INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

Review Article

Hibiscus Sabdariffa: The Tropical Plant with A Wealth of Health Benefit

Swayam Shinde*, Sakshi Wadhai, Deepika Prajapati, Mrunali Tade, Vartika Singh

P.D.E.A.'s Shankarrao Ursal College Of Pharmaceutical Sciences And Research Centre, Kharadi, Pune- 14

ARTICLE INFO

Published: 23 Nov. 2024
Keywords:
Hibiscus sabdariffa, Roselle, Gonguru, Lal ambadi, Anthocyanin, flavonoids, Anti-hypertensive.
DOI:
10.5281/zenodo.14209766

ABSTRACT

Hibiscus sabdariffa, commonly known as roselle, is a tropical plant widely recognized for its medicinal and nutritional properties. The plant is characterized by its fleshy calyxes, which are used to prepare a variety of beverages, teas, and extracts. Numerous studies have explored the pharmacological potential of *Hibiscus sabdariffa*, highlighting its antioxidant, anti-inflammatory, antimicrobial, and antidiabetic activities. Rich in bioactive compounds such as flavonoids, phenolic acids, and anthocyanins, the plant has garnered attention for its potential health benefits, including its ability to lower blood pressure, improve lipid profiles, and support liver health. Additionally, *Hibiscus sabdariffa* has demonstrated potential in cancer prevention and wound healing. Despite promising findings, variability in the effects observed in clinical and preclinical studies suggests the need for more rigorous trials to better understand its mechanisms of action, optimal dosage, and long-term safety. This review aims to provide a comprehensive overview of the pharmacological effects, health benefits, chemical composition, and potential therapeutic applications of *Hibiscus sabdariffa*, while also addressing gaps in current research and directions for future investigation.

INTRODUCTION

Hibiscus sabdariffa, also known as roselle, is a nutritive and medicinal herb from the Malvaceae family. It is an annual summer shrub with a deep penetrating taproot that grows upright and generally branches. Its leaves range in colour from green to red, and its enormous, short peduncled blooms have a dark centre [1]. Roselle is consumed by humans and animals as an important vegetable. Roselle young herbages are eaten fresh in a salad recipe, while the immature fruit, luscious calyces, and sensitive shoots are all chopped and added to the sauce. Its calyces, which are red, green, or dark green, are the part of the plant that is most commonly exploited [2]. *Hibiscus sabdariffa's* dried reddish-brown petals (calyces) are used to

***Corresponding Author:** Swayam Shinde
Address: *P.D.E.A.'s Shankarrao Ursal College Of Pharmaceutical Sciences And Research Centre, Kharadi, Pune- 14.*
Email : swayamshinde07@gmail.com

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

make the aqueous extract known as zobo. The plant is indigenous to Malaysia and India, where it is grown extensively in many tropical nations in both hemispheres [3]. It is a dicotyledonous plant that is widely grown in Nigeria's middle belt states, such as Plateau, Nasarawa, and Benue, as well as its southwestern states, such as Ondo and Osun [3]. Evidence has shown that Roselle contains phytochemicals such as anthraquinones, glycosides, alkaloids, tannins, polyphenols, and saponins [3]. The plant is allegedly an effective treatment for cancer, abscesses, cough, debility, dysuria, scurvy, and fever, as well as an antihypertensive, antiseptic, strict diuretic, and purgative [4]. The extract is typically sweetened to taste with sugar and occasionally flavoured with spices such as ginger hot pepper, as well as natural flavours such as pineapple juice and lime juice or artificial flavours such as strawberry vanilla, etc. The sweetness of the extract is usually determined by personal preference. It is thought of native to Asia (India to Malaysia) or Tropical Africa. The plant is widely grown in tropics like Caribbean, Central America, India, Africa, Brazil, Australia, Hawaii, Florida and Philippines as a home garden crop. In Sudan, it is a major crop of export especially in western part where it occupies second place area wise after pearl millet followed by Sesamum [5]. In addition to Roselle, in English speaking regions it is called as Rozelle, Sorrel, Red sorrel, Jamaica sorrel, Indian sorrel, Guinea sorrel, Sour-sour, Queensland jelly plant, Jelly okra, Lemon bush and Florida cranberry. In North Africa and the Near East, Roselle is called karkade or carcade and it is known by these names in the pharmaceutical and food-flavouring trades in Europe [6]. In Indian languages it is called as Gonguru, Lalambari, Patwa (Hindi), Lal-mista, Chukar (Bengali), Lal-ambadi (Marathi), Yerra gogu (Telugu), Pulichchai kerai (Tamil), Pulachakiri, Pundibija (Kannada), Polechi, Pulichchai (Malayalam) and Chukiar (Assam) [5].

Hibiscus has more than 300 species which are distributed in tropical and subtropical regions around the world. Most hibiscus species are used as ornamental plants, but many are believed to have certain medicinal properties; among them is *Hibiscus sabdariffa* commonly named as “red sorrel” and “roselle” [7]. The species *H. sabdariffa* comprises a large number of cultivated types which, on the basis of their growth habit or end use, are classified broadly under two varieties, *H. sabdariffa* var. sabdariffa and *H. sabdariffa* var. altissima Wester. Former is generally bushy and pigmented and cultivated for the edible calyces; the latter includes tall growing, unbranched types bearing inedible calyces and mainly cultivated for the stem fibre, roselle [24]. Sorrel is cultivated in various parts of Punjab, Uttar Pradesh, Andhra Pradesh, Assam, Bihar, Madhya Pradesh, Maharashtra, Orissa and West Bengal during April to November. The propagation is done by seeds or by rooting shoot cuttings. The edible fleshy calyces are collected after 15-20 days of flowering. Rest of the crop is left in the field until seeds are ready for threshing. The calyces can be dried and stored in air-tight containers [24].

Origin

Roselle may have been domesticated in western Sudan before 4000 BC;[7] it was first recorded in Europe in AD 1576. It seems to have been carried from Africa to the New World by slaves for use as a food plant. Roselle was called Jamaican sorrel in 1707 in Jamaica, where the regular use of the calyces as food seems to have been first practiced

[8]. The use of the plant as "greens" was known in Java as early as 1658 [8]. Taken to the New World, roselle was cultivated in Mexico, parts of Central America, the West Indies, and in southern Florida, Texas and California in the late 19th century. It is now grown for culinary purposes in much of the tropical world. The use of *H. sabdariffa* for fibre seems to have developed in regions other than Africa [7]. Most breeding of roselle has been for its fibre yield [9]. Sudan is presently the major producer of roselle; however, farmers regard it as a famine food. When drought is expected, farmers prefer to cultivate roselle rather than cereals because of its hardiness under adverse conditions [10]. Roselle is grown for its calyces, which are exported from the Sudan, China and Thailand, and it is also grown for its calyces in Mexico. In the Sudan it is collected by goat-herding nomadic tribes, but the product is frequently inferior because of poor processing conditions. Nevertheless, the Sudanese product is attractively bright red, very acidic, and it is extremely popular in Germany, which imports most of the crop. Export prices for the 1992–93 season for Sudanese, Chinese and Thai roselle was of the order of $US1700.00/t [11].

Climate

Roselle plant requires 130 – 250 nm month rainfall in the 1st three to four months of growth; for the desired growth of plant dry weather is well deserved or well tolerated. The quantity and yield of Roselle calyces can be downgraded by the rain or high humidity at the time of harvesting and drying [13]. It grows in kharif season and cannot withstand waterlogging. It required rich loamy soil it may grow in a variety of soils, including new and old alluvium & lateritic loam. The acid soils are not suitable without proper amendment. The Sabdariffa develop chlorosis with high pH of the soil [14].

Planting

Rosella plant is very sensitive to the length changes of the day. Rather than the rainfall requirement the plant requires the planting time to be set according to the length of the day. Deep ploughing is recommended for preparing the seedbed because it is a deep-rooted crop. The seeds required for planting 1-hectare land is about 6 - 8 kg/ hectares, and sowing is about 2.5 cm deep. The seed are generally planted at the beginning of the rainy season. 60 cm-1 1m distance between rows and 45 – 60 cm apart is the criteria for planting. The larger calyx is produced if the planting rate is less. The sowing is done by hand or by using a grain drill machine. Also, the corn planter is also used for sowing the Roselle seed as an alternative tool. Thinning of the plant should done by hand (manpower). There are over 100 cultivars or seed varieties of *H. Sabdariffa*; the wide commercial varieties are growing in China, Mexico, Thailand, and Africa.[15]

Pest Control And Weeds

Major diseases of hibiscus are stem rot and root rot. Prevention techniques include monitoring the water content in an irrigated field, and avoiding the planting of other crops that are also prone to these diseases. Insect damage is minor, but it does exist; pests include stem borer, flea beetles, abutilon moth, cotton bollworm and cutworm. Mealy bugs and leafhoppers are minor concerns, as is the cotton stainer. Plant enemies usually do not compete in a cultivated field [16]. Weeding can increase yield and calyx size. Roselle fields are generally weeded if necessary, and there are many weed's species observed in Sudan.

Harvest And Storage

H. sabdariffa is generally harvested in the period of late November onwards; the harvest is decided according to the ripeness of the seed. The fleshy calyces are harvested after the flower is dropped but before the seed pod has dried and opened. The disease and sun cracking are more susceptible to calyx if the capsule remains for longer time on the

plant after the seed begins to ripen. The calyces ripen about three weeks after flowering, which is 100 – 160 days after the plants are transplanted outdoors. The fruit ripens from the bottom to the top of the calyces. Harvesting is carried out by using manpower, i.e., by intensive hand labour the calyces being picked singly at the appropriate stage [15]. The fruit may be harvested when fully grown but still tender when they can be easily snapped off by hand later harvesting requires clippers. In the morning, the fruit is easy to break up than in the evening or end of the day. Each fruit yields about 7–10 gm of sepals. For the prevention or preservation the food, drying is a traditional method. The two ways the Roselle drying should be done are by harvesting the fresh fruit and sun drying the calyces or leaving the fruit to partially dry on the plant and harvesting the dried fruit, keeping the crop well protected during the process. Dehydration should be done depending on the two fundamental processes of heat transfer and mass transfer also, the fruit, fleshy calyces, is peeled off and then dried it under shade [13].

Botanical Description

The genus Hibiscus (Malvaceae) includes more than 300 species of annual or perennial herbs, shrubs or trees [17]. Hs (syn.: *Abelmoschus cruentus* (Bertol.) *Walp*., *Furcaria sabdariffa Ulbr*., *Hibiscus cruentus Bertol*., *Hibiscus fraternus L*., *Hibiscus palmatilobus Baill*. and *Sabdariffa rubra Kostel* [18] is commonly known as roselle, hibiscus, Jamaica sorrel or red sorrel (English) and in Arabic, karkadeh [19]. Its native distribution is uncertain, some believe that is from India or Saudi Arabia [20], while Murdock [21] showed evidence that Hs was domesticated by the black populations of western Sudan (Africa) sometime before 4000 BC. Nowadays, it is widely cultivated in both tropical and subtropical regions [22] including India, Saudi Arabia, China, Malaysia, Indonesia, The Philippines, Vietnam, Sudan, Egypt, Nigeria and México [23].

Kingdom	Plantae
Division	Tracheophyta
Class	Magnoliopsida
Order	Malvales
Family	Malvaceae
Genus	*Hibiscus L*
Species	*Hibiscus sabdariffa L 4*

Morphology

Hs var. sabdariffa ruber is an annual, erect, bushy, herbaceous subshrub that can grow up to 8 ft (2.4 m) tall, with smooth or nearly smooth, cylindrical, typically red stems. The leaves are alternate, 3 to 5 in (7.5–12.5 cm) long, green with reddish veins and long or short petioles. The leaves of young seedlings and upper leaves of older plants are simple; lower leaves are deeply 3 to 5 or even 7 lobed; the margins are toothed. Flowers, borne singly in the leaf axils, are up to 5 in (12.5 cm) wide, yellow or buff with a rose or maroon eye, and turn pink as they wither at the end of the day. At this time, the typically red calyx, consisting of 5 large sepals with a collar (epicalyx) of 8 to 12 slim, pointed bracts (or bracteoles) around the base, begins to enlarge, becomes fleshy, crisp but juicy, 1 1/4 to 2 1/4 I. Da-Costa-Rocha et al. / Food Chemistry 165 (2014) 424–443 425 in (3.2–5.7 cm) long and fully encloses the velvety capsule, 1/2 to 3/ 4 in (1.25–2 cm) long, which is green when immature, 5-valved, with each valve containing 3 to 4 kidney-shaped, light-brown seeds, 1/8 to 3/16 in (3–5 mm) long and minutely downy. The capsule turns brown and splits open when mature and dry. The calyx, stems and leaves are acid and closely resemble the cranberry (*Vaccinium spp.)* in flavour [22].

Ecology

Hs is easy to grow in most well drained soils but can tolerate poor soils. It requires 4-8 months growth with night-time temperatures with a minimum of 20 C, as well as 13 h of sunlight and a monthly rainfall ranging from 5–1000 (130–250 mm) during the first few months to prevent

premature flowering. Rain or high humidity during the harvest time and drying process can downgrade the quality of the calyces and reduce the yield. The quality of Hs is determined by seed stock, local growing conditions, time of harvest, post-harvest handling and mainly the drying step. Most of the time it grows as a supplement crop and it is susceptible to fungi, viral and bacterial attack and also to insects. A single plant produces about 1.5 kg of fruit, approximately 8 t/ha. Yields of leaves may be about 10 t/ha [25].

Karyotype

2n = 36 [26] and 72 [27] were observed. Somatic tissue showing diploid and tetraploid segments were also occasionally noticed [28]. In a karyomorphological study conducted in India, both root and flower segments showed great similarity in the types of chromosomes in the complement. This indicates that the tetraploid tissue must have arisen in an autotetraploid manner [29]. Later, this species was reported to be tetraploid (2n = 72) [30].

Uses

1. Traditional culinary use:

Fresh or dried calyces of *H. sabdariffa* are used in the preparation of herbal drinks, hot and cold beverages, fermented drinks, wine, jam, jellied confectionaries, ice cream, chocolates, flavouring agents, puddings and cakes [32]. In Egypt, the fleshy calyces are used in making ‘‘cacody tea’’ and fermented drinks [31], while in Sudan and Nigeria, the calyces are boiled with sugar to produce a drink known as ‘‘Karkade’’ or ‘‘Zoborodo’’ [33]. In Mexico this drink is called Jamaica or ‘‘agua de Jamaica’’’ or ‘‘té de Jamaica’’. In the West Indies the calyces can also be used as colouring and flavouring ingredient in rum [20]. The seeds are eaten roasted or ground in meals, while the leaves and shoots are eaten raw or cooked, or as a sour-flavoured vegetable or condiment [34]. In Sudan, the leaves are eaten green or dried, cooked with onions and groundnuts, while in Malaysia the cooked leaves are eaten as vegetables [20]. In Africa, the seeds are roasted or ground into powder and used in meals, such as oily soups and sauces. In China and West Africa, the seeds are also used for their oil [35]. Another use for the seed is as a substitute for coffee [22].

2. Use in local and traditional food and medicine:

Hs has been widely used in local medicines. In India, Africa and Mexico, infusions of the leaves or calyces are traditionally used for their diuretic, cholerectic, febrifugal and hypotensive effects, decreasing the viscosity of the blood and stimulating intestinal peristalsis. It is also recommended as a hypotensive in Senegal [22]. In Egypt, preparations from the calyces have been used to treat cardiac and nerve diseases and also to increase the production of urine (diuresis). In Egypt and Sudan, an infusion of ‘‘Karkade’’ calyces is also used to help lower body temperature [36]. In Guatemala it is used for treating drunkenness [22]. In North Africa, calyces preparations are used to treat sore throats and coughs, as well as genital problems, while the emollient leaf pulp is used for treating external wounds and abscesses [37]. In India, a decoction from the seeds is used to relieve pain in urination and indigestion. In Brazil, the roots are believed to have stomachic and emollient properties. In Chinese folk medicine, it is used to treat liver disorders and high blood pressure [22]. In Iran, sour hibiscus tea is reportedly a traditional treatment for hypertension [38], while in Nigeria the decoction of the seeds is traditionally used to enhance or induce lactation in cases of poor milk production, poor letdown and maternal mortality [39].

3. Medicinal and Industrial Application:

The Roselle plants have many medicinal applications developed worldwide. In China, it is used to treat hypertension, pyrexia, liver damage and Ayurvedic medicine. Recently for the effective treatment of leukaemia the sepals extract

has been used due to its high content in polyphenols, particularly protocatechuic acid. Roselle seed, which has no commercial application, is a source of vegetable oil that is low in cholesterol and rich in other phytosterols and tocopherol, particularly β-sitosterol and γ-tocopherol. The overall characteristics of Roselle seed oil allow for important industrial application and represent added value for its cultivation. *H. sabdariffa* has certain therapeutic properties i.e., reported benefit of taking it internally in the form of herbal tea. Include soothing cold, clearing a block nose, clearing mucous, as an astringent, promoting kidney function, aiding digestion as general tonic, as diuretic and helping to reduce fever, taken as a drink made from the calyx, it is a mild diuretic and purgative, among the many other effects. The drink is said to be a folk remedy for cancer. Restored Roselle drink has no bacterial isolation [44].

4. Source of fibre:

Hs is one of the most important species grown commercially as a fibre plant and became increasingly important in India after independence and partition with Pakistan, where the most important jute (*Corchorus capsularis L. or Corchorus olitorius L.*) growing areas are. It is used as a jute substitute in making clothing, linen, fishing nets, ropes and similar items [40]. Despite the fact that this species is slow growing, as it requires about 180 days to produce a satisfactory yield of fibre, there is still interest in the plant as some varieties of Hs (not edible but fibre type) have a high degree of genetic resistance to root-knot nematodes. The main disadvantages of growing Hs in comparison with other Hibiscus species is:

(1) The slow growth rate which increases costs in weed control and land occupation by the crop.

(2) The difficulty of separating the ribboning stalks from the bark when compared to, for example, *H. cannabinus* [34].

While the world's production of Kenaf fibres (*H. cannabinus*) has reached 272,000 tons in 2008, Hs fibres have not gained the same economic importance. However, Hs fibres are subject to ongoing research showing promising technical properties when used as a substitute for synthetic or mineral fibres in composite materials, as well as a source material for high quality paper production [41].

5. Animal feed:

The leaves are used for animal fodder and fibre [42]. The seeds can be used to feed poultry as well as sheep and the residue from the seeds oil extraction can also be used to feed cattle and chicks.

6. Cosmetic:

In Malaysia the oil is used to produce scrubs and soaps [20].

7. The current importance of *H. sabdariffa*:

Besides its importance as a food or traditional medicine in the countries of its geographic origin, hibiscus flower is traded and used worldwide today as an important ingredient in industrially produced teas and beverages. The United States and Germany are the primary markets for dried cHs. England satisfies most of its consumers demands by importing herbal teas form Germany [42]. Statistics for the volume and value of dried hibiscus imported into these markets were not available, but the major clients for hibiscus importers are herbal teas manufactures, as this plant is used as base in many herbal/fruit teas, along with apple peel, orange peel and lemon twist. [43].

Rosella Tea

Hibiscus Tea:

Hibiscus tea is an herbal tea free from caffeine from a special type of Hibiscus called *Hibiscus sabdariffa*. Specifically, the tea is made out of dried fruit part of Roselle called calyx. It is red in colour and taste like berries. It is also commonly sold in domestic market's [44].

Steps of Preparation of Hibiscus Tea:

First, collect the hibiscus fruits and wash them clean and air dry or dry them in an oven at 70 degrees C for 3days. Peel off the calyx and store them in air-tight containers. To make tea, simply take 2grams of the dried calyx, and crush them into small pieces using a wooden roller. Put them in a teabag or a net, bring out your favourite mug, add 8 oz. of boiling water, steep it for 2-4 min, add sugar if desired, or add other flavours of your choice few drops of lemon juice. You can also refrigerate it and make Hibiscus iced tea [13].

Phytochemistry

The leaf is reported to contain protein, fat, carbohydrate, fibre, ash, calcium, phosphorus, iron, thiamine, β-carotene, riboflavin, niacin and ascorbic acid [45-46]. The flower yields a yellow dye; the major pigment identified is daphniphylline. The plant contains flavonoids such as hibiscitrin and hibiscetin1 and dried calyces contain the flavonoids gossypetine, hibiscetine and sabdaretine. It also contains alkaloids, β-sitosterol, anthocyanin, citric acid, cyanidin-3-rutinose, delphinidin, galactose, pectin, protocatechuic acid, quercetin, stearic acid and wax [47]. Small amounts of delphinidin 3-monoglucoside, cyanidin 3-monoglucoside (chrysanthenin) and delphinidin are also present 3. Three water soluble polysaccharides have been isolated from flower buds; neutral polysaccarides composed of arabinans and arabinogalactans [48].

The calyces are rich in acid and pectin. Analysis of calyces has shown the presence of crude protein and minerals such as iron, phosphorus, calcium, manganese, aluminium, magnesium, sodium and potassium. Mucilage, calcium citrate, ascorbic acid, gossypetin and hibiscin chlorideare also present in calyces [24]. The seeds contain protein (18.8-22.3%), fat (19.1-22.8%) and dietary fibre (39.5-42.6%) content were found to be high. The seeds were found to be a good source of minerals like phosphorus, magnesium, calcium, lysine and tryptophan contents. Seed oil is rich in unsaturated fatty acids (70%), of which linoleic acid constituted 44%. Seeds contain nitrogen, fatty oil, cellulose, pentosans and starch [49]. Steroids and tocopherols have been reported in the seed oil [49-50]. Kaempferol-3-O-rutinoside, kaempferol-3-O-glucopyranoside, quercetin, 3-O-rutinoside, citrusin C, 2,3- dihydro-2-(4'-hydroxy-3'-methoxyphenyl)- 3-β-D-glucopyranosylmethyl-7-hydroxy-5- benzofuranpropanol, corchoionoside C and trans-carveol-6-O-β-glucopyranoside were isolated from 70% aqueous ethanol extract of leaves [51]. The physicochemical analysis of the fresh calyces and leaves are given in Table 1 and phytochemicals present in the various parts of the plant are presented in Table 2.

TABLE 1: - Physicochemical constituents of the fresh calyces and leaves of *H. sabdariffa*

Constituents	Calyces (fresh)	Leaves (fresh)
Moisture	9.2g	86.2%
Protein	1.145g	1.7-3.2%
Fat	2.61g	1.1%
Fivre	12.0g	10%
Ash	6.90g	1%
Calcium	12.63mg	0.18%
Phosphorus	273.2mg	0.04%
Iron	8.98mg	0.0054%
Carotene	0.029mg	-
Thiamine	0.117mg	-
Riboflavin	0.277mg	-
Niacin	3.765mg	-
Ascorbic Acid	6.7mg	-

g and mg/100g

Table 2: - Phytochemicals Of *H. Sabdariffa*

Part of the plant	Chemical constituents
Flower	Carbohydrates, arabinans, mannose, sucrose, thiamin, xylose, mucilage, niacin, pectin, proteins, fat, arabinogalactans, rhamnogalacturans, riboflavin, B-carotene, phytosterols, citric acid, ascorbic acid, fruit acids, maleic acid, malic acid, hibiscic acid, oxalic acid, tartaric acid, (+)-allooxycitronic acid-lactone, allohydroxycitric-acid, glycolic acid, utalonic acid, protocatechuic acid, cyanidin-3-glucoside, cyanidin-3-sambubioside, cyanidin-3-xyloglucoside, delphinidin, delphinidin-3-glucoside, delphinidin-3-sambubioside, delphinidin-3-xyloglucoside, delphinin, gossypetin, gossypetin-3-glucoside, hibiscetin, hibiscin, hibiscitrin, sabdaretin, sabdaritrin, fibre (crude), resin, fibre (dietery), minerals and ash.
Seed	Starch, cholesterol, cellulose, carbohydrates, campesterol, ß-sitosterol, ergosterol, propionic acid, pentosans, pelargonic acid, palmitoleic acid, palmitic acid, oleic acid, myristic acid, methanol, malvalic acid, linoleic acid, sterculic acid, caprylic acid, formic acid, stearic acid, cis-12,13-epoxy-cis-9- octadecenoic acid, isopropyl alcohol, isoamyl alcohol, ethanol, 3-methyl-1- butanol, fibre and minerals.
Leaf	o-Terpinyl acetate, anisaldehyde, B-carotene, B-sitosterol, B-D-galactoside, B-sitosteryl benzoate, niacin, fat, isoamyl alcohol, iso-propyl alcohol, methanol, 3-methyl-1-butanol, benzyl alcohol, ethanol, malic acid, fibre and ash.
Fruit	a-Terpinyl acetate, pectin, anisaldehyde, ascorbic acid, calcium oxalate, caprylic acid, citric acid, acetic acid, ethanol, formic acid, pelargonic acid, propionic acid, isopropyl alcohol, methanol, benzyl alcohol, 3-methyl-1- butanol, benzaldehyde and minerals.
Root	Tartaric acid and saponin.

Bioactive Constituent

The main constituents of *H. sabdariffa* relevant in the context of its pharmacological are organic acids, anthocyanins, polysaccharides and flavonoids [52].

1.Organic acids:

Hs extracts contain a high percentage of organic acids, including citric acid, hydroxycitric acid, hibiscus acid, malic and tartaric acids as major compounds, and oxalic and ascorbic acid as minor compounds. Based on previous studies, the percentage of organic acids in ‘‘hibisci flos’’ varies; hibiscus acid accounts for 13–24%, citric acid 12–20%, malic acid 2–9%, tartaric acid 8% and 0.02– 0.05% of ascorbic acid (vitamin C) [52]. In the late 1930s, citric and malic acids were first reported in aqueous extracts of the calyx [53] and also in five different strains (from Egypt, Senegal, India, Thailand and Central America) of *Hs var. sabdariffa* [54]. Ascorbic acid is also present in cHs but its content varies dramatically between fresh (6.7–14 mg/100 g) [20-22] and dried calyces (260–280 mg/100 g) [20]. The amount of ascorbic acid in the latter report being much higher than the ones previously reported in the literature. The differences observed might be due to different varieties, genetics, environment, ecology and harvest conditions.

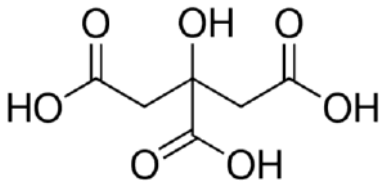

Fig 1. Citric acid

2. Anthocyanins:

The anthocyanins are a group of flavonoid derivatives and natural pigments present in the dried flowers of Hs and their colour varies with pH. Delphinidin and cyanidin-based anthocynins, include delphinidin-3-sambubioside (hibiscin), cyanidin-3-sambubioside (gossypicyanin), cyanidin-3,5-diglucoside, delphinidin (anthocyanidin) and others [55]. The first anthocyanin from the calyx of Hs to be isolated was ‘‘hiviscin’’, also known as ‘‘hibiscin’’, later

named delphinidin-3- sambubioside and assigned the structure of cyanidin-3-glucoside [56], which was later renamed as delphinidin-pentoside-glucoside [56]. From the pigments of cHs, three different anthocyanins were isolated: delphinidin-3-sambubioside (hibiscin), delphinidin-3-glucoside and cyanidin-3-glucoside (chrysanthenin) (Fig. 2) using material from Taiwan and Trinidad [57]. The last study also identified cyanidin-3-sambubioside (gossypicyanin) (Fig. 2). Later, the presence of cyanidin-3, 5-diglucoside and cyanidin-3-(2G-glucosylrutinoside) in the flower pigments of Hs var. altissima [58] was reported. A study conducted with 5 different strains of Hs var. sabdariffa reported cyanidin-3-sambubioside and cyanidin-3-glucoside as the major compounds present in this plant [54]. In one of the strains (Senegalese strain), delphinidin glycosides were absent. In this study, the anthocyanin content reached 1.7% to 2.5% of the dry weight in all strains. A similar anthocyanin content was observed in another study where their amount was about 1.5 g per 100 g of dry weight of cHs, in terms of delphinidin-3-sambubioside [57]. Several studies have identified delphinidin-3-sambubioside (delphinidin-3-O-(2-O-b-D-xylopyranosyl)-b-D-glucopyranoise) and cyanidin-3-sambubioside (cyanidin-3-O-(2-O-b-D-xylopyranosyl)- b-D-glucopyranoside) as the major anthocyanins present in extracts from cHs [59].

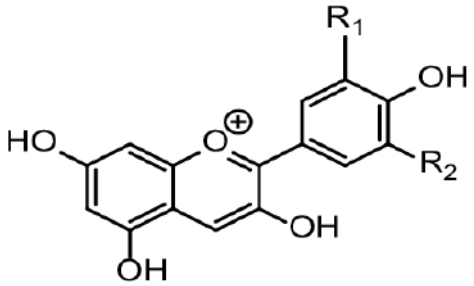

Fig 2. Basic structure of Anthocyanins

3. Flavonoids:

Hs contain polyphenols of the flavonol and flavanol type in simple or polymerised form. The following flavonoids have been described in Hs extracts: hibiscitrin (hibiscetin-3-glucoside), sabdaritrin, gossypitrin, gossytrin and other gossypetin glucosides, quercetin and luteolin [60]; as well as chlorogenic acid, protocatechuic acid, pelargonidic acid, eugenol, quercetin, luteolin and the sterols b-sitosterol and ergosterol [60]. Earlier the flowers of Hs were recorded to contain 3-monoglucoside of hibiscetin (hibiscitrin) [61], 7-glucoside of gossypetin (gossypitrin) and sabdaritrin, which on acid hydrolysis yielded an hydroxyflavone named sabdaretin [61]. The presence of these flavonol glycosides was low, with hibiscitrin being the major compound followed by gossypitrin and sabdaritrin [61]. In 1961, gossypetin-3-glucoside (gossytrin) was isolated [62]. The petals of Hs var. altissima also contain gossypetin-8-glucoside (0.4%) and gossypetin-7-glucoside [58].

From the leaves of Hs, b-sitosteryl-b-D-galactoside [63] and from the seeds ergosterol were reported. b-sitosterol and ergosterol were also reported in Hs extracts [60].

The methanolic extract of the flowers also contains quercetin, luteolin and its glycoside. Quercetin had already been identified in Hs. One study reported that the amount of quercetin present in cHs WE was 3.2 mg/g while rutin was 2.1 mg/g. Quercetin and its conjugated glycosides (quercetin-3-glucoside), as well as, rutin (quercetin-3-rutinoside were frequently identified in cHs WE, alongside with kaempferol [64]. The water extract of the dried leaves showed the presence of catechin (4.25%) and ellagic acid (28.20%), while cHs WE showed the presence of protocatechuic acid (24.24%), catechin (2.67%), gallocatechin (2.44%), caffeic acid (19.85%), gallocatechin gallate (27.98%) . Similar results were reported by Huang and co-workers. Phenolic acid: Protocatechuic acid (PCA) is an important phenolic acid present in Hs extract [60].

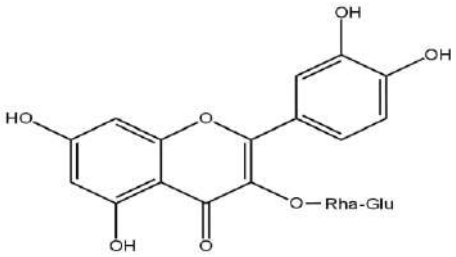

Fig 3. Quercetin-3-rutinoside.

4.Mucilage, pectin and carbohydrates (polysaccharides):

Polysaccharides are another key group of compounds present in large quantities in the cHs WE. In one study, the ethanol precipitated water extract yielded 10% of reddish polysaccharides. The following compounds were identified in two different fractions, arabinose, galactose, glucose, rhamnose and smaller amounts of galacturonic acid, glucuronic acid, manose and xylose [48]. Similar results were obtained in two other studies [48]. The mucilage content was determined in the calyces of five strains of *Hs var. sabdariffa*, reaching 24–28% in strains from Central America and Egypt but only 15% in an Indian strain. This amount was only reached at a later stage of development in the strains from Senegal and Thailand. The pectin content only accounted for 2–4% while the sugars reached a maximum of 3–5% in these five strains. Mucilage and pectin consisted of 60–80% anhydrouronic acid [54]. The petals of Hs yielded 65% of dry weight of mucilage, which on hydrolysis produced galactose, galacturonic acid and rhamnose, while the leaves only yield 10%.

Pharmacological Properties

1. Antihypertensive:

Aqueous extract of petals exhibited antihypertensive and cardioprotective effects in rats. Infusion is also significantly lower both systolic and diastolic pressure in spontaneously hypertensive and normotensive rats. Tea of calyces showed an 11.2% reduction in systolic blood pressure and 10.7% decrease in diastolic pressure. The effectiveness and tolerability of a standardized extract were studied in patients with mild to moderate hypertension, which revealed a reduction in systolic and diastolic blood pressure by more than 10 percent. The aqueous extracts of the calyx showed a dose dependent decrease in the mean arterial pressure of the rats. The extract has a vasodilator effect in the isolated aortic rings of hypertensive rats. These effects are probably mediated through the endothelium-derived nitric oxide-cGMP-relaxant pathway and inhibition of calcium influx into vascular smooth muscle cells. Daily consumption of tea lowers blood pressure in pre and mildly hypertensive adults. It may prove an effective component of the dietary changes recommended for people at risk of developing hypertension [65].

2. Anti-obesity Activity:

Pre-clinical data from Brazil indicates a potential role in the control of certain conditions associated with obesity, such as hyperlipidaemia. However, further studies were suggested A report showed that a standardized (33.64 mg of total anthocyanins per each 120 mg) water extract of calyces of *H. sabdariffa* could reduce weight gain in obese mice while at the same time it increases the liquid intake in healthy and obese mice. This effect is probably achieved through the modulation ofPI3-K/Akt and ERK pathway, which play pivotal roles during adipogenesis. In-vitro and in-vivo studies showed that Hibiscus extract (or tea) inhibited amylase activity, blocking sugars and starch absorption, which may assist in weight loss. A study conducted in Mexico using an ethanol extract of *H. sabdariffa* concluded the extract could be considered as a possible anti-obesity agent due to its effects on fat absorption-excretion and body weight of rats. The therapeutic use of the extract, possibly due to polyphenols, was also evaluated in patients with metabolic syndrome, an obesity-associated collection of disorders. Meanwhile, a study showed that the aqueous extract was more efficient in inhibiting triglyceride accumulation

when devoid of fibre and polysaccharides. Still, when polyphenols were fractionated and isolated, the benefits of the whole extract was greater than the sum of its parts [15].

3. Effects on smooth muscles:

Early studies showed that the alcoholic extract of Hs flowers had an antispasmodic effect by relaxing the uterus and intestine stips in vitro [66]. This was also observed in rabbit aortic smooth muscle [67]. Interestingly, from various isolated muscle preparations, the extract of Hs inhibited the tone of rabbit aortic strip, rhythmically contracting rat uterus, guinea-pig tracheal chain and rat diaphragms, but it stimulated the tone of isolated quiescent rat uterus and frog rectus abdominis [68]. More recently, the Hs WE (1–100 mg/kg) was found to inhibit rat bladder and uterine contractibility in a dose dependent manner, but via a mechanism unrelated to local or remote autonomic receptors or calcium channels [69]as previously suggested by Salah. Later, it was shown that Hs crude extracts mainly induced the endothelium-dependent relaxant effect in the isolated thoracic aorta of rats, via stimulation of NOS enzyme by the Pi3-K/Akt pathway. It was suggested that this was due to polyphenols. The non endothelium dependent relaxation is a direct smooth muscle activation and results in the activation of smooth muscle potassium channels [70].

4. Anticancer Effect:

In-vitro studies have shown that Hibiscus sabdariffa extracts can induce apoptosis in cancer cells. Hibiscus polyphenol-rich extracts (HPE) induce cell death in human gastric carcinoma (AGS) in a concentration-dependent manner; this effect of HPE on AGS cells was mediated via p53 signalling and p38 MAPK/Fas L cascade pathway. Also, Hibiscus anthocyanin extract (a group of natural pigments existing in the dried calyx of *Hibiscus sabdariffa L*.) caused cancer cell apoptosis, in HL-60 cells, similarly, Delphinidin 3-Sambubioside (Dp3-Sam), isolated from the dried calices of *Hibiscus sabdariffa L*. induce apoptosis in human leukaemia cells (HL-60). Anticlastogenic effects of *Hibiscus sabdariffa* extract has been demonstrated against sodium arsenite-induced micronuclei formation in Erythrocytesin mouse bone marrow. Various studies on Hibiscus protocatechuic acid have demonstrated its ability to inhibit the carcinogenic action of various chemicals in different tissues of the rat, including diethyl nitrosamine in the liver, 4-nitroquinoline-1-oxide in the oral cavity, azoxymethane in the colon, N-methyl-N-nitrosourea in glandular stomach tissue and N butyl-N-(4-hydroxybutyl) nitrosamine in the bladder. also demonstrated that Hibiscus protocatechuic acid inhibits the survival of human promyelocytic HL-60 cells in a concentration- and time-dependent manner. Suggest that the compound is an apoptosis inducer in human leukaemia cells and that RB phosphorylation and Bcl-2 protein may play a crucial role in the early stage [71].

5. Antioxidant and Hepatoprotective properties:

Hibiscus anthocyanins (HAs), a class of naturally occurring pigments found in the dried calyx, showed antioxidant activity and liver protection according to the research [72]. Hepatotoxicity and HA antioxidant bioactivity were investigated in rat primary hepatocytes [72]. The findings showed that HAs, at concentrations of 0.10 and 0.20 mg/ml, significantly reduced the leakage of lactate dehydrogenase and the production of malondialdehyde, and significantly decreased the serum levels of hepatic enzyme markers (alanine and aspartate aminotransferase), which in turn reduced oxidative liver damage. The liver's histological analysis showed that roselle pigments decreased the frequency of liver lesions in rats, including necrosis brought on by tert-butyl hydroperoxide (t-BHP) and inflammatory

leucocyte infiltration. In malignant cell lines, an antioxidative activity was also identified [73]. Regardless of age, gender, or dietary supplement use, extracts of its calyces have shown hypo cholesterolemic and antihypertensive effects in animal models [74]. Evidence of potential use as a medication for treating liver diseases in aquaculture was presented by the study of [75] on the hepatoprotective and antioxidant effects on the carbon tetrachloride (CCl4)-induced hepatocyte damage in fish. Roselle extract significantly increased levels of lactate dehydrogenase (LDH), glutamate oxalate transaminase (GOT), glutamate pyruvate transaminase (GSH- Px) [75].

6. Nephroprotective activity:

Two studies were reported on the nephroprotective activity of Hs extracts on diabetic nephropathy in streptozotocin-induced type 1 diabetic rats [76]. Nephropathy may progress to end-stage renal disease. A study was conducted to investigate the effect of the polyphenol extract of Hs (100 and 200 mg/kg/day) in streptozotocin-induced diabetic nephropathy in rats. The extract revealed beneficial effects as the kidney mass was reduced and the hydropic change of renal proximal convoluted tubules was improved, it reduced serum triglyceride, total cholesterol and LDL as well as increased the activity of catalase and glutathione and reduced lipid peroxidation in the kidney [76]. It was found that the extracts reduced kidney mass and improved hydropic change of renal proximal convoluted tubules in this rat model. The positive effect shown by the extracts might be via improving oxidative status and regulating Akt/Bad/ 14-3-3c signalling (anti-apoptotic mechanisms). Another in vivo study also revealed that its nephroprotective effect is a result of the protection of the kidney from the oxidative stressed.

7. Anti-diabetic activity:

Diabetes mellitus can be defined as an endocrine and metabolic disorder characterised by chronic hyperglycaemia, dyslipidemia, and protein metabolism that results from defects in both regulations of insulin secretion and/or insulin action. The protective effect of a polyphenol extract of Hs was studied in a type II diabetic rat model (high fat diet model). At a dose of 200 mg/kg, the extract demonstrated anti-insulin resistance properties as it reduced hyperglycaemia and hyperinsulinemia. It decreased serum triacylglycerol, cholesterol and the ratio of low-density lipoprotein/high-density protein (LDL/HDL), as well as reduced the plasma advanced glycation end products (AGE) formation and lipid peroxidation [77]. The currently accepted therapeutic strategy for the control of postprandial hyperglycaemia is based on the inhibition of a-glucosidase and a-amylase. This results in an aggressive delay of carbohydrate digestion to absorbable monosaccharide. With this in mind, a study was conducted to determine the effect of Hs extract on intestinal a-glucosidase and pancreatic a-amylase activity in vitro. As a result, Hs extract was shown to be a potent pancreatic a-amylase inhibitor. Similar results were found for hibiscus acid (hibiscus-type (2S,3R)-hydroxycitric acid lactone) which inhibited pancreatic a-amylase and intestinal a-glucosidase enzyme [78].

8. Antimicrobial properties:

Roselle is frequently used to treat illnesses. In order to explore the phytochemical components, antibacterial activity, and cytotoxicity of roselle, [79] utilised an aqueous-methanolic extract of the plant. He found that the extract contains cardiac glycosides, flavonoids, saponins, and alkaloids. *Staphylococcus aureus, Bacillus stearothermophilus, Micrococcus luteus, Serratia mascences, Clostridium sporogenes, Escherichia coli, Klebsiella pneumoniae, Bacillus cereus, and Pseudomonas fluorescence* were among the microorganisms it showed antibacterial activity against. While the antimicrobial activity on *Escherichia coli* O157:H7, *Salmonella enterica,*

and Listeria monocytogenes isolates from food, veterinary, and clinical samples [80] indicated that roselle extract was effective and suggested that it might be possible to isolate antibacterial and anticancer agents, the results support the use of this plant in the treatment of diseases like abscesses, bilious conditions, cancer, and coughs in traditional medicine. Protocatechuic acid and roselle calyx extracts were tested for their antibacterial properties against the food spoilage bacteria Salmonella Typhimurium DT104, Escherichia coli O157:H7, Listeria monocytogenes, Staphylococcus aureus, and Bacillus cereus. The results showed inhibitory activity in a dose- dependent manner against the test bacteria in ground beef and apple juice, and it was suggested that these substances might be effective food additives [72].

9. Other activities:

Delphinidin 3-sambubioside, a anthocyanin isolated from the dried calyces of *H. sabdariffa* can induce a dose-dependent apoptosis in human leukemia cells (HL-60) as characterized by cell morphology, DNA fragmentation, activation of caspase 3, 8 and 9, and inactivation of poly (ADP) ribose polymerase [81]. Ethanol and aqueous extracts of its calyces possess antipyretic activity in experimental animals [82]. Ethanol extract of the plant reduces the extent of cisplatin-induced sperm abnormality and enhanced sperm motility in rats [83]. Inhibition of intestinal motility by methanol extract in rats showed a significant dose dependent relaxant effect on rat ileal strip comparable to the effect shown by nifedipin and papaverine as reference compounds [84]. Investigation of the antispasmodic potential revealed that aqueous extract of calyces inhibited the tone of various isolated muscle preparations [85]. Effect of zobo drink (H. sabdariffa water extract) on the pharmacokinetics of acetaminophen in human volunteers was studied and the results showed no statistically significant changes in the absorption parameters t 1/2a, Ka, T max, C max and AUC0-alpha after the administration of zobo [86]. Investigation of the anti-inflammatory activity showed that its extract had no effect on rat paw edema but had an inhibitory effect on yeast induced pyrexia and a significant effect on the hot plate reaction time [87]. Polysaccharides from its flowers can stimulate proliferation and differentiation of Human Keratinocytes [88]. The study also showed that raw polysaccharides and all acidic fractions cause a strong induction of proliferation of human keratinocytes while the neutral polymers were ineffective. Neuropharmacological effects of the aqueous extract of calyx in rodents revealed that the extract produced a remarkable dose dependent decrease in spontaneous motor activity in mice and increased the duration of pentobarbital induced sleep in rats [89].

Interaction With Drugs

The interaction of three Sudanese beverages, including *H. sabdariffa*, with the kinetics of chloroquine was studied in human volunteers [90]. *H. sabdariffa* was found not to have a significant effect on any pharmacokinetic parameter, indicating its safety when taken with drugs that may have the metabolic pathways of chloroquine. More recently, [91] studied the effect of *H. sabdariffa* water extract on paracetamol (acetaminophen) kinetics in healthy men. On the whole, the administration of the extract induced no significant changes in the major kinetic parameters of paracetamol, although very minor and probably biologically insignificant alterations in some were observed. In view of the fact that *H. sabdariffa* drinks may be ingested with medicines, more studies to ascertain the presence or absence of interactions with drugs of different metabolic profiles are warranted.

Toxicological Properties

The LD50 of *H. sabdariffa* calyx extract in rats was found to be above 5000 mg/kg [92], suggesting

that the extract is virtually non-toxic. In spontaneously hypertensive rats, treatment with the extract at doses of 500–1000 mg/kg decreased blood pressure, and also significantly decreased serum creatinine, cholesterol and glucose levels, but significantly increased the serum content of uric acid. The treatment caused no significant effect on either water intake or urine output. Workers from Nigeria have recently studied the effect of sub-chronic administration of aqueous extracts of *H. sabdariffa* calyx on the testes [93], as the plant is often claimed in West African folk medicine to be an aphrodisiac [93]. Rats were given 1.15, 2.3 and 4.6 g/kg/day of an aqueous extract of *H. sabdariffa* calyx in the drinking water for up to 12 weeks. At the end of the treatment period there was a steady decrease in body weight, but no changes in the relative or absolute weights of the testes. However, the higher two doses of the extract caused a significant decrease in the epididymal sperm counts, histological distortion of tubules, disruption of normal testicular epithelial organization and disintegration of sperm cells. The authors postulated that these effects were related to interference by the extract with spermatogenesis that may have been caused by an oestrogenic action of the extract. Indeed, [94] have previously alluded to this possibility. It is, however, difficult to ascribe the above testicular effects to an oestrogenic action in the absence of any significant change in testicular weight, as oestrogens are known to reduce the weights of the male reproductive organs. The relevance of the testicular toxicity of *H. sabdariffa* in humans is not certain when the relatively high amount of extract given in the drinking water for 12 weeks is taken into consideration. [95] suggested that, in rats, the average consumption of 150–180 mg/kg/day of an aqueous-ethanol extract of *H. sabdariffa* calyces appeared to be safe, although higher doses might elevate the activity of some plasma enzymes indicative of tissue function (such as alanine aminotransferase and aspartate aminotransferase). However, the activity of some related plasma enzymes (alkaline phosphatase and lactate dehydrogenase) was not significantly affected, nor was there any evidence of histological damage to the heart and liver of the treated rats. Mutagenicity of roselle colour was reported by [96] and the compound responsible for this activity was suggested to be quercetin.

CONCLUSION

Hibiscus sabdariffa shows significant promise as a natural remedy with various therapeutic applications, particularly in supporting cardiovascular health, regulating blood pressure, and providing antioxidant benefits. Its versatility in both traditional medicine and modern dietary supplements makes it a popular choice for promoting overall wellness. However, while the evidence supporting its benefits is growing, more clinical trials are necessary to confirm its long-term safety and effectiveness. As always, individuals should approach its use with caution, particularly when combining it with other treatments, and seek medical advice to ensure it complements their health needs.

REFERENCES

1. Abou-Sreea, A. I. B., Roby, M. H., Mahdy, H. A., Abdou, N. M., El-Tahan, A. M., El-Saadony, M. T., El-Tarabily, K. A., & ElSaadony, F. M. (2022). Improvement of selected morphological, physiological, and biochemical parameters of roselle (Hibiscus sabdariffa L.) grown under different salinity le.vels using potassium silicate and Aloe saponaria extract. Plants, 11(4), 497
2. Salami, S. O., & Afolayan, A. J. (2020). Assessment of antimicrobial activities and toxicological effects of green and red cultivars of roselle – Hibiscus sabdarifa L. European Journal of Medicinal Plants, 31(15), 11-22.
3. Ogundapo, S. S., Onuoha, J. C., Olekanma, C. N., Okon, A. B., Soniran, O. T., Omoboyowa, D. A., & Okor, D. A. (2014). Alteration in biochemical parameters of Hibiscus sabdariffacalyces (zobo)

supplemented with commercial flavor additive. Journal of Natural Product, 7, 116-123.
4. Olawale, A. S. (2011). Studies in concentration and preservation of sorrel extract. African Journal of Biotechnology, 10(3), 416- 423.
5. N Mahadevan, Shivali and Pradeep Kamboj, Hibiscus Sabdariffa Linn- An overview, 2009
6. Julia F, Roselle, In: Fruits of warm climates, edited by Morton J, Miami, 1987, 281-286 (also available on http:// www.hort.purdue.edu/newcrop/morton/ roselle.html).
7. Wilson, F.D. and Menzel, M.Y. (1964). Kenaf (Hibiscus cannabinus), roselle (Hibiscus sabdariffa). Econ. Bot. 18: 80–91.
8. Lainbourne, J. (1913). The roselle. Agric. Bull. Federated Malay States 2: 59–67.
9. Duke, J.A. (1993). Medicinal plants and the pharmaceutical industry. In New Crops, eds J. Janick and J.E. Simon. John Wiley and Sons, Inc., New York, pp 664–669.
10. Mohamad, O., Mohd. Nazir, B., Abdul Rahman, M. and Herman, S. (2002). Roselle: A new crop in Malaysia. Bio Malaysia: A grand international biotechnology event. Bulletin PGM. Kuala Lumpur.
11. Duke, J.A. and duCellier, J.L. (1993). CRC handbook of alternative cash crops. CRC Press, Boca Raton, FL, USA. 536 pp.
12. Mclean, K. (1973). Roselle (Hibiscus sabdariffa L.), or karkade, as cultivated edible plants. AG. S. SUD/70/543, Project Working Paper, FAO, Rome.
13. Bahaeldeen Babiker Mohamed, Abdelatif Ahmed Sulaiman and Abdelhafiz Adam Dahab: Roselle (Hibiscus sabdariffa L.) in Sudan, Cultivation and Their Uses. Bulletin of Environment, Pharmacology and Life Sciences 2012; 1(6): 48–54.
14. Juhi Agarwal and Ela Dedhia: Current Scenario of Hibiscus sabdariffa (Mesta) In India (Maharashtra). The International Journal of Social Sciences and Humanities Invention 2014; 1(3): 129-135.
15. Himanshu C. Chaudhari and Ghanshyam M. Chavan, A brief review on Hibiscus sabdariffa Linn. With their medicinal uses and pharmacological activity, International Journal of Pharmaceutical Sciences and Research (2022).
16. Plotto, A., Mazaud, F., Röttger, A. and Steffel, K. (2004). Hibiscus: Post-production management for improved market access organisation: Food and Agriculture Organization of the United Nations (FAO), AGST.
17. Wang, M. L., Morris, B., Tonnis, B., Davis, J., & Pederson, G. A. (2012). Assessment of oil content and fatty acid composition variability in two economically important Hibiscus species. Journal of Agricultural and Food Chemistry, 60(26), 6620–6626
18. The Plant list. (2010). A working list of all species. In: http://www.theplantlist.org/ tpl/record/kew-2850461. Accessed in July 2012.
19. Ali, B. H., Al Wabel, N., & Blunden, G. (2005). Phytochemical, pharmacological and toxicological aspects of Hibiscus sabdariffa L.: a review. Phytotherapy Research, 19(5), 369–375.
20. Ismail, A., Ikram, E. H. K., & Nazri, H. S. M. (2008). Roselle (Hibiscus sabdariffa L.) seeds nutritional composition protein quality and health benefits. Food, 2(1), 1–16.
21. Murdock, G. P. (1959). Africa, its peoples and their culture history. New York: McGraw-Hill.
22. Morton, J. F. (1987). Fruits of warm climates. Florida Flair Books.
23. Chewonarin, T., Kinouchi, T., Kataoka, K., Arimochi, H., Kuwahara, T., Vinitketkumnuen, U., et al. (1999). Effects of roselle (Hibiscus sabdariffa Linn.), a Thai medicinal plant, on the mutagenicity of various known mutagens in Salmonella typhimurium and on formation of aberrant crypt foci induced by the colon carcinogens azoxymethane and 2-amino-1-methyl-6-phenylimidazo[4,5- b]pyridine in F344 rats. Food and Chemical Toxicology, 37(6), 591–601.
24. Gautam RD, Sorrel– A lesser-known source of medicinal soft drink and food in India, Nat Prod Rad, 2004, 3(5), 338-342.
25. EcoCrop. (2007). Hibiscus sabdariffa var. sabdariffa. In Food and Agriculture Organization of the UN (FAO).

26. Huang, C. N., Chan, K. C., Lin, W. T., Su, S. L., Wang, C. J., & Peng, C. H. (2009). Hibiscus sabdariffa inhibits vascular smooth muscle cell proliferation and migration induced by high glucose–A mechanism involves connective tissue growth factor signals. Journal of Agricultural and Food Chemistry, 57(8), 3073–3079.
27. Chennaveeraiah, M. S., & Subbarao, G. (1965). Chromosome number and karyomorphology in Hibiscus cannabinus and H. sabdariffa. Journal of the Karnatak University. Science, 9, 78–87.
28. Tjio, J. H. (1948). The somatic chromosomes of some tropical plants. Hereditas, 34, 135–146.
29. Bhatt, R. P., & Dasgupta, A. (1976). Cytotaxonomy of Malvaceae I. Chromosome number and karyotype analysis of Hibiscus azanza and urena. Cytologia, 41, 207–217.
30. Hiron, N., Alam, N., Ahmed, F. A., Begum, R., & Alam, S. S. (2006). Differential fluorescent banding and isozyme assay of Hibiscus cannabinus L. and H. sabdariffa L. (Malvaceae). Cytologia, 71(2), 175–180.
31. Kochhar, S. L. (1986). Tropical crops: a textbook of economic botany. London, UK: Macmillan Publishers Ltd.
32. Bako, I. G., Mabrouk, M. A., & Abubakar, A. (2009). Antioxidant effect of ethanolic seed extract of Hibiscus sabdariffa Linn (Malvaceae) alleviate the toxicity induced by chronic administration of sodium nitrate on some haematological parameters in Wistars rats. Advance Journal of Food Science and Technology, 1(1), 39–42.
33. Gibbon, D., & Pain, A. (1985). Crops of the drier regions of the tropics (1st ed.). Longman, England: English Language Book Society.
34. Wilson, F. D., & Menzel, M. Y. (1964). Kenaf (Hibiscus cannabinus), roselle (Hibiscus sabdariffa). Economic Botany, 18(1), 80–91.
35. Atta, M. B., & Imaizumi, K. (2002). Some Characteristics of Crude oil extracted from Roselle (Hibiscus sabdariffa L.) seeds cultivated in Egypt. Journal of Oleo Science, 51(7), 457–461.
36. Leung, A. Y., & Foster, S. (1996). Encyclopedia of common natural ingredients used in food, drugs, and cosmetics (2nd ed.). New York: John Wiley and Sons.
37. Neuwinger, H. (2000). African traditional medicine. Stuttgart: Medpharm Scientific Publication.
38. Burnham, T., Wickersham, R., & Novak, K. (2002). The review of natural products (3rd ed.). St. Louis, MO: Facts and Comparisons.
39. Gaya, I. B., Mohammad, O. M. A., Suleiman, A. M., Maje, M. I., & Adekunle, A. B. (2009). toxicological and lactogenic studies on the seeds of Hibiscus Sabdariffa Linn (Malvaceae) extract on serum prolactin levels of albino wistar rats. The Internet Journal of Endocrinology, 5(2).
40. Clydesdale, F. M., Main, J. H., & Francis, F. J. (1979). Roselle (Hibiscus sabdariffa L.) anthocyanins as colorants for beverages and gelatin desserts. Journal of Food Protection, 42(3), 204–207.
41. Dutt, D., Upadhyaya, J. S., & Tyagi, C. H. (2010). Studies on Hibiscus cannabinus, Hibiscus sabdariffa and Cannabinus sativa pulp to be a substitute for softwood pulp – Part 1: AS-AQ delignification process. Bio Resources, 5(4)
42. Plotto, A. (2004). Hibiscus: post-production management for improved market access. In: Food and Agriculture Organization of the UN (FAO).
43. McCaleb, R. S. (2000). Market survey: Hibiscus sabdariffa. agribusiness in sustainable natural African plant products. Herb Research Fondation. http://www.herbs.org/ africa/hibiscus.html. Accessed in October 2012.
44. Himanshu C. Chaudhari and Ghanshyam M. Chavan, A brief review on Hibiscus sabdariffa Linn with their medicinal uses and pharmacological activity, International Journal of Pharmaceutical Sciences and Research (2022).
45. Crane, JC, Roselle — a potentially important plant fiber, Econ Bot, 1949, 3, 89-103.
46. Watt JM and Breyer B, The medicinal and poisonous plants of southern and eastern Africa, 2nd ed, E & S, Livingstone, Ltd., Edinburgh and London, 1962.
47. Vilasinee H, Anocha U, Noppawan PM, Nuntavan B, Hitoshi S, Angkana H and Chuthamanee S,

Antioxidant Effects of aqueous extracts from dried calyx of Hibiscus sabdariffa L. (Roselle) in vitro using rat low-density lipoprotein (LDL), Biol Pharm Bull, 2005, 28(3), 481-484.

48. Muller BM and Franz G, Chemical structure and biological activity of polysaccharides from Hibiscus sabdariffa, Planta Med, 1992, 58(1), 60-67.
49. Rao PU, Nutrient composition and biological evaluation of Mesta (Hibiscus sabdariffa) seeds, Plant Foods Hum Nutr, 1996, 49(1), 27-34.
50. Samy MS, Chemical and nutritional studies on roselle seeds (Hibiscus sabdariffa L.), Z Ernahrungswiss 1980, 19(1), 47-49.
51. Akiyoshi S, Chiaki N, Masanori M, Sadayoski M, Yoshiharu M and Sadao K, Glycosides in African dietary leaves, Hibiscus sabdariffa, J Oleo Sci, 2005, 54(3), 185-191.
52. Eggensperger, H., & Wilker, M. (1996). Hibiscus-Extrakt – Ein hautvertraglicher Wirkstoffkomplex aus AHA'a und polysaccharіden. Parfumerie und Kosmetik, 9, 540–543.
53. Buogo, G., & Picchinenna, D. (1937). Chemical characteristics of Roselle hemp. Annali Di Chimica Applicata, 27, 577–582.
54. Khafaga, E. R., Koch, H., El Afry, M. M. F., & Prinz, D. (1980). 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, 54(5/6), 287–318.
55. Williamson, E. M., Driver, S. B., & Baxter, K. (2013). Stockley's herbal medicines interactions: a guide to the interactions of herbal medicines, dietary supplements and nutraceuticals with conventional medicines. London: Pharmaceutical Press.
56. Yamamoto, R., & Osima, Y. (1932). On the red colouring matter of Hibiscus sabdariffa L. (A new glycoside hiviscin) (Vol. 8). Tokyo: Science Paper Institute of Physics Chemical Research.
57. Du, C. T., & Francis, F. J. (1973). Anthocyanins of Roselle (Hibiscus sabdariffa, L.). Journal of Food Science, 38(5), 810–812.
58. Subramanian, S. S., & Nair, A. G. R. (1972). Flavonoids of four malvaceous plants. Phytochemistry, 11(4), 1518–1519.
59. Alarcon-Aguilar, F. J., Zamilpa, A., Perez-Garcia, M. D., Almanza-Perez, J. C., RomeroNunez, E., Campos-Sepulveda, E. A., et al. (2007). Effect of Hibiscus sabdariffa on obesity in MSG mice. Journal of Ethnopharmacology, 114(1), 66–71.
60. McKay, D. (2009). Can hibiscus tea lower blood pressure? AfroFood Industry Hi-Tech, 20(6), 40–42.
61. Rao, R. P., & Seshadri, T. R. (1942). Pigments of the flowers of Hibiscus sabdariffa isolation of sabdaretin, a new hydroxyflavone. Proceedings of the Indian Academy of Sciences, 16A(5), 323–327.
62. Seshadri, T. R., & Thakur, R. S. (1961). Constitution of gossytrin, a new glycoside from the flower petals of Hibiscus sabdariffa. Journal of the Indian Chemical Society, 38, 649–665.
63. Osman, A. M., El-Garby-Younes, M., & Mokhtar, A. (1975). Chemical examination of local plants. XIII. Elucidation of the structure of a new glycoside from the leaves of Egyptian Hibiscus sabdariffa. Australian Journal of Chemistry, 28, 217–220.
64. Beltran-Debon, R., Alonso-Villaverde, C., Aragones, G., Rodriguez-Medina, I., Rull, A., Micol, V., et al. (2010). The aqueous extract of Hibiscus sabdariffa calices modulates the production of monocyte chemoattractant protein-1 in humans. Phytomedicine, 17(3–4), 186–191.
65. Mahadevan N, Shivali and Pradeep Kamboj: Hibiscus sabdariffa Linn overview. Natural Product Radiance 2009; 8(1): 77-83.
66. Sharaf, A. (1962). The pharmacological characteristics of Hibiscus sabdariffa L. Planta Medica, 10, 48–52.
67. Obiefuna, P. C. M., Owolabi, O. A., Adegunloye, B. J., Obiefuna, I. P., & Sofola, O. A. (1994). The petal extract of Hibiscus sabdariffa produces relaxation of isolated rat aorta. Pharmaceutical Biology, 32(1).
68. Ali, M. B., Salih, W. M., Mohamed, A. H., & Homeida, A. M. (1991). Investigation of the antispasmodic potential of Hibiscus sabdariffa

calyces. Journal of Ethnopharmacol, 31(2), 249–257.

69. Fouda, A. M., Daba, M. H., & Dahab, G. M. (2007). Inhibitory effects of aqueous extract of Hibiscus sabdariffa on contractility of the rat bladder and uterus. Canadian Journal of Physiology and Pharmacology, 85(10), 1020–1031.
70. Sarr, M., Ngom, S., Kane, M. O., Wele, A., Diop, D., Sarr, B., et al. (2009). In vitro vasorelaxation mechanisms of bioactive compounds extracted from Hibiscus sabdariffa on rat thoracic aorta. Nutrition & Metabolism, 6(45), 1–12.
71. Abiodun Olusoji Owoade, Adewale Adetutu and Olubukola Sinbad Olorunnisola: A review of chemical constituents and pharmacological properties of Hibiscus sabdariffa L. International Journal of Current Research in Biosciences and Plant Biology 2019; 6(4): 42-51.
72. Puro, K., Sunjukta, R., Samir, S., Ghatak, S., Shakuntala, I., & Sen, A. (2014). Medicinal uses of Roselle plant (Hibiscus sabdariffa L.): A mini review. Indian Journal of Hill Farming, 27(1), 81-90.
73. Akim, A., Lim, C. H., Asmah, R., & Zanainaul, A. Z. (2011). Antioxidant and anti-proliferative activities of Roselle juice on Caov-3, Mcf-7, MDA-MB-231 and hela cancer cell lines. Africa Journal of Pharmacognosy and Pharmacology, 5(7), 957-965.
74. Mckay, D. L., Chen, C. Y., Saltzman, E., & Blumberg, J. B. (2011). Hibiscus sabdariffa L. tea (tisane) lowers blood pressure in prehypertensive and mildly hypertensive adults. Journal of Nutrition, 140, 298-303.
75. Yin, G., Cao, L., Xu, P., Jeney, G., & Nakao, M. (2011). Hepatoprotective and antioxidant effects of Hibiscus sabdariffa extract against carbon tetrachloride-induced hepatocyte damage in Cyprinus carpio. In Vitro Cellular & Developmental Biology-Animal, 47, 10-15.
76. Lee, W. C., Wang, C. J., Chen, Y. H., Hsu, J. D., Cheng, S. Y., Chen, H. C., et al. (2009). Polyphenol extracts from Hibiscus sabdariffa Linnaeus attenuate nephropathy in experimental type 1 diabetes. Journal of Agricultural and Food Chemistry, 57(6), 2206–2210.
77. Peng, C. H., Chyau, C. C., Chan, K. C., Chan, T. H., Wang, C. J., & Huang, C. N. (2011). Hibiscus sabdariffa polyphenolic extract inhibits hyperglycemia, hyperlipidemia, and glycation-oxidative stress while improving insulin resistance. Journal of Agricultural and Food Chemistry, 59(18), 9901–9909.
78. Hansawasdi, C., Kawabata, J., & Kasai, T. (2000). Alpha-amylase inhibitors from roselle (Hibiscus sabdariffa Linn.) tea. Bioscience, Biotechnology, and Biochemistry, 64(5), 1041–1043.
79. Olaleye, M. T. (2007). Cytotoxicity and antibacterial activity of methanolic extract of Hibiscus sabdariffa. Journal of Medicinal Plants Research, 1(1), 9-13.
80. Fullerton, M., Khatiwadu, J., Johnson, J. U., David, S., & William, L. L. (2011). Determination of antimicrobial activity of sorrel (Hibiscus sabdariffa) on E. coli 0157:H7 isolated from food, veterinary and clinical samples. Journal of Medicinal Food, 14(9), 950-956.
81. Hou DX, Tong X, Terahara N, Luo D and Fujii M, Delphinidin 3-sambubioside (Dp3-Sam), a Hibiscus anthocyanin, induces apoptosis in human leukemia cells through reactive oxygen species mediated mitochondrial pathway, Biochem Biophys, 2005, 440(1), 101-109.
82. Reanmongokol W and Itharat A, Antipyretic activity of the extracts of Hibiscus sabdariffa calyces in experimental animals, Songklanakarin J Sci Technol, 2007, 29, 29-38.
83. Amin A and Hamza AA, Effects of roselle and ginger on cisplatin-induced reproductive toxicity in rats, Asian J Androl, 2006, 8(5), 607–612.
84. Salah AM, Gathumbi J and Vierling W, Inhibition of intestinal motility by methanol extract of Hibiscus sabdariffa L. (Malvaceae) in rats, Phytother Res, 2002, 16(3), 283-285.
85. Ali MB, Salih WM, Mohamed AH and Homeida AM, Investigation of the antispasmodic potential of Hibiscus sabdariffa calyces, J Ethnopharmacol, 1991, 31(2), 249-257.
86. Kolawole JA and Maduenyi A, Effect of zobo drink (Hibiscus sabdariffa water extract) on the

pharmacokinetics of acetaminophen in human volunteers, Eur J Drug Metab Pharmac, 2004, 29(1), 25-29.

87. Dafallah AA and Al-Mustafa Z, Investigation of the anti-inflammatory activity of Acacia nilotica and Hibiscus sabdariffa, Am J Chin Med, 1996, 24(3-4), 263-269.
88. Brunold C, Deters A, Sidler FK, Hafner J, Müller B and Hensel A, Polysaccharides from Hibiscus sabdariffa Flowers Stimulate Proliferation and Differentiation of Human Keratinocytes, Planta Med, 2004, 70, 370-373.
89. Amos S, Binda L, Chindo BA, Tseja A, Odutola AA, Wambebe C and Gamaniel K, The neuropharmacological effects of the aqueous extract of Hibiscus sabdariffa calyx, Pharmacol Biol, 2003, 41(5), 325-329.
90. Mahmoud BM, Ali HM, Homeida MM, Bennett JL.1994. Significant reduction in chloroquine bioavailability following coadministration with the Sudanese beverages Aradaib, Karkadi and Lemon. J Antimicrob Chemother 33: 1005–1009.
91. Kolawole JA, Maduenyi A. 2004. Effect of zobo drink (Hibiscus sabdariffa water extract) on pharmacokinetics of acetaminophen in human volunteers. Eur J Drug Pharmacokinet 29: 25–29
92. Onyenekwe PC, Ajani EO, Ameh DA, Gamammiel KS. 1999. Antihypertensive effect of roselle (Hibiscus sabdariffa) calyx infusion in spontaneously hypertensive rats and a comparison of its toxicity with that in Wistar rats. Cell Biochem Func 17: 199–206.
93. Orisakwe OE, Husaini DC, Afonne OJ. 2004. Testicular effects of subchronic administration of Hibiscus sabdariffa aqueous extract in rats. Reprod Toxicol 18: 295–298.
94. Ali MS, Salih WM, Humida AM. 1989. An estrogenic–like activity of Hibiscus sabdariffa. Fitoterapia 60: 547–548.
95. Akindahunsi AA, Olaleye MT. 2003. Toxicological investigation of aqueous–methanolic extract of the calyces of Hibiscus sabdariffa L. J Ethnopharmacol 89: 161–164.
96. Takeda N, Yasui Y. 1985. Identification of mutagenic substances in roselle color, elderberry color and safflower yellow. Agric Biol Chem 49: 1851–1852.

HOW TO CITE: Swayam Shinde*, Sakshi Wadhai, Deepika Prajapati, Mrunali Tade, Vartika Singh, Hibiscus Sabdariffa: The Tropical Plant with A Wealth of Health Benefit, Int. J. of Pharm. Sci., 2024, Vol 2, Issue 11, 1046-1064. https://doi.org/10.5281/zenodo.14209766