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Hibiscus sabdariffa: A comprehensive review of its phytochemistry, traditional uses and therapeutic potentials

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Abstract
The medicinal plant *Hibiscus sabdariffa* L., also called *Roselle*, is a member of the Malvaceae family and has been used for many years. It is distinguished by its vivid red calyces, which are abundant in organic acids, flavonoids, and anthocyanins. It has long been used as an antibacterial, diuretic, and antihypertensive. It also has hepatoprotective, anti-inflammatory, and antioxidant qualities. There is evidence to support the plant's immunomodulatory and antibacterial properties, which may help manage obesity, cancer, and parasite infections. *Roselle*, which is collected for its calyces and dried after harvest for storage, is a nutritious plant that is used in a variety of meals and beverages. It is a contender for more therapeutic investigation due to its varied pharmacological profile.

Keywords: Anthocyanins, traditional medicine, antihypertensive, antioxidant, *Hibiscus sabdariffa*

Introduction

The *roselle*, or *Hibiscus sabdariffa* L (Hs), is a crop that is perfect for developing nations because it is reasonably easy to grow, can be used as food and fibre, and may be planted as part of multi-cropping systems [1]. Muslims from Turkey who invaded India may have carried the *roselle* plant to the west. The Turkish term "Sabdariffa," which was the plant's original name, verified the *roselle*'s provenance [2]. Numerous studies have been conducted on the many health advantages of *roselle* blossoms (*Hibiscus sabdariffa*) [3]. More than 300 species of hibiscus are found in tropical and subtropical regions. A distinct species, *roselle*, also known as Jamaica sorrel (*Hibiscus sabdariffa*), is grown in many tropical places for its leaves, seeds, stem, and calyces. The dried calyces are used to make tea, syrup, jams, and jellies [4]. A miraculous plant with many uses is *roselle* [5]. Although it is indigenous to India and Malaysia, its cultivation has spread to other tropical and subtropical regions, such as China, Thailand (two of the world's major suppliers), Indonesia, Saudi Arabia, Vietnam, Sudan, Egypt, Nigeria, and Mexico, due to its ability to thrive in marginal soils with low fertility and low moisture retention [6]. Now a day, food and beverage manufacturers and pharmaceutical companies are interested in *roselle* because they believe it has potential as a natural food product for herbal medicine and as a colourant to replace some synthetic dyes [7]. The most commonly used part of the *roselle* plant is the medicinally useful floral calyx. Traditionally, *roselle* was used as a nutritious drink by infusing its petals and served hot or cold. Currently, *roselle* is used in a variety of products, such as foods, cosmetics, and medications [8]. Around the world, *roselle* has been given colloquial or regional names that are unique to the languages of the local populace in various nations or areas. In the English-speaking world, it is called rozelle; in Australia and Indonesia, it is called rosella and rosella; in the Indian subcontinent, it is called Mesta; in Malaysia, it is called Asam paya; in Africa, it is called sorrel; and in Thailand, it is called krajeab [9]. *Roselle* is regarded as one of the most well-known folk medicinal plants in a number of nations. The ethnomedical use of *Roselle* in promoting cardiovascular health, preventing hypertension, pyrexia, liver disorders, microorganism growth limitation, and as a diuretic, digestive aid, and sedative is supported by the potential health benefits of many of its chemical components. The red types of *Roselle* exhibit cyclooxygenase inhibitory and antioxidant properties. Additionally, *Roselle* works in the cosmetics and pharmaceutical industries [10]. Every part of *roselle* plants, including the calyces, leaves, seeds, and stems, can typically, be used for a variety of purposes [9]. The root is used as a tonic and appetiser. The fibrous portions are utilised to make rosella hemp cords and string [11].

Fig 1: Flower and fruit of *Roselle* [12].

1. Taxonomy

- **Kingdom:** Plantae
- **Division:** Tracheophyta
- **Subdivision:** Angiospermae
- **Class:** Magnoliopsida
- **Family:** Malvaceae
- **Genus:** Hibiscus
- **Species:** sabdariffa [13].

2. Vernacular Names: Common names Different names for *H. sabdariffa* L. are used depending on the region and ethnic group in the world. In French, Jamaican, and Spanish, Oseille de Guinée, *Roselle* ou thé rose d'Abyssinie; in English, *Roselle*, Sorrel, or Sour tea (UK and USA); Flores de Jamaica in Central America; Groseille de Noël in the West Indies; Karkadé in Arabic (Soudan); Karkandji in Egypt; Nsa in Congo-Brazaville; Ngai-ngai in Central Africa; Bissap in Burkina, Mali, Senegal; Bissap in Wolof (Senegal); Dâ in Bambara (Mali); Isapa in Yorouba and Zobo in Hausa in Nigeria; Sobolo in Ghana; Yakoua in Hausa; Guissima in Zarma; Pollé in Peulh; Karassou in Kanouri (Diffa) [14].

3. Plant Descriptions

Numerous soil types have been identified to support the plant's growth. Although it can function well on comparatively barren soils, a soil that is rich in organic matter and vital nutrients is necessary for economic reasons. During the growing and fruiting seasons, it can withstand comparatively high temperatures [10]. Growing to a height of 2 to 2.5 meters, it is a woody-based sub-shrub or herb that can be either annual or perennial. The leaves are 8-15 cm long, alternately placed on the stems, and deeply 3-5 lobed. The blooms have a robust, fleshy calyx at the base, which is 1-2 cm broad and grows to 3-3.5 cm as the fruit matures. The flowers are 8-10 cm in diameter, white to pale yellow, with a dark red mark at the base of each petal. The maturation period is around six months [15]. Depending on the seed source, stems can be either green or red. Its taproot is robust. Young plants have unlobed leaves, but as they mature, the leaves become shallowly to profoundly palmate, with three or five (even seven) parents. The big flowers have dark crimson eyes and soft yellow petals that might be tinged with pink or red. In the leaf axils, the flowers are often carried solitary. When fully grown, the sepals at the base of the big flowers and fruit can range in colour from dark purple to bright red (sometimes white). Before the flower is fertilised, the calyx grows from 1 to 2 cm in length; in maturity, it reaches 5.5 cm (sometimes longer) [16].

Fig 2: *Roselle* crops [17].

4. Chemical Constituents

Protocatechuic acid and anthocyanins are abundant in *roselle*. The flavonoids hibiscetine, sabdaretine, and gossypetine are present in the dried calyces. Daphniphylline has been identified as the primary pigment, which was previously thought to be hibiscine. There are also trace levels of chrysanthenin (cyanidin 3-monoglucoside), myrtillin (delphinidin 3-monoglucoside), and delphinidin. Lipid-soluble antioxidants, especially γ-tocopherol, are abundant in *roselle* seeds [18]. In raw *Hibiscus sabdariffa* seeds, the phytochemical characteristics revealed the presence of flavonoids, tannin, polyphenols, alkaloids, and saponins, but the absence of terpenes, steroids, glycosides, and tannins. According to the qualitative study, tannin was the most prevalent phytochemical, followed by flavonoids [19].

5. Nutritional Value

The proximate method of nutritional analysis of the *Roselle* plant revealed that its biggest content was carbohydrates (68.7%), followed by crude fibre (14.6%) and ash (12.2%), among other things. Additionally, the plant is reported to be rich in minerals, particularly magnesium and potassium. There were also noticeable levels of the vitamin's pyridoxine, niacin, and ascorbic acid [7]. Additionally, the plant has high levels of calcium, iron, and β-carotene (300 µg/100 g). Alpha-terpinyl acetate, methanol, malic acid, fibre, ash, ani salsehyde, isoamyl alcohol, 3-methyl-1 butanol, niacin, isopropyl alcohol, benzyl alcohol, beta sitosterol, beta carotene, beta D-galactoside, and other chemical components are all found in the *Roselle* leaf itself [13].

6. Harvesting and Post-Harvest Handling

It is important to harvest the fruits early enough before any woody material develops in the calyxes or pods. After being harvested, stems are steeped in water for two weeks, the bark is removed, and then the stems are hammered to separate their fibres. To make fibre, the beaten stems are cleaned, dried, and sorted based on their length, colour, and stiffness. Round, sharpened metal tubes are used to extract the seed capsules from the calyces [4].

7. Traditional Use

China, Egypt, India, Indonesia, Malaysia, Mexico, Thailand, Trinidad & Tobago, Sudan, and other countries have long used Hs. Uses have generally been concentrated on botanical and/or floral elements, medical and culinary difficulties, and as a source of cosmetics [6].

Herbal drinks, hot and cold beverages, fermented drinks, wine, jam, jellied confections, ice cream, chocolates, flavouring agents, puddings, and cakes are all made with fresh or dried H. sabdariffa (c Hs) calyces [1]. *Roselle* is an annual crop that is utilised in pharmaceuticals, food, animal feed, nutraceuticals, and cosmeceuticals. The flavour of the calyces, stems, and leaves is acidic. The calyces' juice is said to be a health-promoting beverage since it contains a lot of vitamin C, anthocyanins, and other antioxidants [18]. *Roselle*, cultivated in Louisiana's fields numerous traditional treatments contain *roselle*. Ascorbic acid and glycolic acid, two diuretic components, are responsible for its mild laxative impact and capacity to stimulate urine. It is used as a cooling herb because it contains citric acid, which increases blood flow to the skin's surface and dilates pores to cool the skin in hot conditions [20].

8. Activities

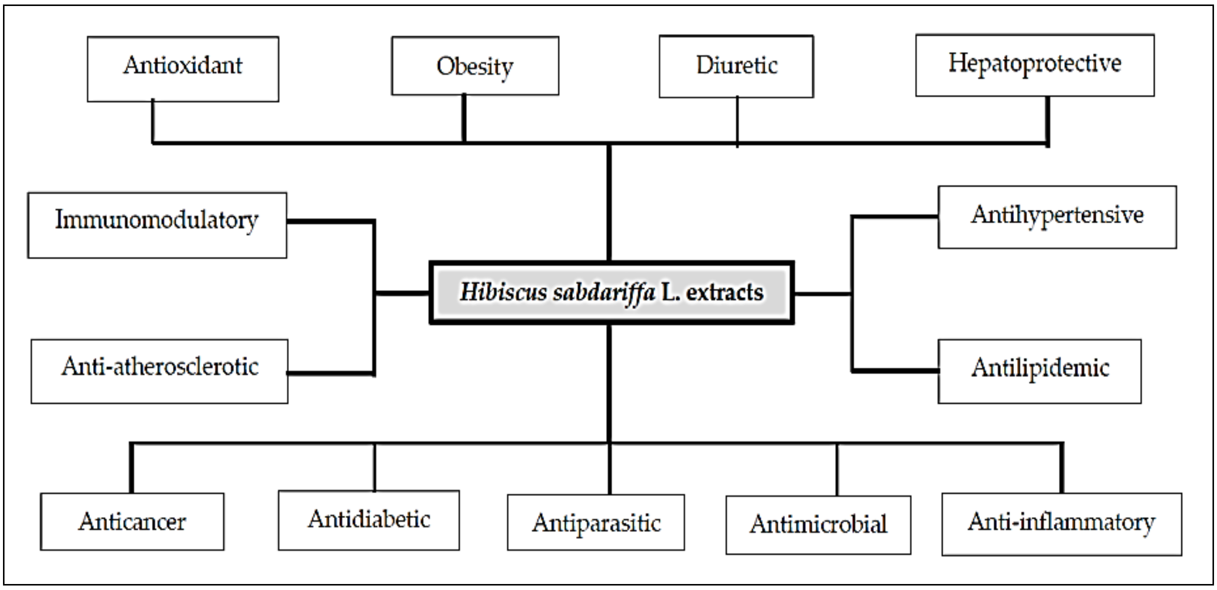

Fig 3: Therapeutic and/or pharmacological properties of *Hibiscus sabdariffa* [6].

9.1 Antimicrobial activity: It is currently unclear which of the several compounds found in the *Hibiscus sabdariffa* extract exhibits antibacterial activity, or if it is the result of two or more compounds working in concert. In a microbiological culture, Higginbotham *et al*. demonstrated that the herb's filtered and autoclaved extracts had possible antibacterial action. Using milk as an experimental paradigm and a microbiological media, processed extracts showed antibacterial activity against Staphylococcus aureus and Escherichia coli [21].

9.2 Anti-inflammatory activity: The most frequent class of flavonoids absorbed through diet are anthocyanins, which give many fruits and vegetables their vivid colours and are typically found in Western-style diets. A powerful chemotactic factor for monocytes, monocyte chemoattractant protein-1 (MCP-1) is a member of the C-C chemokine family and is used as a biomarker to assess inflammatory disorders [22].

9.3 Antihypertensive activity: Hypertension is increasingly regarded as a worldwide health issue because of its consequences, which include the development of cerebrovascular disorders, heart ischaemia, and cardiac and renal failure decreased systolic and diastolic pressure differential in comparison to the control group. Another study indicated that the effectiveness of aqueous extract in hypertensive humans was remarkable, with the systolic pressure dropping significantly while the diastolic pressure stayed constant. The potential of HS extract to inhibit ACE activity, when combined with dietary and lifestyle changes, daily HS ingestion can successfully treat high blood pressure in stage one hypertension [23].

9.4 Antibacterial activity: Antibacterial activity of HS extracts has been reported against many bacterial strains, including multi drug resistant strains. A number of studies have also investigated the specific active compounds that may be responsible for the antibacterial activity of Hs extracts. Hs is known to primarily contain organic acids, flavonoids and phenolic acids, anthocyanins, and polysaccharides, as well as various volatile compounds [24]. The calyces of the plant have also been previously reported to possess antibacterial properties against a variety of pathogens, including foodborne pathogens, methicillin-resistant *Staphylococcus aureus*, *Klebsiella pneu monia* and *Pseudomonas aeruginosa*. Saponins, flavonoids, and tannins are antibacterial substances found in hibiscus flowers (*Hibiscus rosa-si-nensis*.) [13].

9.5 Anti-diabetic activity: Extracted *Roselle*'s polyphenolic components and investigated their impact on a high-fat diet model of type II diabetes in rats. The extract's anti-insulin resistance qualities at a dose level of 200 mg/kg were investigated, along with a decrease in hyperglycaemia and hyperinsulinemia. Triacylglycerol, serum cholesterol, the ratio of low-density lipoprotein to high-density protein (LDL/HDL), AGE formation, and lipid peroxidation were all observed to be reduced by the extract [25].

9.6 Antimicrobial activity: Natural products attract a lot of interest due to their richness in metabolites with antibacterial, antifungal, and antiparasitic qualities. These qualities help fight the growing problem of antibiotic resistance in bacteria. Plants use these mechanisms as a defense against illnesses and diseases throughout their growth and development. Anthocyanins, one of these phytochemicals, prevent the growth and reproduction of various bacteria and parasites, including both Gram-positive and Gram-negative types. *Roselle* is commonly used to treat illnesses. The *roselle* plant contains cardiac glycosides, flavonoids, saponins, and alkaloids. It shows antibacterial activity against several microorganisms, including *Staphylococcus aureus*, *Bacillus stearothermophilus*, *Micrococcus luteus*, *Serratia marcescens*, *Clostridium sporogenes*, *Escherichia coli*, *Klebsiella pneumoniae, Bacillus cereus*, and *Pseudomonas fluorescence*. [15].

9.7 Obesity activity: Excessive body weight and a persistent energy imbalance are characteristics of obesity. Adipocyte hyperplasia and hypertrophy are hallmarks of aberrant adipocyte differentiation brought on by this disturbance in energy homeostasis. This section will look at the polyphenols in *H. sabdariffa's* potential to control energy metabolism and their positive effects on weight loss and cholesterol management, as reported by multiple authors [27].

9.8 Hepatoprotection activity

Extracts of *H. sabdariffa* have been shown to protect rat primary hepatocytes against oxidative stress. Because the plant's natural antioxidants have the ability to scavenge free radicals, the *H. sabdariffa* extracts also provide hepatoprotection by affecting the levels of lipid peroxidation products (MDA) and liver marker enzymes (alanine and aspartate aminotransferase) in experimental hyperammonemia [28].

9.9 Antioxidant activity

Roselle juice's antioxidant properties make it a popular beverage worldwide. Ascorbic acid, β-carotene, lycopene, rutin, isoquercitrin, neochlorogenic acid, chlorogenic acid, and cryptochlorogenic acid are among the many antioxidants found in *roselle*. Significant anti-hyperammonemic and anti-oxidant action was suggested by the discovery that ethanolic extract was associated with a considerable rise in antioxidant levels in brain regions, including catalase (CAT), superoxide dismutase (SOD), glutathione peroxidase (GPx), and reduced glutathione (GSH) [29]. It is commonly known that anthocyanins have antioxidant qualities. Although *roselle* extracts have demonstrated antioxidant potential, the plant has only just gained popularity as a result of increased interest in natural antioxidants. Hai-Yao Wu declares that the *roselle* extract has strong antioxidative qualities and is high in anthocyanins [26].

9.10 Anticancer activity

Roselle may be used as a cancer chemo preventive agent, according to research findings. For example, *roselle*'s anthocyanins have demonstrated the capacity to induce cancer cells to undergo apoptosis, especially in stomach and leukaemia and cancer patients [13]. *Roselle* juice's antiproliferative properties were tested on a variety of cell lines, including cervical (HeLa), breast (MCF-7, MDA-MB-231) and ovarian (Caov-3) cancer cell lines. It was discovered that the MCF-7 cancer cells showed the greatest antiproliferative capability. The effects on human cancer cells (HL-60) were investigated using *Roselle*-anthocyanins (HA), which demonstrated dose- and time-dependent cell death. According to the effects of *Roselle*'s methanolic extract on seven cancer lines, AGS cancer cells are more vulnerable in concentration-dependent forms that impact both intrinsic and extrinsic apoptotic pathways [7]. In human promyelocytic leukaemia (HL-60) cells, delphinidin 3-sambubioside from H. sabdariffa induces dose-dependent death through a mitochondrial malfunction route mediated by reactive oxygen species (ROS) [26].

9.11 Immunomodulation Activity

Bioactive substances known as immunomodulators alter our body's immune response by either preventing white blood cell activity or causing modifications through the production of antibodies. Additionally, *Hibiscus sabdariffa* either stimulates or inhibits the immune system. Fakeye, Titilayo O., *et al*. investigated this in Wistar albino rats and discovered that the percentage of neutrophils, basophils, monocytes, and eosinophils increased as the concentration of *Hibiscus sabdariffa* extract doses increased, respectively, leading to an increase in the RBC count when compared to the control group [21].

9.12 Antiparasitic activity

Tropical and subtropical areas are home to the vector-borne disease human lymphatic filariasis, which poses a threat to public health evaluated the ethanolic extract of *H. sabdariffa* leaves for antifilarial activity using MTT and *in vitro* motility techniques. The findings demonstrated that the extract had an impact on Brugia malayi microfilariae as well as adult worms. Anthocyanin-glycosides were linked to the butanol fraction's notable inhibitory impact [30]. It has been demonstrated that oil derived from *H. sabdariffa* seeds inhibits *Bacillus anthracis* and *Staphylococcus albus in vitro*, but not *Proteus vulgaris* and *Pseudomonas aeruginosa* [31].

9.13 Diuretic activity

Researchers assess diuresis and electrolyte disposal after administering the aqueous extract in increasing doses. They evaluate the renal filtration rate in isolated kidneys using amiloride, furosemide, and plant extract. The aqueous extract of *Hibiscus sabdariffa* exhibits dose-dependent diuretic and natriuretic effects. [16].

10. Conclusion

Hibiscus sabdariffa is a versatile plant with a wide range of uses and benefits. Its rich nutritional profile and pharmacological properties make it a valuable crop for food, medicine, and cosmetics. The plant's antimicrobial, antihypertensive, and antioxidant activities have been extensively studied, and its potential health benefits are promising. Further research is needed to fully explore the therapeutic potential of *Roselle* and to develop new products and applications. With its adaptability to marginal soils and low moisture retention, *Roselle* is an attractive crop for developing nations. Its potential as a natural remedy for various health issues makes it an exciting area of research and development. Overall, *Hibiscus sabdariffa* is a valuable plant with a bright future in the fields of food, medicine, and cosmetics.

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