



Phyto-chemistry and Pharmacological Activities of *Hibiscus sabdariffa* Linn.-A Review

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Authors' contributions

Author PSB designed the study and helped the author MB in final writing of the manuscript. Author MB managed the literature searches, wrote the protocol and first draft of the manuscript. Author GG helped in drawing of different structures by using Chem-Draw software. All authors read and approved the final manuscript.

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ABSTRACT

In present study the literature available on Phyto-chemistry and pharmacological activities of plant *Hibiscus Sabdariffa* Linn. has been studied extensively to review the scientific data in this paper. Major chemical components of the plant *Hibiscus sabdariffa* Linn. are steroids, hibiscin, tannins, carbohydrates and flavonoids. It is being used as herbal drink in the form of hot and cold beverages, as a flavoring agent in the food industry as it contains mallic acid, anthocyanins, ascorbic acid and minerals, especially calcium and iron. *Hibiscus sabdariffa* Linn. is a good antioxidant as it is rich in phenolic compounds. *Hibiscus Sabdariffa* Linn. is being used in the treatment of various diseases like liver, renal, neurological, diabetes, cardiovascular and cancer. It is one of the most important constituents among the widely used herbal formulations as it has wide ethno medicinal use. Leaves of this plant are used orally for the treatment of stomachic and as an emollient externally. They are mainly used as ant-diuretic and anthelmintic. Its decoction is used in the treatment of cough and high blood pressure.

Keywords: *Phyto-chemistry; bioactive compounds; niacin; isoamyl alcohol; Hibiscus sabdariffa; anti-cancer; hypolipidaemic; methanolic extract; hypercholesterolemia.*

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1. INTRODUCTION

Medicinal plants have been used since thousands of years for the treatment of various human and animal diseases, such plants have medicinal value and used in herbalism. These plants are rich sources of secondary metabolites which can be used in the development of drugs. In developing countries about 80% of the population uses traditional medicines for their health care. Worldwide there are 500,000 plant species of which only 1% have been phytochemically investigated [1-2]. The natural products obtained from medicinal plants have proven to be a rich source of biologically active compounds, many of which have been used for the development of new medicines. In Today's world the common pathogens have developed resistance against therapeutic agents used currently, such as antibiotics and antiviral agents, has led to renewed interest of the scientists in the discovery of novel anti-infective compounds derived from various plants [1-4]. Some plants are recommended for their therapeutic values because of their rich nutritive value the examples of such plants are ginger, green tea and walnuts etc. Medicinal plants are frequently used as raw materials for extraction of active ingredients which are widely used in the synthesis of different drugs [5].

2. REVIEW OF LITERATURE

Hibiscus sabdariffa Linn. commonly known as Roselle or Red sorrel in English (Fig. 1), whereas in Ethiopia and Saudi Arabia as Karkadeh, is widely grown in Central and West Africa, South

East Asia, and elsewhere. The family of the plant is Malvaceae, an erect annual herb, the botanical features of which have been described and reported [6]. *Hibiscus sabdariffa* Linn. plant whose fruits are capsule, schizocarps or nuts [7, 8]. The thick red and fleshy flowers are consumed worldwide as a cold beverage and as a hot drink (sour tea). The extracts of the flowers are also used in folk medicine against high blood pressure, liver diseases and fever. The red anthocyanin pigments in the calyces are used as food coloring agents [9-11].

Roselle was planted in Sudan about 6000 years ago. It [*Hibiscus sabdariffa* Linn.] is a well known multipurpose medicinal plant having an annual tropical short shrub and distributed in many tropical and subtropical regions in the world [12]. As it is easy to grow this plant, it can be grown as part of multi-cropping systems and can be used as food and fiber [13]. It is cultivated in warm countries like India, Indonesia, Philippines, Malaysia, tropical Africa and also in Brazil, Australia, Hawaii and Florida etc. There are many types of Roselle depending on color of the sepals [14]. The family consists of 243 genera and *Hibiscus* is among the largest genera in terms of number of species [7,15]. The species of this genus (*Hibiscus*) are well known for their showy flowers and thus known as *Hibiscus* or Rose mallow [16,17]. A large number of epidemiological studies showed that the use of antioxidant vitamins and carotenoids inhibits the development of cancer [18-19,9], coronary heart disease [20], atherosclerosis [21] and hepatoprotective [22].

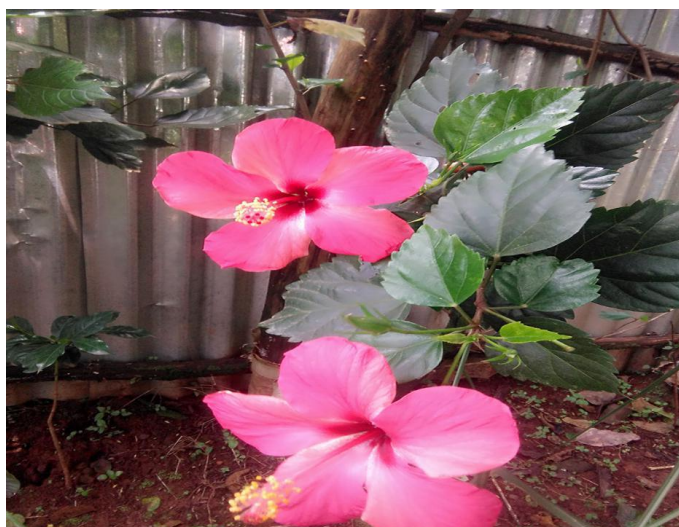


Fig. 1. Roselle [*Hibiscus sabdariffa* Linn.]

3. PHYTO-CHEMISTRY OF *Hibiscus sabdariffa* Linn.

Hibiscus sabdariffa Linn. contains protein, carbohydrate, vitamin C, β -carotene and iron [23,24]. Phyto chemicals are non-nutritive bioactive compounds found naturally in almost all plant parts like flowers, leaves, stem, root, bark, seeds. These prevent humans from many degenerative diseases and pathological processes and also show anti-oxidant activity [25].

3.1 Constituents of *Hibiscus sabdariffa* Linn.

Several studies have been reported on the various constituents of different plant parts like flowers, leaves, stem, root, bark, seeds of *Hibiscus sabdariffa* Linn. [22,26-29].

3.1.1 Organic acids

Tartaric acid along with citric, oxalic, malic, ascorbic and succinic acids (Fig. 2) are detected

in aqueous extracts of *Hibiscus sabdariffa* Linn. flowers [9-10,28].

3.1.2 Anthocyanins

The anthocyanins and anthocyanidin (Fig. 3) present in leaf and stem of the plant have healing properties [30]. The dried flowers contains gossypetin and hibiscetin whereas calyces contains riboflavin, ascorbic acid, niacin, carotene, calcium and iron [31]. The red pigments in red calyces of roselle are anthocyanins these are quantified in *Hibiscus sabdariffa* Linn., the percentage of present anthocyanins are 56% Delphinidin-3-Sambubioside, 33% Cyanidin-3-Sambubioside, 4% Delphinidin-3-Glucoside, 3% Cyanidin-3-Glucoside [32,33]. Anthocyanins have been reported with their antioxidant property in the role of reduction of coronary heart disease and cancer. Beneficial health effects of anthocyanins, ascorbic acid and carotenoids are reported by several researchers [34-35,9].

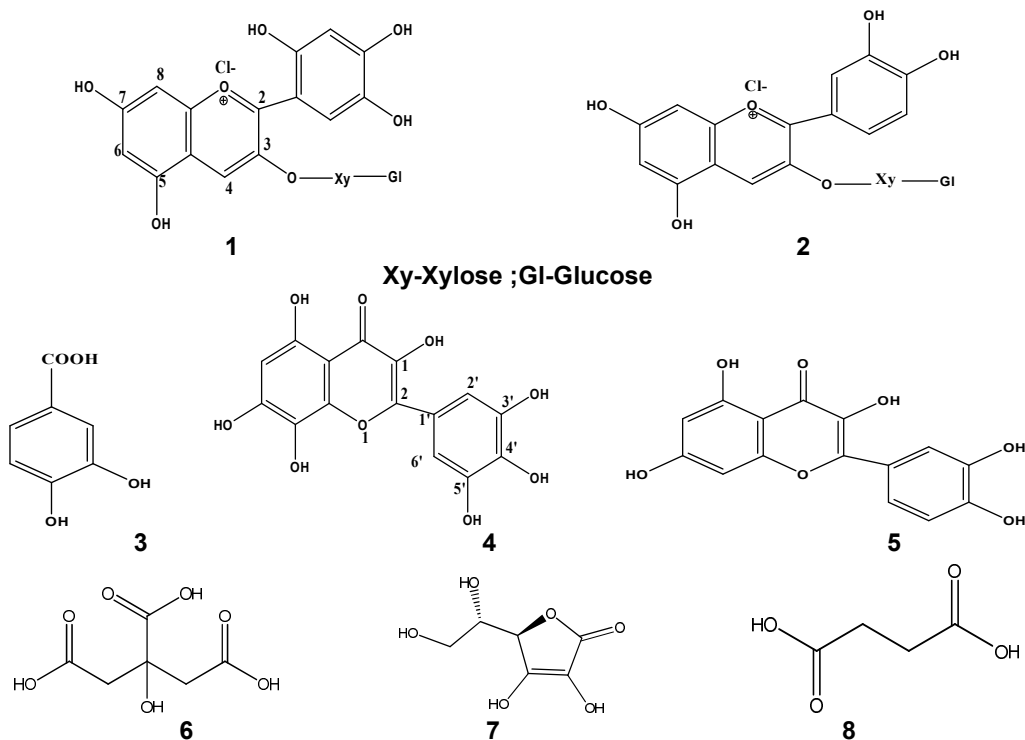


Fig. 2. Some Chemical constituents of *Hibiscus sabdariffa*: 1. Delphinidin-3-sambubioside, 2. Cyanidin-3-sambubioside, 3. Hibiscus protocatechuic acid, 4. Hibiscetin, 5. Gossypetin, 6. Citric acid, 7. Ascorbic acid, 8. Succinic acid [9-10,28]



Fig. 3. Structures of Anthocyanins in *Hibiscus sabdariffa* Linn.: 1. Anthocyanin, 2. Anthocynidin [30]

3.1.3 Flavonoids and phenolic acids

Flavonoids present in all parts of *Hibiscus sabdariffa* Linn. used in treating diabetes, hypertension, rheumatic fever and also known for their anti-viral, anti-inflammatory, antioxidant

activities. The Fig. 4 explains the structures of major flavonoids and phenolic compounds in leaves and petals of Roselle are sabdaretin, gossypetin, hibiscitrin, quercetine, gossypetrin, hibiscetin, catechin, kaempferol, luteolin and delphinidin-3-glucoside [36-37].

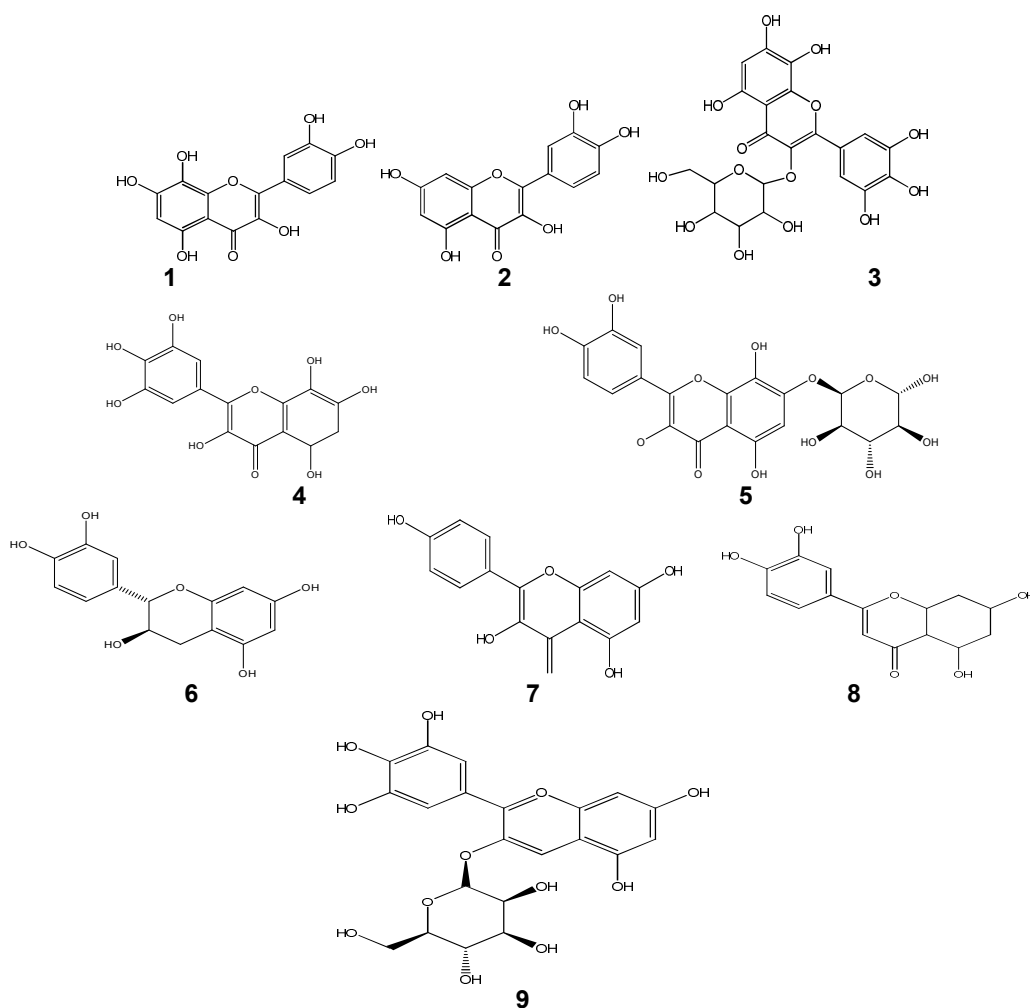


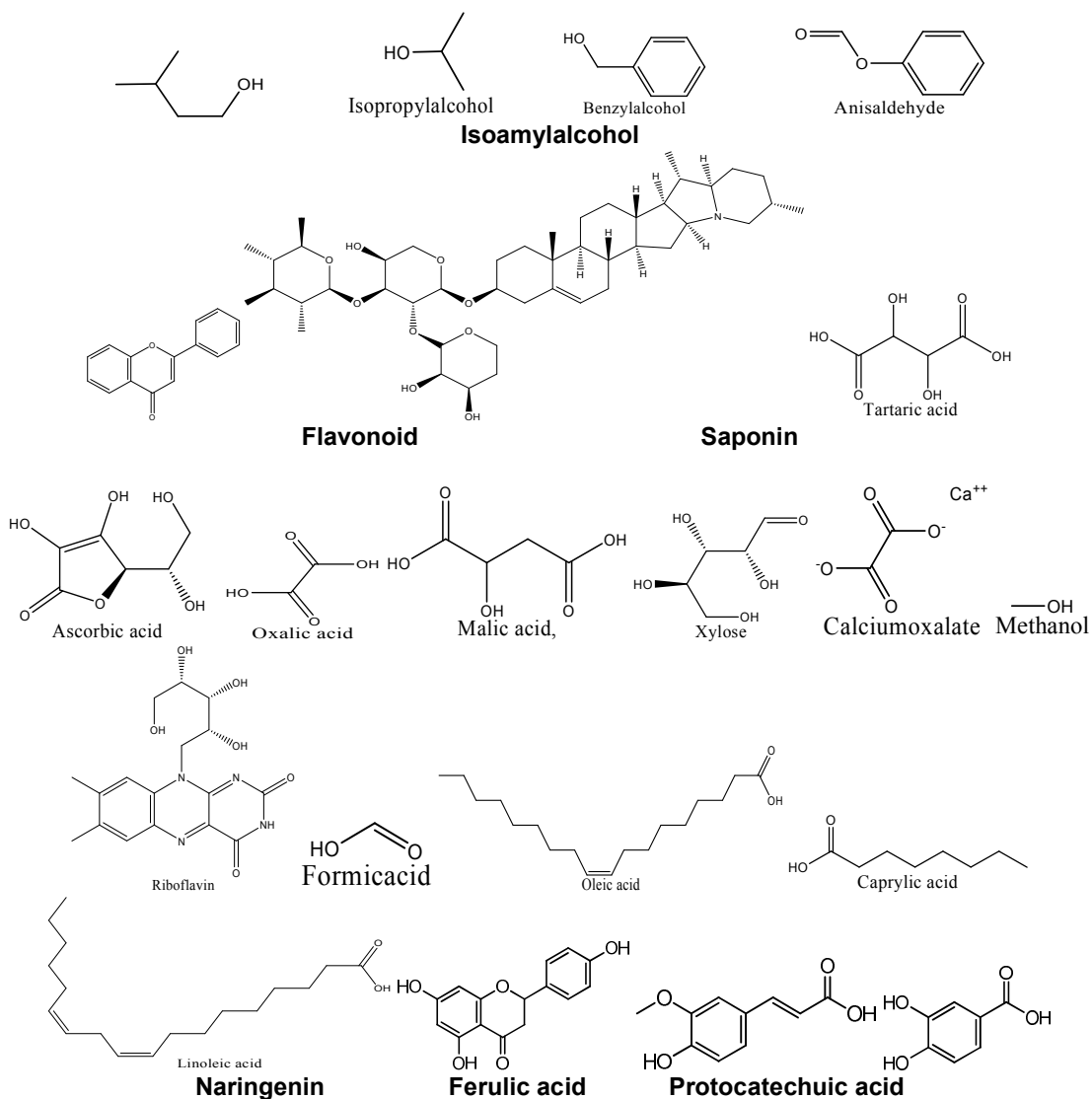
Fig. 4. Structures of Flavonoids in *Hibiscus sabdariffa* Linn : 1. Gossypetin , 2. Quercetine, 3. Hibiscitrin, 4. Hibiscetin, 5. Gossypetrin, 6. Catechin, 7. Kaempferol, 8. Luteolin, 9. Delphinidin-3-glucoside [36-37]

The presence of chlorogenic acid, naringenin, rutin, ferulic acid, protocatechuic acid, epigallocatechin, catechin, epigallocatechin gallate, quercetin, eugenol and caffeic acid in *Hibiscus sabdariffa* Linn. extracts are reported by various researchers [22,26-27,38-39]. *Hibiscus sabdariffa* extracts and its constituents have also been observed to scavenge the t-butyl hydroperoxide radical and hence prevent oxidative damage in rat primary hepatocytes. The extracts also showed strong inhibitory effect on xanthine oxidase activity and superoxide (O_2^-) radical [28].

Leaves of *Hibiscus sabdariffa* Linn. are orally used as an antidiuretic, anthelmintic, stomachic and externally as an emolient. Its decoction is useful for high blood pressure and cough. Phyto-

chemistry of leaves include carbohydrates, fatty acids, Flavonoids, saponins, phenolics, tannins, isoamyl alcohol, isopropyl alcohol, benzyl alcohol, and anisaldehyde (Fig. 5). The stem and root of this plant contains steroids, glycosides, alkaloids, Tartaric acid, Fruit include, calcium oxalate, formic acid, methanol, seed include oleic acid, caprylic acid, leonic acid [40], the flowers contains xylose, riboflavin, ascorbic acid, niacin, proteins, fat, carbohydrate, malic acid, oxalic acid [14,41]. Higher composition of the minerals and vitamins were found in the leaves than the seed [42].

Duke [31] very well explained the chemical composition of fresh leaves of *Hibiscus sabdariffa* Linn. as summarized in Table 1.



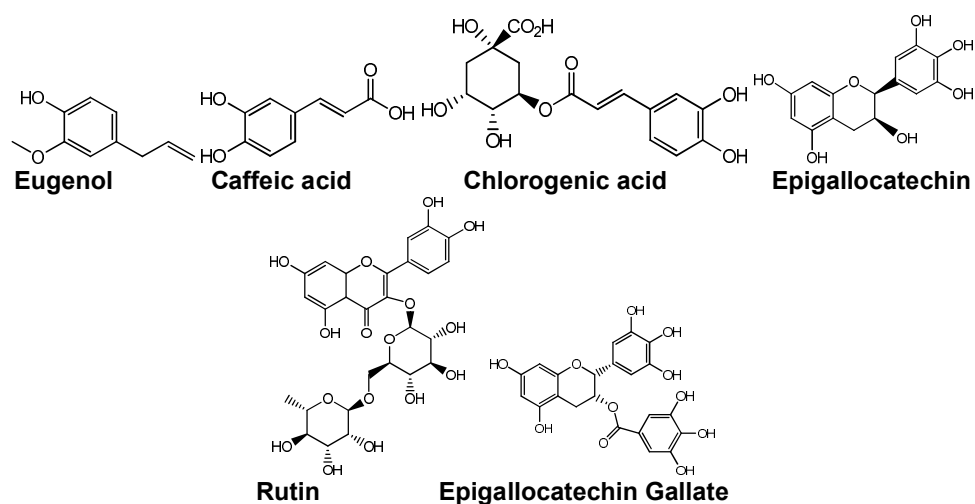


Fig. 5. Chemical structures of constituents in different parts of *Hibiscus sabdariffa* Linn. [14,40-41]

Table 1. General chemical composition of fresh leaf of *Hibiscus sabdariffa* Linn. [31]

Component	Amount (% fresh leaf wt.)	Component	Amount (% fresh leaf wt.)
Water	85.6	Phosphorus	0.093
Protein	3.3	Iron	0.0048
Fat	0.3	β -Carotene	0.0041
Total Carbohydrate	9.2	Ascorbic Acid	0.054
Fiber	1.6	Thiamine	0.00017
Ash	1.6	Riboflavin	0.00045
Calcium	0.213	Niacin	0.0012

The extracts of *Hibiscus sabdariffa* Linn. shows the presence of plants secondary metabolites in the form of phytochemicals, vitamins and vital minerals. These phytochemicals include: tannins, saponins, glycosides, phenols, and flavonoids extracted quantitatively and qualitatively. Table 2 shows the result of qualitative analysis which reveals the presence of the chemical substances [43].

3.1.4 Seed oil contents

The various chemical components of seed oil as reported by different researchers are myristic 2.1%, palmitic 35.2%, linoleic 14.4%, palmitoleic 2%, oleic 34%, stearic 3.4% and three unusual hydrogen bromide reacting fatty acids – cis-12, 13-epoxy-cis-9-octadecenoic (12,13-epoxoleic) 4.5%, sterculic 2.9%, malvelic 1.3%, α -tocopherol 25%, β -tocopherol 74.5% and γ -tocopherol 0.5% (Fig. 6). Other than these different sterols are also present viz. ergosterol,

campasterol, cholesterol, stigmasterol, β -sitosterol and α -spinasterol [44-46].

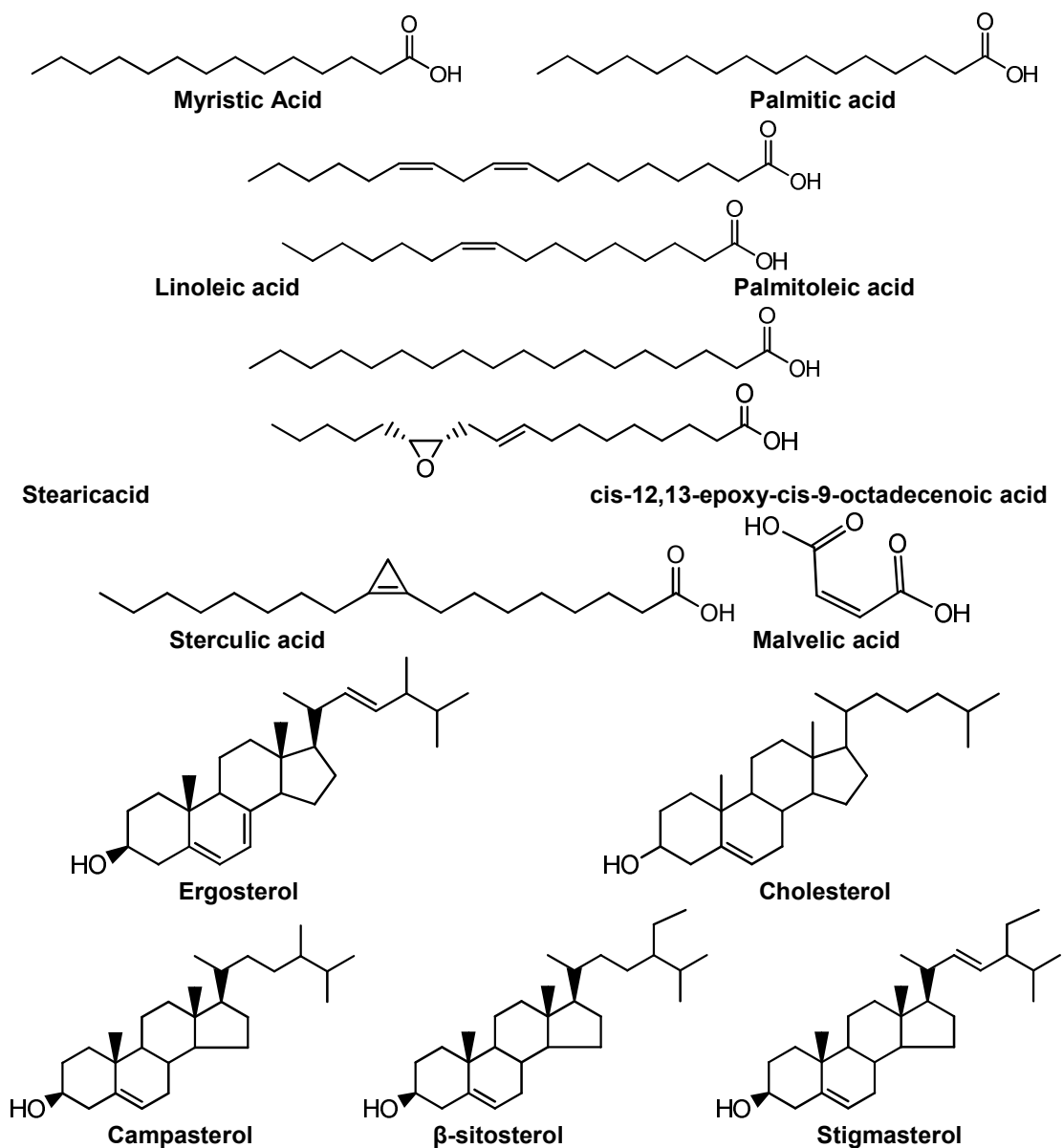
4. PHARMACOLOGICAL ACTIVITIES OF *Hibiscus sabdariffa* Linn.

Hibiscus sabdariffa Linn. a medicinal herb commonly used to make drink and pickle, in folk medicine for the treatment of hypertension, liver diseases, and fever. The plant is reported to possess antihypertensive, antioxidant, anti-cancer, anti-clastrogenic, hypolipidaemic, hepatoprotective, anti-stress, antispasmodic, antidiuretic and antidiarrheal activities [47-49].

Roselle tea is used to control high blood pressure, to treat cold, toothache, urinary tract infection, hangovers and its leaves are used as a source of mucilage in pharmacy and cosmetics [50]. Bioactivities of different extracts of *Hibiscus sabdariffa* Linn. reported by several researchers are summarized in Table 3.

Table 2. Qualitative phyto-chemical analysis of *Hibiscus sabdariffa* Linn. [43]

Parameter	Distilled water	Ethanol	Methanol	Petroleum ether	Ethyl acetate
Glycoside	++	++	++	+	++
Tannin	-	-	-	++	++
Emulsion	++	+	-	++	++
saponnin frothing	+	-	-	++	++
Alkaloid	-	++	++	-	-
Phenol	++	-	++	-	-
Steroid	-	-	-	-	-



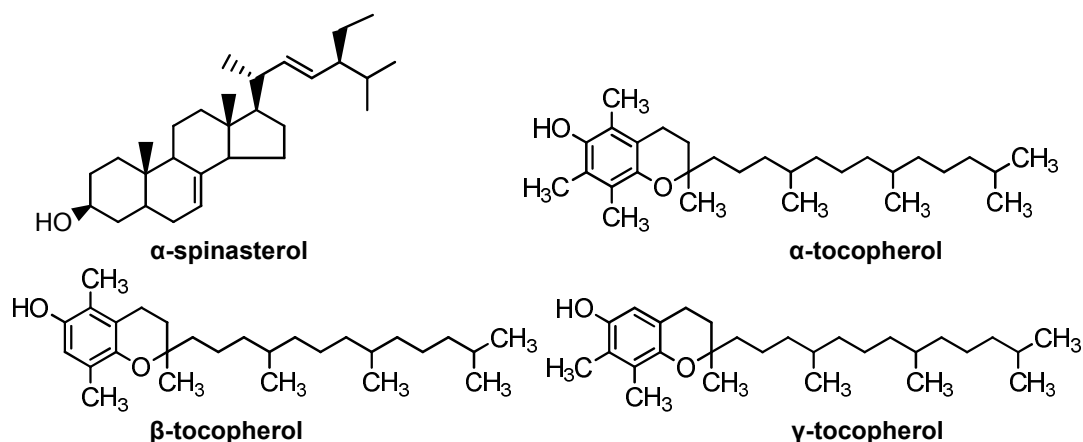


Fig. 6. Chemical structures of seed oil constituents in *Hibiscus sabdariffa* Linn. [44-46]

Table 3. Pharmacological activities of different extracts of *Hibiscus sabdariffa* Linn.

<i>Hibiscus species</i>	Part and extract used	Bioactivity	Bioassay methods	Reference
<i>Hibiscus sabdariffa</i> Linn.	Ethanol extract of leaves.	Antioxidant activity	DPPH activity	Bako et al. (2009)
	Ethanol seed extract.	Antioxidant activity	Toxicity induced by chronic administration of sodium nitrate in Wistar rats	Anokwuru et al. (2011)
	Calyx in methanol, ethanol, acetone and water extract	Antioxidant activity	(DPPH) inhibition and lipid. Peroxidation inhibition	Fullerton et al., (2011)
	80% aqueous methanol of freeze-dried calyces.	Antibacterial activity (<i>Escherichia coil</i> O157:H7)	Disk diffusion method	Edema and Alaga,(2012)
	Methanoic extract of dried calyces	Antibacterial and antifungal activities	Agar well diffusion method	Al-Hashim (2012)
	Water and ethanolic extracts of dried red calyces	Antioxidant and antibacterial activities	Agar cup diffusion, ferricthiocyanate, reducing powder, chelating of ferrous ion	Yang et al. (2012)
	Water extract of crushed seeds	Antibacterial activity	Agar diffusion method	Nwaiwu et al., (2012)

5. ANTIMICROBIAL ACTIVITY

Many naturally occurring compounds found in medicinal plants, herbs, and spices have been shown to possess antimicrobial activities against many pathogens. The use of herbal products as antimicrobial agents may provide the best alternative to the wide use of synthetic antibiotics. The demand for plant based therapeutics is increasing in both developing and developed countries because of growing recognition that they are natural products, non-narcotic, and easily biodegradable, producing

minimum environmental hazards, having no adverse side effects.

5.1 Anti-bacterial, Antifungal and Anti-parasitic Actions

Extracts of *Hibiscus sabdariffa* Linn. flower calyces are reported to have an antimicrobial effect on different pathogenic and food spoilage microorganisms. Methanol extracts of *Hibiscus sabdariffa* Linn. calyces were reported to have a lower antimicrobial effect on a series of bacteria compared to ethanol and aqueous extracts, but

the methanol extract was more effective against *Streptococcus pneumonia* [51-52].

Roselle calyx shows the presence of proto-catechuic acid. Roselle calyx extract and proto-catechuic acid were both found to decrease lipid oxidation levels in ground beef tissue. Proto-catechuic acid also exhibited dose-dependent effect. The addition of Roselle calyx extract or proto-catechuic acid did not affect cooking loss, pH value, sensory attributes and content of fat, protein, and moisture of beef samples during storage at 4°C for 15 days. Roselle calyx extract and proto-catechuic acid serve as a good food preservative and may be used for muscle foods to prevent contamination from campylobacter and delay lipid oxidation [53]. An aqueous extract of dried sepals of the plant (100 ppm) was active against *Schisto somamansoni*. However, an aqueous extract of dried seeds (10 000 ppm) was inactive against trematode [54]. Hibiscus acid isolated from acetone extract of *Hibiscus sabdariffa* Linn. calyces were studied against *Salmonella* strains and *Escherchia coli* bacteria. The results showed that hibiscus acid has greater antibacterial effect than the acetone extract against all the bacterial strains tested. Hibiscus acid is a potential alternative to control multi drug resistant bacteria [55].

The antimicrobial activities of *Hibiscus sabdariffa* Linn. and *Sesbania grandiflora* were examined against *Escherichia coli*, *Staphylococcus aureus* and *Pseudomonas aeruginosa*. The study indicates that both extracts exhibited concentration dependent effects. The extract of *Hibiscus sabdariffa* Linn. showed the highest inhibition activity against all bacterial strains at 500 mg/ml concentration in comparison to *Sesbania* extract [56]. Methanol extract of *Hibiscus sabdariffa* Linn. calyces have been reported to possess antimicrobial activity against each *Staphylococcus aureus*, *Bacillus stearothermophilus*, *Serratia marcescens*, *Clostridium sporogenes*, *Escherichia coli*, *Klebsiella pneumonia* and *Pseudomonas* species at different concentrations [57,58].

Staphylococcus aureus, *Bacillus cereus*, *Proteus vulgaris*, *Escherichia coli*, *Klebsiella pneumonia* and *Pseudomonas aeruginosa* were isolated as spoilage bacteria of water melon and ethanol extract of *Hibiscus sabdariffa* showed maximum inhibition of spoilage bacteria in water melon [59]. Crude aqueous extract of *Hibiscus sabdariffa* was analyzed for antibacterial activity against Enteropathogenic *Escherichia coli*

(EPEC). The extract was able to impede pedestal induction, not only did the extract inhibited performed pedestals but it prevented pedestal induction as well, it also promoted the formation of EPEC filaments as shown by other antibiotics [60].

6. ANTIOXIDANT ACTIVITY

Roselle flower extract that has antioxidant effects contains quercetin, sianidin, β -carotene, and vitamin C, compounds having the absorption ability and easily metabolized [61]. Oxidative stress enhances making of free radicals which has a major role in the pathogenesis and development of diabetes and decreases antioxidant protections. Free radicals such as hydroxyl radicals and hydrogen peroxide are made via reduction of molecular oxygen from superoxide anions. The increase of reactive oxygen species leads to destruction of membrane lipids, cellular proteins and nucleic acids [62].

7. ANTICANCER ACTIVITY

The investigation for the anticancer potential of the *Hibiscus sabdariffa* plant began roughly in the last decade that emerged with encouraging results [63-69]. Both crude extracts and pure compounds of the plant were reported to induce chemoprevention, selective cytotoxicity, cell cycle arrest, apoptosis, autophagy and antimetastasis effects in various types of human cancer cells. *Hibiscus sabdariffa* contains a high quantity of polyphenolic compounds and at least two of them delphinidin-3-sambubioside and protocatechuic acid exhibited apoptosis in human leukaemia cells and gastric cancer cells respectively [63].

Several researchers reported the cytotoxic, antimutagenic, antimetastatic, antiproliferative, apoptotic antiangiogenic activity of *Hibiscus sabdariffa* both in human and animal cancer cells. This activity of *Hibiscus sabdariffa* is due to the presence of polyphenols in it, which attributes towards its antioxidant and anticarcinogenic activities [64-69]. The anticancer potential of *Hibiscus sabdariffa* leaves extracts (methanol, ethanol, ethyl acetate and chloroform) on hepatocellular carcinoma cell line Hep 3B was tested and methanolic extract showed a greater cytotoxic effect when compared with others [70]. Ethanol, ethyl acetate and hexane extracts of *Hibiscus sabdariffa* Linn are found to be potential natural anticancer agents against A 549 lung

cancer cell line [71]. In another study the effects of *Hibiscus sabdariffa* aqueous extract had been evaluated against cyclophosphamide (CPA) on male Wistar rats treated with monosodium glutamate. The group treated with the aqueous extract of *Hibiscus sabdariffa* revealed a 91% reduction in micronucleus frequency when compared with the positive control group and it is a potential candidate as a chemopreventive agent against carcinogenesis [72].

8. USES OF *Hibiscus sabdariffa* Linn.

The fresh calyx of *Hibiscus sabdariffa* Linn. is eaten raw in salads, is cooked and used as a flavoring agent in cakes [73]. Beverages made from *Hibiscus sabdariffa* Linn. are used as cooling herb, providing relief during hot weather by increasing the flow of blood to the skin surface and dilating the pores to cool the skin. *Hibiscus sabdariffa* Linn. flower extract 'Zobo' drink is caffeine free, having no empty calories and suitable for human consumption. *Hibiscus sabdariffa* Linn. leaves are used on sores and wounds. The ripe calyces, when boiled in water can be used to treat bilious attacks and cure ulcer and in combination with the flower can be used for tonic tea for digestive and kidney functions. The stem of the plant is also used for the production of best fiber [43].

It is widely used for preparing beverages with medicinal and culinary purposes. The traditional medicine use of this plant as diuretic, for treating gastrointestinal and liver diseases, fever, hypercholesterolemia, pyrexia, liver disorders and hypertension etc [74-75]. In-vivo pharmacological activities as antipyretic, antioxidant and anti cholesterol products were screened in rats and rabbits [10,76].

9. CONCLUSION

This review reveals that *Hibiscus sabdariffa* Linn. shows significant antimicrobial, antioxidant and anticancer properties against common human pathogens tested. Some of the bioactive constituents of this plant were isolated, purified and analyzed for possible use in making drugs. Thus this plant have great medicinal potential for bacterial infection, coronary heart disease, fungal infections, liver infection, cancer, hypertension, fever, cough and stomachic etc,. The present study shows that *Hibiscus sabdariffa* Linn. has great medicinal as well as nutritive values for human beings and animals.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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