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Hibiscus sabdariffa L. (Traditional Medicine and Food Ingredients)

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Abstract

Hibiscus sabdariffa has been used as food, herbal drinks, and flavoring ingredients in the food and pharmaceutical industries. This study aims to explain the botany, utilization and bioactivity of *H. sabdariffa*. This research was carried out using library research, especially from Google Scholar, using the keywords *H. sabdariffa*, *H. sabdariffa* bioactivity, and *H. sabdariffa* use. The *H. sabdariffa* is a species belonging Malvaceae, which easy found in the yard and has been cultivated. The traditional medicine, *H. sabdariffa* is used to treat digestive disorders, liver disease, fever, hypercholesterolemia, hypertension, obesity, prevention/treatment of cancer, cardiovascular and gout. The use of *H. sabdariffa* as a traditional medicine is related to its bioactivity such as antioxidant, diuretics, anti-microbial, anti-hypercholesterolemia, anti-diabetes mellitus, anti-hypertension, anti-cancer. and hepatoprotective. The bioactivity of *H. sabdariffa* is related to secondary metabolites, especially the anthocyanins delphinidin-3-O-sambubioside and cyanidin-3-O-sambubioside. *H. sabdariffa* has great potential to be developed as a nutraceutical to treat hypertension and diabetes mellitus.

Keywords: *Hibiscus sabdariffa*; Anti-hypertension; Diabetes mellitus; Cyanidin-3-O-sambubioside

1. Introduction

Rosella or *H. sabdariffa* is a type of plant that is easily found in the yards in Indonesia. The beautiful of flower structure to be widely used as ornament plant. The *H. sabdariffa* has been used as food coloring; herbal drinks; and flavoring ingredients in the food and pharmaceutical industries [1;2]. The dye produced by *H. sabdariffa* has been used in the food, cosmetics and pharmaceutical industries [3]. Its use as a food ingredient is related to its nutritional content; so it can be developed as a powerful chemo-preventive agent and natural healthy food [4].

The petal of *H. sabdariffa* is used as diuretic, to treat digestive disorders, liver disease, fever, hypercholesterolemia, hypertension [5], anti-obesity [6;7], prevention/treatment of cancer [7;8], cardiovascular disorders [7] and gout [9]. Healthy men who consumed *H. sabdariffa* were implicated in significant decreases in the concentrations of creatinine, uric acid, citrate, tartrate, calcium, sodium, potassium, and phosphate in urine [9]. The use of *H. sabdariffa* as a traditional medicine is related to its bioactivity. The extract of *H. sabdariffa* shows activities as antioxidant [3;7]; antimicrobial [3] and anti-cancer [7].

Bioactive compounds of *H. sabdariffa* prevent chronic and degenerative diseases related to oxidative stress. [10]. The bioactivity of *H. sabdariffa* as an anticancer is related to its secondary metabolite content that induces chemoprevention, selective cytotoxicity, cell cycle arrest, apoptosis, autophagy, and anti-metastasis effects on various types of human cancer cells [11].

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The *H. sabdariffa* has the potential to be developed as a food ingredient because it is rich in nutritional content. The nutrient content of *H. sabdariffa* is organic acids (including citric, malic, tartaric, allo-hydroxycitric), beta carotene, vitamin C, protein, and sugar [7]. The use of *H. sabdariffa* as a food and medicine is related to its bioactive compound content. *Hibiscus sabdariffa* is rich in polyphenols; especially anthocyanins; polysaccharides and organic acids; so it has great prospect in modern therapeutic use [10]. The therapeutic properties of *H. sabdariffa* are attributed to bioactive compounds from the plant; especially phenolic acids; flavonoids; anthocyanins; and organic acids (citric; hydroxycitric; hibiscus; tartaric; malic; and ascorbic) [12].

To minimize toxic effects, knowledge of the dose that can be tolerated by the body is needed [13]. In the long term, the dose of *H. sabdariffa* causes effects on the testes of mice [9]. *H. sabdariffa* has activity as a diuretic and antihypertensive, so that when consumed it has an impact on lowering blood pressure and the effect is proportional to the dose [13]. This study aims to explain the botany, utilization and bioactivity of *H. sabdariffa*.

2. Methods

The method used in this study is library research. Literature was obtained online; especially from Google Scholar using the keywords *H. sabdariffa*, bioactivities *H. sabdariffa*, and uses *H. sabdariffa*. The results obtained were synthesized so that the botany, utilization and bioactivity of *H. sabdariffa* were explained in a comprehensive manner.

3. Results and Discussion



Figure 1 the Rosella or *Hibiscus sabdariffa*. A. Habitus; B. Flowers are blooming; C. Fruit

3.1. Uses of *Hibiscus sabdariffa*

3.1.1. Traditional Medicine and Its Bioactivities

The use of *H. sabdariffa* as a traditional medicine has been long time and has developed in line with human civilization. In traditional medicine, rosella calyx extract is used to treat hypertension, liver disorders and fever [9]. The use of plants as traditional medicine is related to their bioactivity. The bioactivity of *H. sabdariffa* has diuretic, choleric, analgesic, antitussive, antihypertensive, antimicrobial, immunomodulatory, hepatoprotective, antioxidant, and anti-cancer effects [2;12]. The below we will explain further about the bioactivity of *H. sabdariffa* as an antioxidant; anti-kidney stone; anti-microbial; anti-hypercholesterolemia; anti-diabetes mellitus; anti-hypertension; anti-cancer; and hepatoprotective.

3.1.2. Anti-Oxidant

Antioxidant compounds are compounds that can inhibit the formation of free radicals. The bioactivity of *H. sabdariffa* as an antioxidant has been widely reported by Chumsri et al [16]; Zhen et al [17]; Mohd-Esa et al [18]; Farombi & Fakoya [19]; Joven et al [20]; and Fernández-Arroyo et al [21] and Alaa [22]. To make it easier to serve as medicine; especially as an antioxidant; *H. sabdariffa* petals are made into a herbal tea mixture [23]. Bread treated with roselle seeds had reduced lipid oxidation compared to bread treated with BHT [18].

The bioactivity of *H. sabdariffa* as an antioxidant varies depending on the organ; the compound used for the extract and its concentration. The *H. sabdariffa* processing process affects the bioactive content and its bioactivity as an antioxidant. Processing by boiling is the best processing method with the highest nutritional value and polyphenol content [24]. The antioxidant bioactivity of *H. sabdariffa* is associated with the content of phenolic acids; flavonoids [17;18]; anthocyanins; and phenols [16]. Mohd-Esa et al [18] reported that rosella seed extract has the highest antioxidant activity compared to other organs. The ethyl acetate fraction from the ethanol extract of *H. sabdariffa* flowers has higher antioxidant and free radical effects compared to the chloroform fraction [19].

The chloroform fraction and ethyl acetate fraction are better scavengers of O₂⁻; OH and H₂O₂ compared to BHA; quercetin and α-tocopherol [19]. The total phenol content of *H. sabdariffa* was 77.2 mg/g and 87.7 mg/g for water and alcohol; respectively. Antioxidant activity was similar in levels for both rosella alcohol extract and BHT artificial antioxidant (75.67%); the alcohol extract showed the highest reducing ability with a level of 222.60%; iron ion chelation in water and alcohol extracts was 73.97 and 32.29 % at a concentration of 5 mg/ml [22]. Soluble dietary fiber was 0.66 g/L in the beverage; and 66% of the total extractable polyphenols contained in Roselle flowers were passed to the beverage and showed an antioxidant capacity of 335 mol Trolox equivalent/100 mL beverage measured by (2;2'-azinobis-(3-ethylbenzotiazolin)-6- sulfonate acid)/ABTS [25].

3.1.3. Hepatoprotective

Hepatoprotective compounds are compounds that can restore liver function. The extract of *H. sabdariffa* also demonstrated hepatoprotection by influencing the levels of lipid peroxidation products and liver marker enzymes in experimental hyperammonemia [26]. The antihepatotoxic activity of Hibiscus sabdariffa extract in STZ diabetic rats may be partly related to the antioxidant activity and the presence of flavonoids [27]. The water extract of *H. sabdariffa* given to hepatotoxic mice (induced with paracetamol) orally at a concentration above 200 mg/Kg for five days showed that liver histology and biochemical indices of liver damage returned to normal [9].

The oral administration of *H. sabdariffa* dried flower extract (200 and 300mg/kg body weight) significantly decreased 37% sodium arsenate (SA) and malondialdehyde (MDA) formation in the liver [28]. Protocatechuic acid and anthocyanins from *H. sabdariffa* protect against oxidative damage caused by tertiary-Butyl-hydroperoxide (t-BHP) in rat primary hepatocytes [4]. The aqueous fraction of *H. sabdariffa* petals rich in flavonoids from its methanol extract has anti-hepatotoxic activity in streptozotocin-induced diabetic Wistar rats [27]. Increased levels of aspartate amino transferase (AST); alanine amino transferase (ALT) and alkaline phosphatase (ALP) in the serum of diabetic mice were restored in treated Hibiscus sabdariffa [27].

3.1.4. Anti-Cancer

Cancer is a disease caused by excessive cell division. Plants used as anti-cancer agents produce compounds that can inhibit cancer cell division but do not interfere with normal cells. Protocatechuic acid from *H. sabdariffa* inhibits the carcinogenic action of various chemicals in various rat tissues [26]. The crude extract of *H. sabdariffa* induces chemoprevention; selective cytotoxicity; cell cycle arrest; apoptosis; autophagy; and anti-metastasis effects in various types of human cancer cells [11]. The calyx of *H. sabdariffa* methanol extract showed significant selective activity against leukemia lines (with concentration dependent; cytotoxic and cytotoxic effects [29].

High amounts of polyphenol content are associated with inducing strong anticancer effects [11]. The highest contents of phenolics and flavonoids were observed in leaf extract (389.98 and 104.52 mg g⁻¹; respectively) and petal extract (474.09 and 148.35 mg g⁻¹; respectively) [29]. *H. sabdariffa* anthocyanins and polyphenols have been proven to cause cancer cell apoptosis; especially in leukemia and gastric cancer. Various extracts of *H. sabdariffa* show activity against atherosclerosis; liver disease; cancer; diabetes and other metabolic syndromes [4].

3.1.5. Anti-Hypertension

Hypertension is a metabolic disorder that results in blood vessel pressure above normal. The use of *H. sabdariffa* as an antihypertensive has been widely reported. The calyx of *H. sabdariffa* extract has demonstrated hypocholesterolemia and antihypertensive properties [23]. *Hibiscus sabdariffa* has been used effectively in traditional medicine for the treatment of hypertension [4]. The infusion *H. sabdariffa* is a very popular drink in various parts of the world and its phytochemicals are associated with antioxidant; hypotensive and anti-atherosclerotic effects [30]. The tea of *H. sabdariffa* is as effective in lowering blood pressure as the commonly used blood pressure medication Captopril; but less effective than Lisinopril [13].

Daily consumption of *H. sabdariffa* tea; in amounts readily incorporated into the diet; lowers blood pressure in pre- and mildly hypertensive adults [23]. In hypertensive and normotensive rats after intravenous injection of 1-125 mg/kg *H. sabdariffa* has negative antihypertensive; hypotensive and chronotropic effects. A significant reduction in arterial pressure was found in hypertensive rats (L-NAME induced) compared with controls [31]. Patients with hypertension receiving two cups of standard tamarind tea every morning for 1 month showed a significant reduction in systolic blood pressure [32]. Administration of *H. sabdariffa* tea reduced systolic blood pressure by 11.2% and diastolic blood pressure by 10.7% in the experimental group 12 days after starting treatment; compared with the first day. Three days after stopping treatment; systolic blood pressure increased by 7.9%; and diastolic blood pressure increased by 5.6% in the experimental and control groups [33].

Hibiscus sabdariffa extract reduces blood pressure in humans and this effect is due to the inhibition of angiotensin-converting enzyme (ACE) activity [2;5] and a direct vasorelaxant effect or modulation of calcium channels [2]. Polyphenols induce beneficial endothelial responses that should be considered in the management of metabolic cardiovascular risk [20]. Water extract of dried petals of *Hibiscus sabdariffa* contains the anthocyanins delphinidin-3-O-sambubioside and cyanidin-3-O-sambubioside with competitive ACE inhibitor activity [5]. Phenolic acids (especially protocatechuic acid); organic acids (hydroxycitric acid) and anthocyanins (delphinidin-3-sambubioside and cyanidin-3-sambubioside) are thought to contribute to the anti-hypertensive effect [2]. *H. sabdariffa* aqueous extract (HSE) is rich in phenolic acids; flavonoids and anthocyanins [4].

The crude methanol extract of *H. sabdariffa* petals (HSE) shows anti-hypertensive effects in humans and experimental animals because it has a vasodilator effect on the aortic ring. This effect may be mediated through the endothelium-derived nitric oxide-cGMP relaxant pathway and inhibition of calcium (Ca^{2+}) influx into vascular smooth muscle cells [34]. The average blood pressure of patients given *H. sabdariffa* extract decreased from 52.2 ± 12.2 to 34.5 ± 9.3 mmHg so that *H. sabdariffa* has a positive effect on type II diabetes patients with mild hypertension [35].

In a randomized clinical trial (RCT); daily consumption of tea or extracts produced from *H. sabdariffa* petals significantly reduced systolic blood pressure (SBP) and diastolic blood pressure (DBP) in adults with pre- to moderate essential hypertension and type 2 diabetes [13]. The hypotensive and anti-cholesterol genic effects relate to the inhibitory effect of anthocyanins on LDL-C oxidation; which inhibits atherosclerosis; and is an important cardiovascular risk factor. The extract *H. sabdariffa* shows promise as a treatment for hypertension and hyperlipidemia [13].

3.1.6. Anti-Diabetes Mellitus

Diabetes mellitus is a metabolic disorder that results in blood glucose levels above normal; therefore anti-diabetic compounds are compounds that can inhibit glucose formation. *H. sabdariffa* bioactivity as an anti-diabetic inhibitor of α -glucosidase and α -amylase [2]. Phenolic acids (especially protocatechuic acid); organic acids (hydroxycitric acid) and anthocyanins (delphinidin-3-sambubioside and cyanidin-3-sambubioside) are associated with anti-diabetes mellitus [2]. The petals *H. sabdariffa* contain chemical compounds (Quercetin; Hibiscetin; Gossypetin; Protocatechuic Acid) which have lower docking scores and better potential as inhibitors of the protein enzyme Phosphoenolpyruvate Carboxylase (PEPCK) than Metformin (a standard drug for diabetes mellitus) [36].

3.1.7. Anti-Hypercholesterolemia

Hyper-cholesterolemia is a condition where blood serum cholesterol levels are above normal which can result in various metabolic disorders in the body. *H. sabdariffa* has long been used as a soft drink and medicinal herb in Taiwan; having been found to reduce blood lipids in animals [26]. The use of *H. sabdariffa* as an anti-hyper-lipidemia has been widely reported; including Hirunpanich et al [37]; Lin et al [26]; Gurrola-Díaz et al [38]; and Gosain et al [39].

Administration of dry extract of rosella flower petals (doses of 500 and 1000 mg/kg for 6 weeks) to hypercholesterolemic mice significantly reduced cholesterol levels (22% and 26% respectively) and triglyceride levels (33% and 28%); blood serum LDL levels. (22% and 32%); but did not affect high density lipoprotein (HDL) levels. The aqueous extract of dried rosella petals has both effects on low density lipoprotein (LDL) oxidation; and hypolipidemic effects in vivo [37].

Clinical trials of *H. sabdariffa* extract using oral capsules caused a significant reduction in serum cholesterol levels after 4 weeks [26]. Patients treated with high density lipoprotein extract had significantly reduced total cholesterol; increased HDL-c; and increased TAG/HDL-c ratio; a marker of insulin resistance [38]. Administration of *H. sabdariffa* ethanol extract (200 mg/kg and 300 mg/kg) to hyperlipidemic mice showed a significant reduction in serum cholesterol levels (18.5% and 22%); serum triglyceride levels (15.6% and 20.6%); serum LDL levels (24% and 30%); and serum very low density lipoprotein (VLDL) levels (15.5% and 20.5%); compared with the cholesterol group. Administration

of *H. sabdariffa* ethanol extract (HSSE) at a concentration of 300 mg/kg is more effective than HSEE at a dose of 200 mg/kg but less effective than the standard drug; atorvastatin [39].

Total cholesterol; low-density lipoprotein cholesterol (LDL-C); and triglycerides were lowered in most normolipidemic; hypolipidemic; and animal models of diabetes; whereas high-density lipoprotein cholesterol (HDL-C) was generally not affected by *H. sabdariffa* extract consumption. Anthocyanins found abundantly in *H. sabdariffa* petals are generally considered to be the phytochemicals responsible for their antihypertensive and hypo-cholesterolemic effects; but evidence has also been provided for the role of hibiscus polyphenols and acids [13].

3.1.8. Anti-Obesity

Obesity is a condition associated with the accumulation of excess fat in the body; energy imbalance; lipogenesis; which increases the mass of adipose tissue through adipogenesis which poses a risk to health [40]. Water extract of Hibiscus sabdariffa petals reduces body weight in animal models of obesity caused by administration of monosodium glutamate. Hibiscus sabdariffa water extract; contains 33.64 mg of total anthocyanins per every 120 mg of extract. Administration of *H. sabdariffa* significantly reduced weight gain in obese mice (orally 120 mg/kg/day for 60 days) and increased fluid intake in healthy individuals and obese mice. Triglyceride and cholesterol levels showed an insignificant decrease in the treated animals with Hibiscus sabdariffa [41].

The toxicity of consuming *H. sabdariffa* is dose dependent and can cause side effects when administered over a long period of time [40]. The bioactivity of *H. sabdariffa* in the treatment of obesity with marked reduction in body weight; inhibition of lipid accumulation and suppression of adipogenesis through the PPAR pathway and other transcription factors [40]. Anthocyanins significantly decrease LDL oxidation; inhibit adipogenesis by regulating adipogenic signaling pathways and transcription factors; and modulate the expression of certain microRNA genes [30].

3.1.9. Anti-Microbial

The aqueous-methanol extract of *H. sabdariffa* has antimicrobial activity [42;43]. The extract of *H. sabdariffa* contains cardiac glycosides; flavonoids; saponins and alkaloids [42]. *H. sabdariffa* extract has antibacterial to *Staphylococcus aureus*; *Bacillus stearothermophilus*; *Micrococcus luteus*; *Serratia marcescens*; *Clostridium sporogenes*; *Escherichia coli*; *Klebsiella pneumoniae*; *Bacillus cereus*; and *Pseudomonas fluorescens* [42]. The antibacterial activity of roselle extract against *E. coli*; *S. aureus*; *S. mutans* and *Pseudomonas aeruginosa*; showed various levels of inhibition in the organisms tested [22].

Roselle was found to be rich in malic acid; anthocyanins; ascorbic acid and minerals; especially Ca and Fe; but low in glucose [43]. The ethanolic inhibition of roselle extract against *B. subtilis* and *S. aureus* was slightly higher than that of the water extract but this difference was not significant. However; *E. coli* was strongly inhibited by Roselle water extract at concentrations of 25 and 50 mg/mL as determined by the paper disk method [43].

3.1.10. Treat to Kidney Stones

Kidney stones; also known as nephrolithiasis; is a condition where solid deposits form in the kidneys which originate from chemicals in the urine. Plants that are able to treat kidney stones are related to their uricosuric effects [44]. *H. sabdariffa* has been widely used in Traditional Mexican Medicine as an antihypertensive and diuretic [41]. Various plants have long been used to treat kidney stones; such as cat's whiskers and *Strobilanthes crispus*. A cup of tea made from 1.5 g of dried *H. sabdariffa* flower petals was given to subjects twice a day (morning and evening) for 15 days and after drinking it; it showed clearance of uric acid in the kidney stone group [44]. The bioactivity of Hibiscus sabdariffa water extract for treating kidney stones is influenced by its concentration and bioactive compounds [41]. *H. sabdariffa* water extraction contains delphinidin-3-O-sambubioside; cyanidin-3-O-sambubioside; quercetin; rutin and acids that cause the release of nitric oxide from the vascular endothelium and promote renal vasorelaxation by increasing renal filtration [41].

3.1.11. Foodstuffs

Plants that can be used as food are plants that have nutritional value. Hibiscus sabdariffa flower drink is widely consumed in Mexico [25] and Indonesia. Roselle flowers contain dietary fiber as the largest component (33.9%) and are rich in phenolic compounds (6.13%) [25]. The main nutritional content of *H. sabdariffa* is glucose (sugar); malic acid (organic acid); tocopherol and linoleic acid (fatty acid) [3]. Roselle seeds are rich in fatty acids such as linoleic/oleic (most abundant); sterols (β -sitosterol; campesterol; -5-avenasterol; cholesterol; and clerosterol); and tocopherol [45].

Ash content (3.15%); crude fat (10.89%) and water content (1.16%) in rosella flower petals (red) samples soaked in ash; while crude fiber content (8.12%); carbohydrate content (79.68%) and protein content (6.64%) are high. Roselle flower petals (green) soaked in wood ash also showed a decrease in ash content (4.45%); crude fat (0.85%); water content (78.91%) [46]. *H. sabdariffa* is very rich in essential minerals and nutrients such as: Iron; copper; calcium; magnesium; manganese necessary for healthy growth in humans. *H. sabdariffa* extract contains tannins (17.0%); saponins (0.96%); phenols (1.1%); glycosides (0.13%); alkaloids (2.14%) and flavonoids (20.08%) [47].

Rosella petals can be considered as a food rich in lutein; chlorogenic acid and anthocyanin (delphinidin 3-sambubioside) [48] and ascorbic acid (vitamin C) [49]. *H. sabdariffa* is also widely used as an additive in food processing so that it can improve the taste of these foods; such as flavoring for sauces; jellies; marmalades and soft drinks or for use as food coloring; and is a promising source of natural red coloring that is soluble in water [50].

Food ingredients added with *H. sabdariffa* extract have more attractive colors and last longer [3]. Anthocyanin; which is a natural water-soluble flavonoid pigment [50]. Anthocyanins in *H. sabdariffa* petals contain delphinidin-3-sambubioside; cyanidin-3-sambubioside; delphinidin-3-monoglucoside and cyanidin-3-monoglucoside [50] which is thought to be related to the color content. The compound 5-(Hydroxymethyl) furfural is the most abundant non-anthocyanin compound; while delphinidin-3-O-sambubioside is the main anthocyanin in both extracts [3]. Other ingredients in *H. sabdariffa* are carotenoids (all-trans-lutein and all-trans- β -carotene); phenolics (delphinidin 3-sambubioside; 3-caffeoylquinic acid). The phenolic content of rosella petals is almost 60% (w/w) [48]. Two main anthocyanins are found in cold and hot extracts: delphinidin-3-sambubioside and cyanidin-3-sambubioside [51]. The degradation rate of delphinidin 3-O-sambubioside is higher than cyanidin 3-O-sambubioside [52]. In general; cold and hot extraction yield similar phytochemicals but; under cold extraction; color degradation is significantly lower and extraction time is 15-fold longer [51]. The quality of *H. sabdariffa* petals depends on the main ingredients; namely delphinidin-3-sambubioside and cyanidin-3-sambubioside [53].

4. Conclusion

- In traditional medicine; *H. sabdariffa* is used to treat digestive disorders; liver disease; fever; hypercholesterolemia; hypertension; obesity; prevention/treatment of cancer; cardiovascular and gout.
- The use of *H. sabdariffa* as a traditional medicine is related to its bioactivity; including as an antioxidant; anti-kidney stone; anti-microbial; anti-hypercholesterolemia; anti-diabetes mellitus. anti-hypertension; anti-cancer; and hepatoprotective.
- The bioactivity of *H. sabdariffa* is related to the content of secondary metabolites; especially the anthocyanins delphinidin-3-O-sambubioside and cyanidin-3-O-sambubioside

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest in this manuscript.

Statement of ethical approval

There is no animal/human subject involvement in this manuscript.

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