>Hibiscus eetveldeanus</i> De Wild. & T. Durand	<i>Hibiscus acetosella</i> Welw. ex Hiern
<i>Hibiscus elatus</i> Sw.	<i>Talipariti elatum</i> (Sw.) Fryxell
<i>Hibiscus esculentus</i> L.	<i>Abelmoschus esculentus</i> (L.) Moench
<i>Hibiscus ficulneus</i> L.	<i>Abelmoschus ficulneus</i> (L.) Wight & Arn.
<i>Hibiscus flavus</i> Forssk.	<i>Pavonia arabica</i> Hochst. & Steud. ex Boiss.
<i>Hibiscus glaber</i> Matsum. ex Nakai	<i>Talipariti glabrum</i> (Matsum. ex Nakai) Fryxell
<i>Hibiscus hakeifolius</i> Giord.	<i>Alyogyne hakeifolia</i> (Giord.) Alef.
	<i>Cienfuegosia hakeifolia</i> (Giord.) Hochr.
	<i>Fugosia hakeifolia</i> (Giord.) Hook.
<i>Hibiscus hamabo</i> Siebold & Zucc.	<i>Talipariti hamabo</i> (Siebold & Zucc.) Fryxell
<i>Hibiscus hastatus</i> L. f.	<i>Talipariti hastatum</i> (L. f.) Fryxell
<i>Hibiscus laevis</i> All.	<i>Hibiscus militaris</i> Cav.
<i>Hibiscus lampas</i> Cav.	<i>Thespesia lampas</i> (Cav.) Dalzell
<i>Hibiscus macrophyllus</i> Roxb. ex Hornem.	<i>Talipariti macrophyllum</i> (Roxb. ex Hornem.) Fryxell

Chart 3. Traditional uses: Traditional uses of *Hibiscus* species

Species	Country/Region	Plant part used	Traditional uses	Proportional administration	References
<i>H. asper</i>	Nyong valley in Cameroon	Whole plant	To cure female infertility	-	Jiofack et al. [8]
<i>H. cannabinus</i> L.	Africa	Stem peels	To cure fatigue and anaemia	-	Agbor et al. [9] and Lee et al. [10]
<i>H. cannabinus</i>	Kwa Nibela, Peninsula, St Lucia, South Africa	Whole plant	To cure chicken pox	Boiled juice	Kokwaro, [11] and Williams, [12]
<i>H. linarifolius</i> wild	Nigeria	Leaves	Treatment of Typhoid fever	Decoction	Borokini et al. [13]
<i>H. macrophyllus</i> Roxb.	Tripura, India	Leaves and Flower	To cure cough and sexual problems	-	Sen et al. [14]

Species	Country/Region	Plant part used	Traditional uses	Proportional administration	References
<i>H. rosa-sinensis</i>	Guimaras island, Phillipines	Flower	To cure boils	Crush and apply as poultice	Ong et al. [15]
<i>H. rosa-sinensis</i>	Bangladesh	Flower	Regulation of menstrual cycle	Decoction	Alam , [16]
<i>H. rosa-sinensis</i>	China	Flower and Bark	Emmenagogue	Hot water extract	Burkhill, [17] and Pardo et al. [18]
<i>H. rosa-sinensis</i>	Cook Islands	Flower and leaves	Ailing infants, Gonorrhea	Hot water extract	Whistler, [19]
<i>H. rosa-sinensis</i>	East Indies	Flower and leaves	Regulate menstruation produce abortion. To stimulate expulsion of afterbirth	Hot water extract of flower.	Burkhill, [17]
<i>H. rosa-sinensis</i>	Fiji	Leaves	Digestion, Diarrhea	Juice	Singh, [20]
<i>H. rosa-sinensis</i>	French Guiana	Flowers	Grippe	Hot extract	Luu, [21]
<i>H. rosa-sinensis</i>	Ghana	Peeled Twig	Chewstick	-	Adu-Tutu et al. [22]
<i>H. rosa-sinensis</i>	Guadeloupe	Flowers	Sodorific, Anti-tussive	Hot extract	Vitalyos, [23]
<i>H. rosa-sinensis</i>	Guam	Leaves	To Promote draining of abscesses	-	Haddock, [24]
<i>H. rosa-sinensis</i>	Haiti	Leaves and Flowers	Flu & cough, stomach pain, Eye problems	Decoction	Kobayashi, [25]
<i>H. rosa-sinensis</i>	Hawaii	Flowers	Lactation	-	Nath et al. [26]
<i>H. rosa-sinensis</i>	India	Stem and Flowers	Abortion, Antifertility, Contraceptive, Diuretic, Menorrhagia, bronchitis, Emmenagogue, Demulcent, Cough, Abortifacient	Hot water extract	Nath et al. [26], Tiwari et al. [27], Maheswari et al. [28], Jain et al.[29], Malhi et al. [30], Reddy et al. [31], Dixit, [32] and Hemadri et al.[33]
<i>H. rosa-sinensis</i>	Indonesia	Leaves and Flowers	Menstruation, Abortion, Emmenagogue, Women in labor	Juice	Quisumbing, [34] and Van et al.[35]
<i>H. rosa-sinensis</i>	Japan	Leaves	Anti-diarrhoeal	Decoction	Shimizu et al. [36]
<i>H. rosa-sinensis</i>	Kuwait	Flowers	Aphrodisiac	-	Alami et al. [37]
<i>H. rosa-sinensis</i>	Malaysia	Roots and Flowers	Fever, Expectorant, Emmenagogue	Hot water extract	Burkhill, [17] and Hooper, [38]
<i>H. rosa-sinensis</i>	Mexico	Barks and leaves	Dysentery	Infusion	Zamora-Martinez, [39]
<i>H. rosa-sinensis</i>	Nepal	Roots	Cough	Hot water extract	Suwal, [40]
<i>H. rosa-sinensis</i>	New Britain	Flowers	Menstruation	Hot extract	Holdsworth, [41]
<i>H. rosa-sinensis</i>	New Caledonia	Flowers	Abortifacient	Decoction	Holdsworth et al. [42]
<i>H. rosa-sinensis</i>	Northern Ireland	Flowers	To induce labor	Water extract	Ramirez et al. [43]
<i>H. rosa-sinensis</i>	Peru	Flowers	Contraceptive, Emmenagogue	Hot water extract	Pardo et al.[18]
<i>H. rosa-sinensis</i>	Philippines	Flowers	Bronchial Catarrh, Emmolients,	Hot water extract	Watt et al. [44]

Species	Country/Region	Plant part used	Traditional uses	Proportional administration	References
<i>H. rosa-sinensis</i>	Trinidad	Flowers	Cancerous, Swellings Amenorrhea	Decoction	Wong ,[45] and Ayensu, [46]
<i>H. rosa-sinensis</i>	Vanuata	Stem and bark	Menorrhagia	Decoction	Bourdy et al. [47]
<i>H. rosa-sinensis</i>	Vietnam	Flowers	Dysmenorrhea, Abortive	Infusion	Quisumbing, [34]
<i>H. sabdariffa</i> L.	India, Africa, Mexico	Infusion of leaves or calyces	Diuretic, Chlorectic. Febrifungal, hypotensive effect	-	Morton, [48]
<i>H. sabdariffa</i> L.	Egypt	Calyces	Treatment of cardiac and nerve diseases, increase production of urine	-	Leung, [49]
<i>H. sabdariffa</i> L.	Egypt and Sudan	“Karkade” Calyces	To lower body temperature	-	Leung, [49]
<i>H. sabdariffa</i> L.	India	Seeds	Relieve pain in urination and indigestion	Decoction	Morton, [48]
<i>H. sabdariffa</i> L.	Brazil	Roots	Stomachache emollient properties	-	Morton, [48]
<i>H. sabdariffa</i>	Chinese Folk Medicine	Roots	To treat liver disorder and high blood pressure	-	Morton, [48]
<i>H. sabdariffa</i>	Iran	Sour hibiscus tea	To treat hypertension	-	Burnham et al. [50]
<i>H. sabdariffa</i>	Nigeria	Seeds	Rise or induce lactation in cases of poor milk production, poor letdown and maternal mortality	-	Gaya et al. [51]
<i>H. schizopetalous</i> (Mast.) Hook. F.	India	Leaf and Flower	Fresh wound	-	Sens et al. [14]
<i>H. surratenius</i>	Nyong valley in Cameroon	Aerial parts	Polyhydromnius	-	Jiofack T. et al. [8]
<i>H. surratenius</i>	South Africa	Leaves	Malaria	Decoction/ Oral	Yetein et al. [52]
<i>H. talbotii</i>	India	Roots	Indigestion	-	Jagtap et al. [53]
<i>H. tiliaceous</i>	Srilanka	Flower	Earache	Boiled in milk	Dixit, [32]
<i>H. tiliaceous</i>	Srilanka	Flower	Emollient properties and anti-depressant like activities	-	Dixit, [32]
<i>H. tiliaceous</i>	Srilanka	Bark, branches, and Flower buds	Mild laxative and lubricant in childbirth or labor pain and rubbed on stomach to treat bronchitis	Slimy sap	Hemadri et al. [33]
<i>H. tiliaceous</i>	Srilanka	Wood and flower	Treatment of skin diseases	-	Hemadri et al. [33]

Table 1. Phytochemical studies of different *Hibiscus* species

Species	Solvent used for Extraction	Class	Bioactive compound	Reference
<i>H. cannabinus</i>	Acetone	-	Grossamide K1, Erythrocanabisine H2, Phellandrene, Phytol, Nonanal, 5-Methyl-furfural, 2-Hexenal, Benzene acetaldehyde	Pappas et al. [54], Moujir et al. [55], Seca et al. [56]
<i>H. esculentus</i> <i>H. mutabilis</i>	Aqueous Aqueous	Flavonoid Anthocyanin	(-)-Epigallocatechin Cyanidin 3-xylosylglucoside and cyanidin 3-glucoside, the red flowers of <i>H. mutabilis</i> contained quercetin 3-sambubioside, isoquercitrin, hyperin, guaijaverin and kaempferol glycosides	Shui et al. [57] Ishikura, [58]
<i>H. mutabilis</i> <i>H. mutabilis</i> <i>H. mutabilis</i> <i>H. mutabilis</i>	Aqueous Methanol Aqueous Methanol, chloroform and petroleum ether	Anthocyanin Flavonoids Flavonoids Phenols, flavonoids, and anthocyanins	Cyanidin-3-sambubioside Quercetin and hyprosides Quercetin 3- sambubioside and cyanidin 3-sambubioside Quercetin, Quercemericrine, Quercetin-3-D-syloside, Quercetin-3-Sambubioside, Isoquercetin, Kaempferol, Cyanidine, Cyanidine-3-slosylglucose, Cyanidine-3-monoglucoside, Hibiscones, Hibiscoquinones, Beta-sitosterol	Amrhein et al. [59] Iwaoka et al. [60] Lowry et al. [1] Barve et al. [61]
<i>H. mutabilis</i>	Aqueous	Phenols and flavonoids	Steppogenin, genistein, salicylic acid, rutin, potengriffioside A, kaempferol 3-O-rutinoside and emodin	Hou et al. [62]
<i>H. rosa sinensis</i>	Aqueous	Anthocyanin	Cyanin, cyanidin chorides, methyl-10-oxa-11-octadecynoate, methyl-8-oxa-9- octadecynoate, methyl-9-methylene-8-oxaheptadecanoate and methyl10-methylene-9-oxactadecanoate	Sharma et al. [63]
<i>H. rosa sinensis</i>	Choloroform	Anthocyanin	Cyanidin3-sophoroside	Vastrad et al. [64] and Bhakta et al. [65]
<i>H. rosa sinensis</i> <i>H. rosa sinensis</i> <i>H. rosa sinensis</i>	Methanol Aqueous Aqueous and methanol	Glucoside Sterols Flavonoids	Luteolin-8-C-glucoside. Beta Sitosterol Quercetin-3- di-0-beta-D-glucoside, quercetin-3-7-di-0-beta-D-glucoside, quercetin-3-0-beta-D-sophorotrioside, kaempferol-3-0-beta-D-xylosyl-glucoside, cholesterol, campesterol, β -sitosterol, catalase	Begum et al. [66] Khare et al. [67] Ross et al.[68] and Subramanian et al. [69]
<i>H. rosa sinensis</i>	Methanol	Flavonoids	Cyclopeptide alkaloid, quercetin, hentriacontane	Srivastava et al. [70] and Khokhar, [71]
<i>H. rosa sinensis</i>	Aqueous	Flavonoids	Quercetin-3,5-diglucoside, quercetin-3,7- diglucoside, cyanidin-3,5-diglucoside and cyaniding-3-sophoroside3-5-glucoside and kaempferol-3-xylosylglucoside	Joshi et al. [72]

Species	Solvent used for Extraction	Class	Bioactive compound	Reference
<i>H. rosa sinensis</i>	Methanol	Flavonoids	Quercetin, quercetin-3-diglucoside, β -sitosterol, cyanidin-3,5-diglucoside	Kumar, [73]
<i>H. rosa sinensis</i>	Aqueous	Phenols, flavonoids, and anthocyanins	Hibiscetin, Cyanidin, Cyanidine glucosides, Taraxeryl acetate, b-Sitosterol Campesterol, Ergosterol, Cyclopropenoids	Gilani et al. [74], Adhirajan et al. [75], Kholkute [76], Singh et al. [77], Gauthaman et al. [78], Sachdewa et al. [79], Sachdewa et al. [80], Sharma et al. [81], Sharma et al. [82] and Ajay et al.[83]
<i>H. sabdariffa</i>	Aqueous	Anthocyanin	Delphinidin-3-sambubioside, Cyanidine-3-sambubioside, Delphinidin-3-sambubioside	Jabeur et al.[84]
<i>H. sabdariffa</i>	Aqueous and methanol	Anthocyanin	Delphinidin-3-sambubioside (hibiscin), cyanidin-3-sambubioside (gossypicyanin), cyanidin-3,5-diglucoside, delphinidin (anthocyanidin)	Hida et al. [85]
<i>H. sabdariffa</i>	Aqueous	Anthocyanin	Delphinidin-3-sambubioside (hibiscin), delphinidin-3-glucoside and cyanidin-3-glucoside (chrysanthenin)	Williamson et al. [86]
<i>H. sabdariffa</i>	Aqueous	Anthocyanin	Cyanidin-3-sambubioside (gossypicyanin), cyanidin-3,5-diglucoside and cyanidin-3-(2G-glucosylrutinoside)	Du et al. [87] and Shibata et al.[88]
<i>H. sabdariffa</i>	Aqueous	Flavonoids	Hibiscitrin (hibiscetin-3-glucoside), sabdaritrin, gossypitrin, gossytrin and other gossypetin glucosides, quercetin and luteolin	Subramanian et al.[69]
<i>H. sabdariffa</i>	Aqueous	Flavonoids	Chlorogenic acid, protocatechuic acid, pelargonidic acid, eugenol, quercetin, luteolin and the sterols β -sitosterol and ergosterol	McKay, [89] and Williamson et al. [86]
<i>H. sabdariffa</i>	Aqueous	Flavonoids	3-monoglucoside of hibiscetin (hibiscitrin)	McKay, [89] and Williamson et al. [86]
<i>H. sabdariffa</i>	Methanol	Flavonoids	7-glucoside of gossypetin (gossypitrin) and sabdaritrin and hydroxyflavone named sabdaretin.	Rao et al. [90] and Rao et al. [91]
<i>H. sabdariffa</i>	Methanol	Flavonoids	Gossypetin-8-glucoside (0.4%) and gossypetin-7-glucoside	Rao et al. [90] and Rao et al. [91]
<i>H. sabdariffa</i>	Aqueous	Flavonoids	β -sitosteryl- β -D-galactoside	Subramanian et al. [69]
<i>H. sabdariffa</i>	Aqueous	Flavonoids	Quercetin, luteolin and its glycoside	Salama et al. [92], McKay, [89] and Williamson et al. [86]
<i>H. sabdariffa</i>	Aqueous	Flavonoids	Quercetin-3-glucoside, rutin, quercetin-3-rutinoside kaempferol	Salah et al. [93]
<i>H. sabdariffa</i>	Aqueous, Ethenol and chloroform	Flavonoids	Atechin and ellagic acid, protocatechuic acid, catechin, gallic acid, gallic acid, gallic acid gallate	Beltran-Debon et al. [94], Herranz-Lopez et al. [95], Peng et al. [96], Ramirez-Rodrigues et al. [97] and

Species	Solvent used for Extraction	Class	Bioactive compound	Reference
<i>H. sabdariffa</i>	Aqueous	Organic Acids	Citric Acid, Mallic Acid, Tartaric Acid, Ascorbic Acid.	Ramirez-Rodrigues et al. [98] Eggensperger et al. [99] and Schilcher, [100].
<i>H. sabdariffa</i>	Aqueous	Organic Acids	Citric Acid, Mallic Acid	Buogo et al. [101], Indovina et al.[102] and Reaubourg et al.[103]
<i>H. sabdariffa</i>	Aqueous	Organic Acids	Ascorbic Acid and Hydroxycitric acid(2S,3R)	Ismail et al. [104] and Morton, 1987
<i>H. sabdariffa</i>	Methanol	Phenolic Acid	Protocatechuic acid (PCA)	Lin et al. [105] and Yang et al. [106]
<i>H. sabdariffa</i>	Aqueous and methanol	Phenolic Acid	Chlorogenic acid	Lee et al. [107], Lin et al. [108], McKay, [89], Williamson et al. [86], Clifford et al. [109] and Alarcon et al. [110]
<i>H. sabdariffa</i>	Methanol	Phenolic compounds	Protocatechuic acid and Catechin	Kuo et al. [111]
<i>H. sabdariffa</i>	Aqueous	Phenolic compounds	Ergosterol	Osman et al. [112]
<i>H. sabdariffa</i>	Aqueous	Flavonoids and Phenolic acid	Chlorogenic acid isomer I, Chlorogenic acid Chlorogenic acid isomer II 5-O-Caffeoyl-shikimic acid, 3-Caffeoylquinic acid, 5-Caffeoylquinic acid, 4-Caffeoylquinic acid	
<i>H. sabdariffa</i>	Hydroethanol	Flavonoids and phenolic compounds	Kaempferol-3-O- rutinoside, Kaempferol-3-p-coumarylglucoside, Myricetin-pentosylhexoside, Quercetin-3-sambubioside, Quercetin-3-rutinoside, Quercetin- pentosylhexoside	Jabeur et al. [84]
<i>H. sabdariffa</i>	Aqueous	Phenols, organic acids and anthocyanins	b-Carotene, Anisaldehyde, Arachidic acid, Citric acid, Malic acid Tartaric acid, Glycinebetaine, Trigonelline Anthocyanins, Cyanidin-3-rutinoside, Delphinidin, Delphinidin-3-glucoxyloside.	Dafallah et al.[113], Farombi et al. [114], Chen et al. [115], Ali et al. [116], [117], Kamei et al. [118], Chang et al. [119], Suboh et al. [120], Pool-Zobel et al. [121] and Meiers et al. [122]
<i>H. syriacus</i>	Chloroform	-	Hibiscuside, Syringaresinol, Feruloyltyramines, Isoflavonoids, Syriacusins A–C, Pentacyclic triterpene caffeic acid esters, Clemicosin A, C and D, Scopoletin, 8-Hydroxy-5,6,7-trimethoxycoumarin	Yokota et al. [123], Yoo et al.[124] and Yun et al. [125]
<i>H. taiwanensis</i>	Methanol	-	8-Hydroxy-5,6,7-trimethoxycoumarin, (7S,8S)-Demethylcariolignan E, Hibiscuwanin A, Hibiscuwanin B, Clemicosin A and C, 9,90 -O-Feruloyl(-)secoisolariciresinol Dehydroconifenyl alcohol, Erythro-cariolignan E, b-Syringaresinol, Hibisculide A, Hibisculide B, Hibisculide C,	Wu et al. [126,127]

Species	Solvent used for Extraction	Class	Bioactive compound	Reference
<i>H. tilliaceus</i>	Aqueous	Anthocyanin	Hibiscutaiwanin, Hibiscusin, Mansonone H, Uncarinic acid, Myceric acid	Lowry et al. [1]
<i>H. tilliaceus</i>	Methanolic	Anthocyanin	Cyanidin-3- glucoside	Shikawa et al. [128]
<i>H. tilliaceus</i>	Aqueous	Amide	Cyanidin 3-O-sambubioside	Chen et al. [129]
<i>H. tilliaceus</i>	Aqueous	Couamirn	Hibiscusamide	Chen et al. [129]
<i>H. tilliaceus</i>	Aqueous	Phenols	Hibiscusin	Subramanian et al.[130]
<i>H. tilliaceus</i>	Methanolic	Phenolic compounds	p-coumaric acid, fumaric acid, kaempferol, kaempferol-3-O-D-galactoside, quercetin and quercetin3-O-D-galactosid	Yang et al. [106]
<i>H. tilliaceus</i>	Methanol	Phenolic compound	Ergosta-4,6,8, friedelin, germanicol, glutinol, lupeol, pachysandiol, β -sitosterol, stigmast-4,22-dien-3-one, stigmast-4-en-3-one, stigmasterol and 22-tetraen-3-one	Hossain et al. [131]
<i>H. tilliaceus</i>	Methanol	Phenolic compounds and organic acids	Catechin, rutin, quercetin, and ellagic acid	Kobayashi, [25], Singh et al. [132] and Whistler, [19]
<i>H. tilliaceus</i>	Aqueous	Organic acids, phenolic compounds, and flavonoids	Stigmasterol, Stigmastadienol, Stigmastadienone, 27-Oic-3-oxo-28-friedelanoic acid, Vanillic acid, Syringic acid, Scopoletin, <i>N-trans</i> -Feruloyltyramine, <i>N-cis</i> -Feruloyltyramine, b-Sitostenone, Stigmasta-4,22-dien-3-one	Zhong et al. [133]
<i>H. tilliaceus</i>	Aqueous	Organic acids and phenolic compounds	Azelaic acid, cleomiscosin C, daucosterol, friedelin, fumaric acid, hibiscolactone, kaempferol, quercetin, rutin, scopoletin, β -sitosterol, succinic acid, syriacusin A and vanillin	Chen et al. [129]
<i>H. tilliaceus</i>	Chloroform	Triterpene	Vanillic acid, syringic acid, p-hydroxybenzoic acid, phydroxybenzaldehyde, scopoletin, N-transferuloyltyramine, N-cis-feruloyltyramine, β -sitosterol, stigmasterol, β -sitostenone and stigmasta-4-dien-3- one.	Li et al. [134]
<i>H. vitifolius</i>	Ethenol	Flavonoids	27-oic-3-oxo-28-friedelanoic acid	Kunnumakkara et al. [135]
			Flavonol bioside	

Table 2. Anti-bacterial activity of various species of genus *Hibiscus*

Species	Part used	Solvent used for extraction	Test organism	Observation	Author and year
<i>H. rosa-sinensis</i>	Flower	Methanol and Ethanol	<i>S. aureus</i> , <i>Streptococcus sp.</i> , <i>B. subtilis</i> , <i>E. coli</i> , <i>Salmonella sp.</i> , <i>P. aeruginosa</i>	Highest zone of inhibition is recorded against <i>B. subtilis</i> and <i>E. coli</i> as (18.86±0.18) and (18.00±1.63) mm respectively shown by methanol extract.	Ruban et al. [136]
<i>H. rosa-sinensis</i>	Leaves	Hexane, Ethylacetate, Methanol and Aqueous	<i>Staphylococcus aureus</i> , <i>B. subtilis</i> , <i>Streptomyces alboniger</i> , <i>Micrococcus luteus</i> , <i>S. epidermis</i> , <i>Pseudomonas aeruginosa</i> , <i>Bordetella bronchiseptica</i>	Methanol extract is best solvent showing maximum anti-bacterial activity.	Patel et al.[137]
<i>H. rosa-sinensis</i>	Leaves and Flower	Methanol	<i>E. coli</i> , <i>S. aureus</i>	Zone of inhibition for <i>E. Coli</i> and <i>S. aureus</i> is 23±1.01 mm and 13.75±0.99 mm respectively.	Tiwari et al. [138]
<i>H. rosa-sinensis</i>	Leaves	Aqueous and Methanol	<i>Bacillus subtilis</i> , <i>S. aureus</i>	Methanol extract had highest zone of inhibition 18.82±0.18 mm against <i>B. subtilis</i> .	Udo et al. [139]
<i>H. rosa-sinensis</i>	Leaves	Aqueous and ethanol	<i>P. aeruginosa</i> and <i>A. hydrophilla</i>	Ethanol extracts have maximum antibacterial activity with inhibition zone of 6 to 9 mm against <i>P. aeruginosa</i> and <i>A. Hydrophilla</i> respectively.	Singh et al. [140]
<i>H. rosa-sinensis</i>	Flower	Ethanol, Methanol, Aqueous and Ethylacetate	<i>E. coli</i> , <i>P. aeruginosa</i> , <i>S. aureus</i>	Maximum antibacterial activity is shown by Methanol extracts against all three bacterial strains.	Sobhy et al. [141]
<i>H. rosa-sinensis</i>	Leaves and Silver and gold nanoparticles	Deionized water	<i>Pseudomonas aeruginosa</i> , <i>Bacillus subtilis</i> , <i>Micrococcus luteus</i> , <i>S. aureus</i> , <i>S. epidermidis</i> , <i>Enterobacter aerogenes</i> , <i>E. coli</i> , <i>S. pneumoniae</i> , <i>Aeromonas hydrophila</i>	Plant extract shows antibacterial activity against test organisms in concentration dependent manner.	Tyagi et al. [142]
<i>H. rosa-sinensis</i>	Leaves	Ethanol	<i>Aeromonas hydrophila</i>	Highest inhibition zone is 11mm.	Vijayaraj et al. [143]
<i>H. rosa-sinensis</i>	Leaves	Aqueous	<i>Aeromonas hydrophila</i>	Maximum inhibition zone is 24mm at 50% concentration.	Amita et al. [144]

Species	Part used	Solvent used for extraction	Test organism	Observation	Author and year
<i>H. rosa-sinensis</i>	Leaves	Ethanol, methanol and distilled water	<i>S. aureus</i> and <i>E. coli</i>	Methanol extract with 10% and 5% concn. Had antibacterial activity against all the test organisms.	Vastrad et al. [64]
<i>H. rosa-sinensis</i>	Flowers	Methanol, water and ethyl acetate	<i>E. coli</i> , <i>B. subtilis</i> and <i>S. aureus</i>	Methanolic extract show more activity than other two solvents against all three bacteria.	Vijayakumar et al.[145]
<i>H. rosa-sinensis</i>	Flower	Methanol and Ethanol extract	<i>Klebsiella pneumoniae</i> , <i>Escherichia coli</i> , <i>Bacillus subtilis</i> , <i>Staphylococcus aureus</i> , <i>Pseudomonas aeruginosa</i> and <i>Salmonella sp.</i>	Methanolic extracts show less antibacterial activity than Ethanolic extracts.	Singh et al. [146]
<i>H. sabdariffa</i>	Green and red calyx	Methanol and water (4:1)	<i>Bacillus cereus</i> , <i>Streptococcus faecalis</i> , <i>Clostridium sporogenes</i> , <i>Micrococcus luteus</i> , <i>E. coli</i> <i>Pseudomonas aeruginosa</i> , <i>Klebsiella pneumonia</i> , <i>Serratia marcescens</i> , <i>Proteus vulgaris</i> and <i>Proteus rettgeri</i>	Extract shows largest inhibition zone against <i>Micrococcus luteus</i> .	Adebisi et al. [147]
<i>H. sabdariffa</i>	Calyces	80% aqueous methanol	<i>E. coli</i>	The maximum Zone of inhibition was 12.66mm for 10%, 10.75mm for 5% and 8.9mm for 2.5% conc.	Fullerton et al. [148]
<i>H. sabdariffa</i>	Fruits	85% methanol	<i>Sarcina lutea</i> , <i>Shigella dysenteriae</i> , <i>E. coli</i> , <i>Shigella boydii</i> , <i>Bacillus subtilis</i> , <i>B. megaterium</i> , <i>B. anthracis</i> , <i>B. cereus</i> and <i>P. aeruginosa</i>	Fruit extracts had highest activity against <i>Sarcina lutea</i> i.e. 13±0.21mm.	Mamun et al. [149]
<i>H. sabdariffa</i>	Leaves	Ethanol extract	<i>Listeria monocytogenes</i> , <i>S. typhimurium</i> , <i>E. coli</i>	Ethanolic extracts of leaves had effective antibacterial activity against the test organisms.	Zhang et al. [150]
<i>H. sabdariffa</i> L. (roselle)	Calyces	Aqueous and Ethanol extract	<i>E. coli</i> , <i>Staphylococcus aureus</i> , <i>Salmonella typhi</i> , <i>Shigella dysenteriae</i> , <i>Streptococcus mutans</i>	Ethanol extracts have better activity as compared to aqueous extract against all the tested organisms.	Edema et al. [151]
<i>H. sabdariffa</i>	Calyces	Water and ethanol	<i>Bacillus subtilis</i> , <i>S. aureus</i> and <i>E. coli</i>	Ethanol extract exhibit slightly higher activity against <i>B. subtilis</i> and <i>S.</i>	Jung et al. [152]

Species	Part used	Solvent used for extraction	Test organism	Observation	Author and year
<i>H. sabdariffa</i>	Calyces	Petroleum ether and ethanol	<i>Kleibsellla pneumoniae</i> , <i>Strephylococcus aureus</i> , <i>B. cerus</i> , <i>Lactobacillus brevis</i>	<i>aureus</i> than that of water extract However, Roselle water extract has more activity against <i>E. coli</i> . Extracts made in Petroleum ether was most effective against bacteria like <i>Bacillus cereus</i> , <i>Klebsiella pneumoniae</i> , <i>Staphylococcus aureus</i> and <i>Lactobacillus brevis</i> .	Das et al. [153]
<i>H. sabdariffa</i>	Calyx	Petroleum ether, ethyl acetate, methanol and water.	<i>Staphylococcus aureus</i> (ATCC25923), <i>Bacillus subtilis</i> (NCTC10073) <i>Klebsiella pneumonia</i> (ATCC70063) and <i>Escherichia coli</i> (ATCC25922).	The aqueous extracts have the greatest anti-bacterial activity with MICs of 125–250 µg/mL.	Osei et al. [154]
<i>H. sabdariffa</i>	Leaves	Aqueous	<i>Escherichia coli</i> , <i>Klebsiella pneumonia</i> , <i>Staphylococcus aureus</i> and <i>Pseudomonas aeruginosa</i> .	Extract conc.200µg/mL has maximum activity against <i>P. aeruginosa</i> .	Sulaiman et al. [155]
<i>H. sabdariffa</i>	Leaves	Methanol	<i>S. typhi</i> , <i>E. coli</i> and <i>S. aureus</i>	Extract exhibit maximum antibacterial activity against <i>S. aureus</i> .	Adamu et al. [156]
<i>H. sabdariffa</i>	Calyx	Hexane, Ethyl acetate and Methanol	<i>E. coli</i> (ATCC25922), <i>S. aureus</i> (ATCC29213), <i>Pseudomonas aeruginosa</i> (ATCC27853), <i>Salmonella typhi</i> , <i>Bacillus subtilis</i>	500µg/mL is the minimum inhibitory concentration (MIC) against <i>Escherichia coli</i> for both ethyl acetate and methanol extracts while hexane extracts show no activity at all.	Ajoku et al. [157]
<i>H. sabdariffa</i>	Calyx	Aqueous and hydro ethanol 30%	<i>E. coli</i> , <i>S. aureus</i> , <i>P. aeruginosa</i> and <i>B. subtilis</i>	Hydro ethanol extract had more potent anti bacterial activity.	Mensah et al. [158].
<i>H. sabdariffa</i>	Seed coats	Aqueous ethanol, hexane and methanol	<i>E. coli</i> , <i>S. aureus</i> , <i>S. pneumoniae</i> , <i>K. aerogenes</i> , <i>S. species</i> , <i>P. aeruginosa</i>	None of the extracts show any antibacterial activity against any test organism.	Nathaniel et al. [159]
<i>H. sabdariffa</i>	Leaves and fruits	Methanol	<i>Streptococcus mutans</i> , <i>Staphylococcus aureus</i> , <i>Escherichia coli</i> and <i>Pseudomonas aeruginosa</i>	Extract exhibit more anti-bacterial activity against gram positive bacteria than gram negative bacteria.	Sekar et al. [160]
<i>H. sabdariffa</i>	Leaves and seeds	Phosphate buffer	<i>Staphylococcus sp.</i>	Extract showed maximum zone of inhibition of 9mm.	Thiripurasudari et al. [161]
<i>H. sabdariffa</i>	Calyces	80%methanol	<i>Escherichia coli</i> ATCC25922,	The maximum antibacterial activity of	Abdallah et al. [162]

Species	Part used	Solvent used for extraction	Test organism	Observation	Author and year
			<i>Salmonella enteric</i> ATCC5174, <i>Klebsiella pneumonia</i> ATCC27736, <i>Proteus vulgaris</i> ATCC49132, and <i>Pseudomonas aeruginosa</i> ATCC27853, <i>Staphylococcus aureus</i> ATCC25923, <i>Staphylococcus epidermidis</i> ATCC49461 and <i>Bacillus cereus</i> ATCC10876.	<i>H. sabdariffa</i> calyces extract was recorded against <i>S. aureus</i> (18.5±0.5mm).	
<i>H. sabdariffa</i>	Calyx	Methanol	<i>Corynebacterium diphtheria</i> , <i>S. aureus</i> , <i>Enterococcus faecalis</i> , <i>Listeria monocytogenes</i> , <i>B. cereus</i> , <i>Proteus mirabilis</i> , <i>Proteus vulgaris</i> , <i>Pseudomonas aeruginosa</i> (ATCC27853), <i>Serratia marcescens</i> , <i>E. coli</i> (ATCC25922), <i>Klebsiella pneumonia</i> (ATCC70063) <i>S. aureus</i>	Methanol extracts exhibit more activity against all bacteria with inhibition zone ranging from 14 to 36mm.	Garbi et al. [5]
<i>H. sabdariffa</i>	Calyces	Hot and cold aqueous	<i>S. aureus</i>	The cold aqueous extract at concentration 40mg/mL was exhibiting the maximum antibacterial activity against tested bacteria.	Salman et al. [163]
<i>H. sabdariffa</i>	Calyces	Methanol	<i>E. coli</i> (ATCC25922), <i>P. aeruginosa</i> (ATCC27853), <i>K. pneumonia</i> (ATCC15380), <i>S. typhi</i> (ATCC4561), <i>B. subtilis</i> (NCTC8236), <i>S. aureus</i> (ATCC25923)	Maximum activity was reported against <i>B. subtilis</i> .	Youns et al. [164]
<i>H. sabdariffa</i>	Flower	Methanol	<i>Aeromonas hydrophila</i>	Roselle flower extract had antibacterial activity against <i>A. hydrophila</i> in a conc. dependent manner.	Bariyyah et al. [165]
<i>H. sabdariffa</i>	Leaves and stem	80% aqueous methanol	<i>Staphylococcus aureus</i> , <i>Pseudomonas aeruginosa</i>	Leaf extracts show better activity against <i>S. aureus</i> and <i>P. aeruginosa</i> than stem extract.	Kumar et al. [166]
<i>H. syriacus</i>	Leaves	Petroleum ether, Benzene, Chloroform, Methanol and	<i>Bacillus cereus</i> , <i>Staphylococcus epidermis</i> , <i>Klebsiella</i>	Methanol extracts show maximum zone of inhibition against all the test	Punasiya et al.[167]

Species	Part used	Solvent used for extraction	Test organism	Observation	Author and year
<i>H. tiliaceus</i>	Leaves and bark	Aqueous extracts Ethanol	<i>pneumonia, Bacillus subtilis</i> <i>Staphylococcus aureus, S. epidermidis, S. saprophyticus, S. pyogenes, Plesiomonas shigelloides, Shigella dysenteriae, S. flexneri, S. boydii, S. sonnei, Pseudomonas aeruginosa, Vibrio cholera, Salmonella typhi</i>	organisms. Bark extract has maximum antibacterial effect against <i>S. aureus</i> and <i>S. epidermidis</i> among all the test organisms.	Abdul et al. [168]
<i>H. tiliaceus</i>	Fruits, leaves and twigs	Methanol and chloroform, methanol and ethyl acetate fractions	<i>Pseudomonasa erouginosa</i>	The strongest anti-bacterial activities were exhibited by the chloroform fraction of fruits at a conc. of 80%.	Andriani et al. [169]

Table 3. Antioxidant activity of various species of genus *Hibiscus*

Species	Part used	Solvent used for extraction	Assay performed	Observations	Author and year
<i>H. acetosella</i>	Stem	Water and ethanol (70/30)	DPPH	IC50 value for stem extracts is 44µg/mL.	Abdoulaye et al. [170]
<i>H. asper</i>	Leaves and calyx	80% methanol	DPPH	Calyx extract had higher % inhibition (53.33-0.25%) against DPPH radical than leaf extract (36.33-0.45%).	Gbadamosi et al.[171]
<i>H. cannabinus</i>	Leaves, bark, flowers and seeds	Water	DPPH	Methanol extract of flower (71.84%) exhibit maximum DPPH activity.	Ryu et al. [172]
<i>H. cannabinus</i> <i>H. platanifolius</i>	Leaves Leaves	Ethanol Ethanol and Aqueous	DPPH Reducing power and hydrogen peroxide scavenging assay	IC50 value for ethanol extract is 44.48µg/mL. Ethanol extract shows radical scavenging activity in conc. dependent manner.	Rusmini et al. [173] Saravanan et al. [174]
<i>H. rosa-sinensis</i>	Flower	Methanol	DPPH	IC50 value for methanol extract is 43.9µg/mL.	Falade et al. [175]
<i>H. rosa-sinensis</i>	Leaves	80%ethanol	Ferric thio cyanate, Hydrogen peroxide scavenging, DPPH, ABTS radicals' cations and Super oxide an ion radical scavenging by riboflavin methionine illuminate	Crude extract of leaves exhibits potent antioxidant activity against all the studied assay.	Mandade et al. [176]

Species	Part used	Solvent used for extraction	Assay performed	Observations	Author and year
<i>H. rosa-sinensis</i>	Flower	Ethanol	system SOD, GPx, CAT	Ethanol extract at 250mg/kg conc. was more effective than other two doses.	Sankaran et al. [177]
<i>H. rosa-sinensis</i>	Stem and leaves	Aqueous and methanol	DPPH reduction assay, scavenging of SO, H ₂ O ₂ and NO, reducing power, FRAP assay.	Methanol extract possesses significant antioxidant activity as compared to aqueous extract.	Garg et al. [178]
<i>H. rosa-sinensis</i>	Leaves	70% ethanol/water extract	Butylated hydroxyl toluene (BHT), Ascorbic acid (ASA)	Extract has two times more antioxidant activity than BHT and ASA.	Ghaffar et al. [179]
<i>H. rosa-sinensis</i>	Flowers	Methanol	DPPH	100µg/mL varies between 30.95 to 55.11% scavenging effect.	Sheth et al. [180]
<i>H. rosa-sinensis</i>	Root	Aqueous	Super oxide anions and Hydroxyl radicals	The effect was dose dependent and highest i.e.58% for SO and 48% for hydroxylion at peak concentration (500mg/mL).	Kumar et al. [181]
<i>H. rosa-sinensis</i>	Petals	Ethanol and ethyl acetate fraction	DPPH	IC ₅₀ value for ethanol extract is 36±1.7 µg/mL.	Pillai et al. [182]
<i>H. rosa-sinensis</i>	Corolla and calyx	Methanol extract	Ferric ion Reducing Power Assay [FRAP] Nitric Oxide Scavenging assay	Maximum % inhibition of calyx extracts 66.66% and Corolla is 71.25% against NO.	Guleria et al. [183]
<i>H. rosa-sinensis</i>	Flower	Water, ethanol, and absolute ethanol extract	DPPH, Nitric oxide, hydroxyl radical scavenging activity	Flower extract against DPPH show highest activity of 90.20±0.29% at 500mg/ml conc.	Afifty et al. [184]
<i>H. rosa-sinensis</i>	Leaves	Ethanol	DPPH, Nitricoxide, Superoxide radical	Extract conc.i.e.1000µg/mL has maximum% inhibition i.e. 91.15±1.32% for DPPH, 86.45±2.09 for NO and 79.12±1.56 for super oxide radicals.	Mondal et al. [185]
<i>H. rosa-sinensis</i>	Flowers	Methanol	DPPH, hydrogen peroxide and superoxide radical scavenging activity	The extract showed IC ₅₀ values of 28.41±1.7, 36.69±2.3 and 33.32±2.5 µg/mL against DPPH, H ₂ O ₂ and superoxide radical respectively.	Purushotaman et al. [186]
<i>H. rosa-sinensis</i>	Flower	Ethanol	Hydrogen peroxide scavenging assay	The flower extract exhibits a concentration dependent hydrogen peroxide radical scavenging activity.	Ghosh et al. [187]
<i>H. rosa-sinensis</i>	Leaves	Aqueous and Ethanol	DPPH, NO, FRAP and H ₂ O ₂	DPPH 11.8mg/g, NO 66.8, FRAP 15.4, H ₂ O ₂ 23.04mg/g.	Prasanna et al. [188]

Species	Part used	Solvent used for extraction	Assay performed	Observations	Author and year
<i>H. rosa-sinensis</i>	Leaves	Mucilage from leaves	FRAP, DPPH, hydroxyl, superoxide, nitricoxide and hydrogen peroxide scavenging assay.	The mucilage showed antioxidant potential against all the assays, but it was detected to be lower as compared to the standards used.	Vignesh et al. [189]
<i>H. rosa-sinensis</i>	Flower	Methanol and Ethanol extract	DPPH	IC50 value for methanol extract is maximum i.e.19.54µg/mL.	Singh et al. [146]
<i>H. rosa-sinensis</i>	Flower	Ethanol extract	DPPH	IC50 value for the ethanol extract is 231.110±1.59µg/mL.	Wahid et al. [190]
<i>H. sabdariffa</i>	Calyces	Methanol	DPPH	IC50 for the extract is 230.01±2.40µg/mL.	Luvongal et al. [191]
<i>H. sabdariffa</i>	Leaves	Ethanol	DPPH	Anti radical power 0.41mg DPPH/mg.	Zhang et al. [150]
<i>H. sabdariffa</i>	Leaves	Aqueous, 95 percent ethanol, ethyl acetate fraction	DPPH	IC50 values for the extracts is ranging from 46.13±0.37 to 94.16± 0.56µg/mL.	Kumar et al. [192]
<i>H. sabdariffa</i>	Calyces	Water and ethanol extract	DPPH	Dose dependent activity is shown by both the extracts.	Jung et al. [152]
<i>H. sabdariffa</i>	Calyces	Ethanol, methanol, petroleum ether and aqueous	DPPH	Petroleum ether extract show better activity as compared to all other solvents used.	Das et al. [153]
<i>H. sabdariffa</i>	Petal	Methanol	DPPH	IC50 is 0.24mg/mL.	Obouayeba et al. [193]
<i>H. sabdariffa</i> L.	Calyx	Ethanol extract	DPPH	At a conc.250µg/mL calyx extract has maximum 86% scavenging activity.	Sirag et al. [194]
<i>H. sabdariffa</i> L.	Flower	Methanol	DPPH and ABTS assay	IC50 for DPPH and ABTS were 17.14-2.24 and 85.91-6.72µg/mL respectively.	Zhang et al. [195]
<i>H. sabdariffa</i>	Leaves and calyx	Methanol extract	DPPH	IC50 for leaves is 43.48 and for calyces is 37.15µg/mL.	Formagio et al. [196]
<i>H. sabdariffa</i> L.	Calyx	Ethanol	FRAP and DPPH	The DPPH radical scavenging activity of ethanol extracts is dose dependent and ranged between 14.09 to 35.92% The FRAP value of calyx extract was 0.784±0.01mg ascorbic acid equivalent/g.	Ghosh et al. [197]
<i>H. sabdariffa</i>	Calyx and callus	Methanol	DPPH	Calyx extract shows more antioxidant activity as compared to callus extract.	Kouakou et al. [198]
<i>H. sabdariffa</i>	Calyx	Aqueous and 30% hydro ethanol	DPPH and hydroxyl radical	A dose-dependent radical scavenging of hydroxyl radicals was observed for each extract.	Mensah et al. [158]
<i>H. sabdariffa</i>	Leaves	Ethanol	DPPH	IC50 value is 184.881g/MI at a conc.50.01g/mL.	Subhaswaraj et al. [199]
<i>H. sabdariffa</i>	Flower	Methanol	DPPH, ABTS, FRAP	IC50 for DPPH is 195.73µg/mL, ABTS is	Widowati et al. [200]

Species	Part used	Solvent used for extraction	Assay performed	Observations	Author and year
<i>H. sabdariffa</i> L.	Silver nano particles from bark extract	Methanol	assay DPPH and ABTS	74.58 and 46.24 μ M fe (II)/ μ g for FRAP. DPPH and ABTS assays have IC50 31.74 \pm 2.06 and 15.45 \pm 2.72 μ g/mL respectively.	Islam et al. [201]
<i>H. sabdariffa</i>	Calyces	Methanol	DPPH	Percentage inhibition activity shown by the extract is 53 \pm 0.09%.	Youns et al. [164]
<i>H. sabdariffa</i>	Calyx	Methanol	DPPH	DPPH radical scavenging activity was reported maximum in genotype 4920 i.e.95.09%.	Jamini et al. [202]
<i>H. schizopetalus</i>	Flower	Methanol	DPPH	IC value 50 is 38.2 \pm 0.08 μ g/mL.	Zahid et al. [203]
	Leaves	Methanol	DPPH	IC 50 is 58.9 \pm 0.13 μ g/M.	
	Flower	Methanol	Nitric oxide	Flower extract showed 80.70% antioxidant activity.	
<i>H. syriacus</i> L.	Leaves	Methanol	Nitric oxide	Leaf extract showed 75.2% antioxidant activity.	Umachig et al. [204]
	Leaves	Methanol	DPPH, Superoxide radical scavenging activity in NBTsystem, reducing power and Inhibition of lipid peroxidation induced by TBARS in liver homogenate.	EC50 value is 248.00 and 105.00 μ g/mL for DPPH and superoxide radicals respectively and EC50 for lipid peroxidation of liver homogenate is 281.61 μ g/mL.	

Table 4. Anti-fungal activity of various species of genus *Hibiscus*

Species	Part used	Solvent used for extraction	Organism used	Observations	Author and year
<i>H. rosa-sinensis</i>	Leaves	Aqueous, Ethanol, Methanol	<i>Trichophyton rubrum</i> , <i>Candida albicans</i>	Ethanol extract showed maximum antifungal activity among all three solvents used.	Das et al. [205]
<i>H. rosa-sinensis</i>	Flower	Acetone	<i>Candida albicans</i> , <i>Aspergillus niger</i> , <i>Trichoderma viride</i> , <i>Rhizopus microsporus</i>	Maximum zone of inhibition for <i>Candida albicans</i> is 20mm, <i>Aspergillus niger</i> is 16mm <i>Trichoderma viride</i> is 12mm and <i>Rhizopus microsporus</i> is 21mm.	Durga et al. [206]
<i>H. sabdariffa</i>	Calyces	80% ethanol	<i>Candida albicans</i>	Zone of inhibition for <i>Candida albicans</i> is 45.0±0.4 mm.	Edema et al. [151]
<i>H. sabdariffa</i>	Calyx	Hexane, Ethylacetate, Methanol	<i>Candida albicans</i>	The ethyl acetate fraction exhibited most significant antifungal activity against <i>Candida albicans</i> at MIC of 16µg/mL.	Ajoku et al. [207]
<i>H. sabdariffa</i>	Calyx	Aqueous and hydroethanol 30%	<i>Candida albicans</i>	Hydro ethanol extract is more potent antifungal extract.	Mensah et al. [158]
<i>H. sabdariffa</i>	Calyces	Methanol	<i>Candida albicans</i> (ATCC7596786)	Extract has maximum inhibition zone of 21mm against <i>Candida albicans</i> .	Youns et al. [164]
<i>H. syriacus</i> gagoma	Root	Methanol	<i>Trichophyton mentagrophytes</i>	Methanolic extract of <i>H. syriacus</i> gagoma exhibited four times higher activity than its parent against <i>Trichophyton mentagrophytes</i> .	Jang et al. [208]

Table 5. Anti cancerous activity of various species of genus *Hibiscus*

Species	Activity	Part used	Organism used	Observations	Author and year
<i>H. cannabinus</i> L.	Cytotoxic activity	Seeds extract and seed oil	Human cancer cell lines	Seed extract exhibited a greater cytotoxic activity as compared to seed oil.	Wong et al. [209]
<i>H. calyphyllus</i> , <i>H. deflersii</i> , <i>H. micranthus</i>	Anti-cancer	Aerial parts	HepG2, MCF-7 cell lines	<i>H. deflersii</i> petroleum ether fraction showed the most significant cytotoxic effect on HepG2 and MCF-7 with IC50 14.4 and 11.1µg/mL, respectively.	Alam et al. [210]
<i>H. rosa-sinensis</i>	Anti cancer activity	Flower	Hela cell lines	Flower extract exhibited potent anti cancer activity against helacell lines.	Durga et al. [206]
<i>H. sabdariffa</i> <i>H. sabdariffa</i> L.	Cytotoxicity Anti-tumour activity	Fruits Seeds	Brine shrimp lethality bioassay Human cervical hela cells	LC value for fruit extract is 5.082±12 µg/mL. Percentage inhibition against hela cell lines reached upto 83.67±3.07% at 20µg/mL concentrations.	Mamun et al. [149] Zhang et al. [195]
<i>H. sabdariffa</i>	Anti-tumor activity	Leaves and calyx	Leukaemia line k-562	Methanol extract from calyx show significant antitumor activity.	Formagio et al.[196]

Species	Activity	Part used	Organism used	Observations	Author and year
<i>H. sabdariffa</i>	Cytotoxicity	Seeds	H9c2 cardiomyoblast cells	Pre-treatment with seed extract significantly reduced cell apoptosis at concentration of 31.25-250µg/mL.	Hosseinia et al. [211]
<i>H. sabdariffa</i>	Anti-proliferative	Calyx	Caco-2, hepG-2, HCT8 and A549 cell lines	Calyx extract has significant cytotoxic activity.	Maciela et al. [212]
<i>H. sabdariffa</i>	Cytotoxic activity	Leaves	HepG2 cell lines	Administration of leaf extract showed increased cell growth inhibition and decreased cell viability in a dose dependent manner.	Sangeetha et al. [213]
<i>H. syriacus</i>	Anti proliferative effect	Root bark	Human lung cancer cells	Acetone extract of <i>H. syriacus</i> has potent and dose dependent anti proliferative activity.	Cheng et al. [214]
<i>H. tiliaceus</i>	Cytotoxic effect	Leaves and bark	Brine shrimp	Leaf extract of plant has moderate cytotoxic activities with LC50 is 20µg/mL while bark has low cytotoxic effect LC50 is 50µg/mL.	Abdul et al. [168]
<i>H. vitifolius</i>	Cytotoxic activity	Flowers	Hela cell lines	IC50 value against thella cell lines is 81.27µg/mL.	Nishitha et al. [215]

Table 6. Other medicinal activities of various species of genus *Hibiscus*

6.1. Effect on lipid metabolism					
Species	Activity	Part used	Organism used	Observations	Author and year
<i>H. platanifolius</i>	Hypoglycaemic and hypolipidemic activity	Leaves	Rats	Administration of extract dose of 100 mg and 150mg/kg helps to decrease the increased biochemical parameters in all diabetic rats.	Saravanan et al. [174]
<i>H. rosa-sinensis</i>	Lipid lowering effect	Flower petals	Albino Rats	After administration of flower extract, the levels of free fattyacids, phospholipids TG, VLDL, LDL and HDL cholesterol were back to nearly normal.	Gomathi et al. [216]
<i>H. rosa-sinensis</i>	Hypoglycaemic and hypolipidemic activity	Flower	Rats	500mg/kg/day dose showed potent hypoglycaemic and hypolipidemic activities.	Bhasker et al. [217]
<i>H. rosa-sinensis</i>	Anti-hyperlipidaemic activity	Leaves	Mice	500mg/kg dose of methanol extract showed decrease in levels of cholesterol, triglyceride, and low-density lipids.	Mishra et al. [218]
<i>H. rosa-sinensis</i>	Hypoglycaemic and hypolipidemic activity	Flowers	Rats	The decreased levels of blood glucose, carbohydrate metabolizing enzymes, TBARS, and lipid profiles were found after the administration of flower extract.	Sankaran et al. [177]

<i>H. rosa-sinensis</i>	Antihyperlipidemic activity	Flowers	Rats	Oral dose of 500mg/kg body wt. of the ethanolic extract exhibited a significant reduction ($p < 0.01$) lipid parameters, LDL, VLDL total cholesterol, triglycerides and increase in HDL in rat serum.	Sikarwar et al. [219]
<i>H. rosa-sinensis</i>	Hyperlipidaemic activity	Leaves	Rabbits	After treatment with 400mg/kg dose of extract, decrease in total cholesterol, triacylglycerol, low-density lipoprotein cholesterol and high-density lipoprotein cholesterol in diabetic rabbits is observed.	Ojiako et al. [220]
<i>H. rosa-sinensis</i>	Hypolipidemic properties	Flower	Albino Wistar Rats	240mg/kg dose has significant hypolipidemic activity.	Biswas et al. [221]
<i>H. rosa-sinensis</i>	Hypoglycaemic effect	Leaves	Rats	The treatment of diabetic rats with leaf extract helps to reduce the amount of plasma alanine amino transferase (ALT) enzyme, glucose, cholesterol, aspartate amino transferase (AST) enzyme, uric acid, creatinine and hepatic malon dialdehyde.	Zaki et al. [222]
<i>H. sabdariffa</i>	Hypolipidemic activity	Leaves	Hyperlipidic rats	300 mg per kg dose possessed the best hypolipidemic activities.	Gosian et al. [223]
<i>H. sabdariffa</i>	Hyperglycaemia, hyperinsulinemia, and hyperlipidaemia activity	Calyces	Rat	A dose of 200mg/kg showed significant results against Hyperglycaemia, hyperinsulinemia, and hyperlipidaemia activities.	Peng et al. [96]
<i>H. sabdariffa</i>	Hypoglycaemic and hypolipidemic effects	Leaves	Rats	A significant ($p < 0.05$) reduction in levels of serum cholesterol, triglycerides. LDL-cholesterol and increase in HDL-cholesterol was observed.	Ndarubu et al. [224]
<i>H. sabdariffa</i>	Hypolipidemic effect	Calyces	Albino rats	Administration of plant extract lowers the serum lipid levels.	Gaffer et al. [225]
<i>H. schizopetalus</i> (Mast) Hook	Hypolipidemic activity	Flowers and leaves	Rats	Cholesterol and triglycerides levels were significantly decreased after the administration of plant extracts.	Zahid et al. [203]
6.2. Hepato-protective activity					
<i>H. esculentus</i>	Hepato-protective activity	Pods	Wistar albino rats	Administration of pod extract showed reduction in liver enzymes like SGOT, SGPT, ALP, cholesterol, TG and malondialdehyde, non-protein sulfhydryl showing its hepatoprotective activity.	Alqasoumi et al. [226]

<i>H. rosa-sinensis</i>	Hepato-protective activity	Leaves	Albino rats	Leaf extracts have significant hepatoprotective activity, where enzymes like ALT, AST, ALP and total bilirubin were decreased.	El-Sayed et al. [227]
<i>H. sabdariffa</i>	Hepato-renaltoxicity	Calyx	Albino rats	After the treatment with extract significant increase was observed in the renal indices, urea, uric acid and creatine but sodium and potassium were decreased.	Abubakar et al. [228]
<i>H. sabdariffa</i>	Hepato-protective activity	Leaves	Rats	Oral administration of extract exhibits a potent reduction in AST, ALP, ALT and bilirubin levels.	Bhavana et al. [229]
<i>H. sabdariffa</i>	Hepato-curative effect	Leaves	Albino rats	Increase the levels of blood in dose dependent manner.	Joshua et al. [230]
<i>H. sabdariffa</i>	Ethanol induced hepatotoxicity	Leaves	Rats	Levels of SGOT, SGPT and bilirubin were decreased after the treatment with leaf extract.	Olanrewaju et al. [231]
<i>H. vitifolius</i> (Linn.)	Hepato-toxicity activity	Root	Albino rats	The extracts were found to be safe upto a dose of 2000mg/kg but higher than this were toxic.	Samuela et al. [232]
6.3. Anti-inflammatory activity					
<i>H. asper</i> hook. F.	Anti-inflammatory	Leaves	Wistar albino rats	Methanolic extract has significant dose dependent activity.	Simplice et al. [233]
<i>H. cannabinus</i>	Anti-inflammatory	Seeds	Mice	Maximum effect at 400mg/kg dose was observed.	Chaudhari et al. [234]
<i>H. rosa-sinensis</i> and <i>H. rosa-sinensis</i> alba	Anti-inflammatory	Flower and leaf	Rats	Dose up to 500mg/kg is not toxic. The white hibiscus had more potent anti-inflammatory effect.	Raduan et al. [235]
<i>H. sabdariffa</i>	Anti-inflammatory	Calyx	Wistar rats	All the administered doses revealed anti-inflammatory effect.	Saptarini et al. [236]
<i>H. sabdariffa</i>	Anti-inflammatory	Seeds	Rats	Extract showed a significant dose dependent anti-inflammatory activity.	Ali et al. [237]
6.4. Analgesic activity					
<i>H. cannabinus</i>	Analgesic activity	Seeds	Mice and rats	Seed extracts had central and peripheral analgesic activities.	Chaudhari et al. [234]
<i>H. rosa-sinensis</i>	Analgesic potentials	Roots	Albino rats	Root extracts showed significant dose dependent activity.	Soni et al. [238]
<i>H. sabdariffa</i>	Analgesic activity	Leaves	Wistar albino rats	A dose of 750mg/kg of extract showed analgesic potency as similar as morphine.	Omodamiro et al. [239]
<i>H. sabdariffa</i>	CNS stimulant activity	Flowers	Albino rats	Increase in the locomotory activity proved that the extract has the CNS Stimulant activity.	Gresamma et al. [240]
6.5. Haemato-toxicity					

<i>H. cannabinus</i>	Haematinic activity	Leaves	Rats	A Significant increase in the red blood count, haemoglobin concentration and pack cell volume was observed after extract administration.	Agbor et al. [241]
<i>H. rosa-sinensis</i>	Haemato-protective	Flowers	Rats	Exhibit significant Haemato-protective activity.	Meena et al. [242]
<i>H. rosa-sinensis</i>	Anti-haemolytic activity	Flowers	Venous blood samples	The extract had the ability to reduce hydrogen peroxide induced haemolysis.	Purushotaman et al. [186]
<i>H. sabdariffa</i>	Haemato-toxicity	Calyces	Rats	After administration of extract increased levels of RBC, haemoglobin and decreased levels of WBC were observed.	Famurewa et al. [243]
6.6. Anti-diabetic activity					
<i>H. platanifolius</i>	Anti-diabetic activity	Stem	Rats	Ethanollic extract of stems at 250mg/kg dose revealed a decrease in blood glucose level.	Raghavendra et al. [244]
<i>H. rosa-sinensis</i>	Anti-diabetic	Leaves	Rats	Upon treatment with leaves extract Diabetic rats blood glucose was elevated to normal values.	Anandhi et al. [245]
<i>H. rosa-sinensis</i>	Effect on diabetes	Flower	Rats	Administration of flower extracts decreased blood glucose levels.	Afiune et al. [246]
<i>H. sabdariffa</i>	Anti-diabetic	Leaves, stem, roots	Rats	Leaf extract Reduce sugar level in rats more significantly than stem and root extracts.	Ojewumi et al. [247]
<i>H. syriacus</i>	Anti-diabetic	Leaves	Rats	Treatment with leaves extract showed a decrease in blood glucose level.	Nirosha et al. [248]
6.7. Anti-hypertensive activity					
<i>H. sabdariffa</i>	Anti-hypertensive activity	Calyces	Rats	Extract administration helps to reduce hypertension.	Nkumah et al. [249]
<i>H. sabdariffa</i>	Hypertension	Leaves	Wistar rats	Extract revealed anameliorative effect against hypertension.	Balogun et al. [250]

flowers, seeds etc have been well worked out for exploring the antioxidant potential following different assays like DPPH, FRAP, ABTS, H₂O₂, NO etc and the same have been highlighted in this review. The solvents used for the preparations of the plant extracts were mainly water, methanol, ethanol and ethylacetate. Numerous *Hibiscus* species have been well acknowledged for higher Antioxidant potential out of which *H.sabdariffa* and *H.rosa-sinensis* have been well studied however only few reports on *H.asper*, *H.cannabinus*, *H. platanifolius* and *H.syriacus* were found suggesting further explorative studies. The details of the same have been mentioned in Table 3 along with the plant part used, assay followed and observations.

2.2.3 Anti-fungal activity

Besides anti-bacterial activity, *Hibiscus* also illustrates anti-fungal behaviour against various detrimental genera of fungi like *Candida albicans*, *Aspergillus niger*, *Trichoderma viride*, *Rhizopus microsporus* and *Trichophyton mentagrophytes*. Plant parts used as well as the extracts used for the studies were like those used in anti-bacterial studies. Comparative analysis of potential of plant extracts in different solvents was also done by different researchers but positive results were obtained only in few solvents against different genera of fungi. All the results are depicted in Table 4 reflecting anti-fungal properties of *Hibiscus*.

2.2.4 Anti-canceractivity

Different cell line studies revealed anti-cancer activities of *Hibiscus*. *H. sabdariffa* is maximum explored member in this regard displaying positive results. Different cell lines like human cancer, Hela cell lines, Leukemia line k-562, hepG2 etc.were used for these demonstrating the anti-cancer activity of different parts of *Hibiscus* like flower, leaves, calyx, roots, fruit, bark etc. All these details are presented in Table 5.

3. SOME OTHER MEDICINAL PROPERTIES

Besides aforementioned activities, *Hibiscus* also displays excellent health benefits like effects on lipid metabolism where rat, rabbit, mice were used for experimental studies and positive behaviour of the *Hibiscus* extracts was elucidated (Table 6.1). Similar studies were

conducted by various researchers to demonstrate hepatoprotective activity of *Hibiscus* where extracts were known to regulate essential liver enzymes like Aspartate aminotransferase (AST), Alanine transaminase (ALT), Serum glutamic oxaloacetic transaminase (SGOT), Serum glutamic pyruvic transaminase (SGPT) (Table 6.2). The plant extracts also showed anti-inflammatory properties as depicted in Table 6.3. A significant dose dependent analgesic behaviour of the extracts was observed and the same has been presented in Table 6.4. Morphine like activity of the *Hibiscus* extracts was reported by few reports. Effect of the extracts on blood cells like RBCs and WBCs was also observed where the extracts were seen to enhance the blood cell count (Table 6.5). Maintenance of blood sugar levels by the extracts was also observed and the extracts exhibit antidiabetic properties which are of greater use and can be considered subject of exploitation for commercial uses (Table 6.6). Reduction in Hypertension levels by the extracts were observed by various researchers and the same has been presented in Table 6.7.

4. CONCLUSION

In conclusion this survey features the therapeutic capability of various species of genus *Hibiscus*. Due to the presence of its extraordinary mix of various phytochemicals like phenols, flavonoids, tannins, sterols, glucosides, lignin, anthocyanin and many more, which could be additionally surveyed and exposed to clinical preliminaries for their legitimate approvals. The enormous information in regards to the traditional uses and pharmacological impacts of genus *Hibiscus* has already been added to the existing data base by means of this article but at the same time capabilities of certain more species of the genus is not get disclosed so this can be considered as future possibilities that should be worked out.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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