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REVIEW ARTICLE

Diving into the Vibrant World of Roselle Extraction: Unraveling Its Benefits

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Abstract

Roselle (Hibiscus sabdariffa L.) is a perennial plant native to tropical and subtropical areas. It is called *jamaica* in Spanish, and can also be found in China, Egypt, Indonesia, Malaysia, Nigeria, Thailand, and Saudi Arabia. The Roselle plant is an attractive and highly economical crop, rich in powerful bioactive compounds that help improve human health and well-being. Furthermore, the plant's aerial components are utilized in various cultures. The plant's flower is used to prepare various traditional foods, drinks, and medicines. Extraction methods are crucial to the Roselle extraction yield and extract qualities. This review highlighted several extraction methods that can be used in Roselle processing, this includes supercritical fluid extraction, solvent extraction, and mechanical pressing. The market demand for the Roselle was briefly explained, and the finding revealed that its demand is progressively growing. History shows that the utilization of Roselle extracts is mostly in the beauty, pharmaceutical, and food industries.

Keywords: Roselle; *Hibiscus sabdariffa L*.; Extraction; Natural Die; Industry Applications

Introduction

The *Hibiscus sabdariffa*, or roselle, is a flowering plant endemic to Africa, especially in the West African region. It became established in Asia and the West Indies during the 16th and early 17th centuries, and it has since expanded to several locations throughout those regions. Roselle flowers (Hibiscus sabdariffa) have been extensively studied for their numerous health benefits. The flower (Fig. 1) contains a substantial amount of cellulose, comprising 44–63.5% of its total content. Roselle is cultivated globally in tropical regions, including countries such as Senegal, Malaysia, the Philippines, India, and Mexico (Jamini & Islam, 2021). In Malaysia, roselle is commercially grown year-round, particularly in Terengganu, Johor, Penang, Selangor, Perak, and Kedah.

The calyces of the roselle are a great source of anthocyanins and are traditionally used to prepare a bright red beverage by decoction (Shi et al., 2021; Wu et al., 2018). Roselle calyces contain varieties of organic acids, phenolic compounds, and glucoside chemicals in addition to anthocyanins. The industrial use of roselle crops may increase if anthocyanins from roselle dry

calyces are recovered and used as a natural food coloring. The vibrantly colored roselle calyx is loaded with phytochemicals of pectin, organic acids, and anthocyanins. Anthocyanidin is a naturally occurring red pigment that dissolves in water. It is a derivative of flavonoids, which are present in phenolic substances. Besides their vibrant colors, anthocyanins also have anti-oxidant and bioactive properties linked to certain health benefits; for example, they have properties linked to anti-diabetic, anti-inflammatory, and anti-cancer effects (Santhakumar et al., 2015; Zaa et al., 2023). Many people recognize that foods prepared from Roselle calyx not only satisfy hunger but also provide a variety of health benefits. The primary bioactive compounds contributing to its health-promoting properties are phenolic compounds, predominantly concentrated in the calyx. The types of edible phenolic chemicals are phenolic acids and flavonoids. Roselle comprises several phenolic acids, including dihydroferulic acid-4-O-glucuronide, methyl chlorogenate, cryptochlorogenic acid, neochlorogenic acid, and chlorogenic acid (Izquierdo-Vega et al., 2020). It is known that the roselle calyx contains at least 95 flavonoids. Anthocyanins, which mostly consist of cyanidin-3-O-sambubioside and delphinidin-3-O-sambubioside, are the most prevalent type of flavonoids that have been found (Hapsari et al., 2021). Along with myricetin, kaempferol, methyl epigallocatechin, quercetin, and quercetin-3-glucoside, these flavonoids are also often mentioned. Overall phenolic content and antioxidant activity are favorably associated. Studies on phenolic chemicals conducted in the last few decades have supported the availability of numerous functional and therapeutic ingredients (Novais et al., 2022).

Roselle seeds, with their high phenolic, high fiber, and high protein contents, present a promising option for the development of health-promoting food products. Healthy foods encompass a range of foods that not only directly promote health by lowering the risk of chronic disease over a short period, but also foods enhanced with vitamins and polyphenols and meals that enhance consumers' overall well-being (Bagchi & Nair, 2016). Conversely, roselle leaves, which are rich in flavonoids, phenols, organic acid, and tocopherols, can be used to make silver nanoparticles and in the food and pharmaceutical industries.

The purpose of this review is to present a thorough analysis of the phenolic compounds found in Roselle, including their biological activity, composition, and health benefits for humans. It reviewed the color and oil extraction from the calyx of the Roselle flower. The future and the applications of the roselle in the various industries were also highlighted.



Figure 1. Roselle flower with a variety of benefits

Extraction Method of Roselle

Synthetic colorants are gradually taking the place of natural colorants due to their superior stability (against light, oxygen, heat, and pH), homogeneity, coloring power, independence from microbial contamination, and relatively low manufacturing costs (Mount & Anderson-Carnahan, 1988). However, because of the potential health hazards, the use of synthetics is gradually declining.

The food and pharmaceutical sectors use roselle, as a source of anthocyanins, which can subsequently be used as a source of natural colorants or pharmacologically active components. Therefore, it is required to upscale the extraction process to maximize its yield and engineer the resultant extracts into a concentrated form or dry powder. Variety methods such as supercritical carbon dioxide (SC-CO_2) (Norazlina & Kamal, 2015; Putra et al., 2023), solvent extraction (Hashim et al., 2023), and mechanical pressing (Chew et al., 2024; Savoire et al., 2013) have been used to extract natural products. The usage of sustainable natural products has grown in importance as people become more conscious of the negative environmental effects of synthetic items (Idham et al., 2022). It is crucial to select the best extraction methods and conditions in order to obtain excellent extraction yields from natural materials. Because of their qualities, benefits for health, and lower cytotoxicity than synthetic colorants, natural colorants are becoming more popular.

Supercritical Carbon Dioxide (SC-CO_2)

Supercritical carbon dioxide (SC-CO2) extraction, a key innovation in green technology, is experiencing rapid advancements and broader applications. This method is particularly advantageous due to its reduced solvent consumption, accelerated extraction times, and minimal waste generation. In place of solid sample extraction, this method is quickly becoming more and more popular (Zabihi et al., 2020). Moreover, it is rather new and shows great promise. In a study by Putra et al. (2023), the optimal particle size for SC-CO_2 extraction of roselle was investigated to maximize the recovery of total phenolic compounds (TPC), total anthocyanin compounds (TAC), and total flavonoid compounds (TFC). The results indicated that the highest yields were obtained under conditions of 30 MPa, 40 °C, and a particle size range of 250 µm to 355 µm. Specifically, the study achieved yields of 11.96% for TAC, 42.93 mg/100 g for TPC, and 239.36 mg/100 g for TFC. Fig. 2 illustrates the schematic architecture of the SC-CO2 extraction process, where ethanol was employed as a cosolvent.

Naeem et al. (2019) studied roselle extraction using the SC-CO_2, solvent extraction, hydraulic-press extraction, and screw-press extraction methods. According to their findings, the oil extracted from roselle seeds using a solvent had the highest oil content and extraction rate (17.98% and 98.34%, respectively) and the lowest acid and peroxide values. Compared to other extraction techniques, SC-CO_2 extraction yielded higher concentrations of alpha, gamma, and delta-tocopherol. In the fatty acid analysis, linoleic acid was the predominant component, followed by oleic and palmitic acids. When comparing solvent extraction to cold-press extraction, the quantities of these fatty acids were higher in the oil extracted using SC-CO_2. Oil extracted by SC-CO_2 showed the highest level of stability (20 hrs), TPC of 22.18 mg GAE/g, and antioxidant activity (DPPH, 65.15). This was followed by solvent extraction, screw pressing, and hydraulic press. The results indicated that optimizing parameters such as rotational speed, screw press temperature, extraction time, and motor power significantly improved the properties of the extracted roselle seed oil, including oxidative stability, total phenolic content (TPC), and radical scavenging activity. Notably, cold press extraction methods, compared to SC-CO2 extraction, yielded a higher amount of oil and proved to be more cost-effective.

In a related study, Idham et al. (2022) utilized SC-CO_2 to isolate anthocyanins, the naturally occurring red pigments, from roselle calyces. The study employed response surface methodology (RSM) with a three-factorial design to evaluate the effects of temperature, pressure, and co-solvent ratio (ethanol) on the extraction process. The RSM models assessed the extraction

efficiency of anthocyanins, total phenolic content (TPC), total flavonoid content (TFC), and color properties, including lightness (L*), chroma (C*), and hue (h°). The optimal conditions identified were 58 °C, 27 MPa, and an 8.86% co-solvent ratio, which maximized flavonoid, phenolic, and anthocyanin content while minimizing L* and C* values. Under these conditions, the extraction process yielded 1197 mg/100 g of anthocyanins from dried roselle calyces. The study also aimed to determine the optimal particle size for SC-CO2 extraction to enhance recovery of TPC, TAC, and TFC, and employed models to compute extraction yield, diffusivity, and solubility in SC-CO_2.

Silva et al. (2017) have conducted a comparative analysis of the advantages and disadvantages of various anthocyanin extraction techniques, including solid-liquid extraction, SC-CO_2, pressurized liquid extraction (PLE), ultrasound-assisted extraction (UAE), and microwave-assisted extraction (MAE). During the lengthy extraction period required for the solid-liquid extraction procedure, anthocyanin degradation may occur due to exposure to light, air, and acid. In the UAE approach, anthocyanin degradation may also result from heat-induced energy dissipation. Degradation is also facilitated by the high temperatures required for the extraction of PLE and MAE. The features of the vegetal matrix, the solvents utilized, the extraction process, and the storage conditions all have a major impact on the quality of natural extracts. To optimize yield and selectivity, great consideration must be given to the choice of solvents (Quispe-Fuentes et al., 2022).

Recently, the use of pure carbon dioxide in anthocyanin extraction from Roselle has been argued. SC-CO_2 extraction is not appropriate for anthocyanin recovery because of the polarity difference between CO_2 and anthocyanins, despite being a green extraction technique because it employs a benign solvent (Rizkiyah et al., 2023). To increase the polarity of CO_2, ethanol is now employed as a co-solvent. Thus, SC-CO_2 and ethanol as a co-solvent can be used to extract anthocyanins. Nonetheless, a higher co-solvent content in the mixture would lead to solvent-solvent interactions competing for the solutes' solvation, hence decreasing recovery (Putra et al., 2022). Ethanol is categorized as a generally recognized as safe (GRAS) solvent under the United Nations Sustainable Development Goals for Good Health and Well-Being because it is non-hazardous and falls under Class 3 of the US Food and Drug Administration's Guidance for Industry (Gad & Jr, 2014).

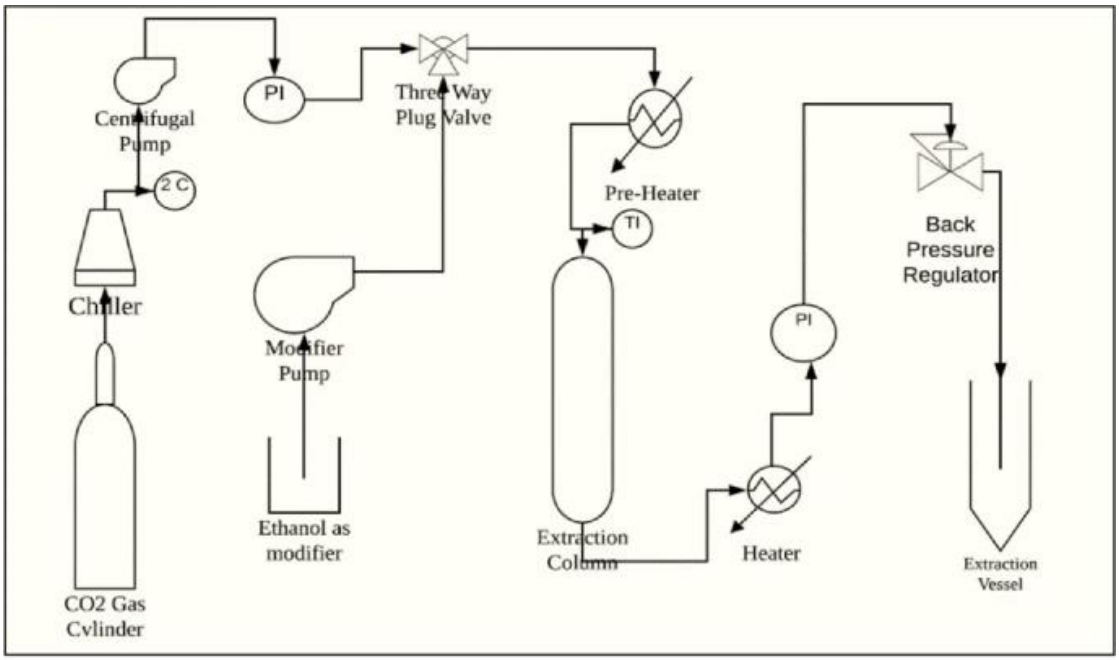


Figure 2. The SC-CO_2 schematic diagram (Putra et al., 2023)

Solvent Extraction

The solvent extraction of roselle is a critical process for obtaining valuable phytochemicals, particularly anthocyanins and antioxidants. The quantity and purity of these chemicals are highly dependent on different extraction techniques and solvents. Studies on the use of methanol and ethanol as solvents have revealed that the latter produce extracts with higher total phenolic content and antioxidant capabilities than the former (Lai et al., 2024).

Studies have shown that ethanolic extracts provide better antioxidant capabilities and overall phenolic content compared to aqueous extracts, indicating that ethanol and methanol are frequently utilized solvents. Due to its high ascorbic acid and anthocyanin content, Roselle has drawn the interest of several fruit juice producers in Malaysia. On the other hand, ascorbic acid and anthocyanin pigments are easily lost when fruit juice is processed. Thus, the effects of various processing techniques, including hot water extraction (HWE), hot water blending, cold water blending, and screw press, on the variations in ascorbic acid and anthocyanin concentrations of roselle juice were assessed in a study conducted by Wong et al. (2003). Their findings demonstrated that the HWE extraction process yields the highest anthocyanin and ascorbic acid levels, measuring 43 g L^{-1} and 2.34 g kg^{-1}, respectively. The ideal conditions for extracting juice were achieved at 60 °C for 3 hrs.

In recent years, there has been a lot of interest in deep eutectic solvents (DESs) as a novel environmentally friendly, and sustainable solvent for the extraction of bioactive chemicals from plants. The purpose of the research conducted by Zannou et al. (2020) was to determine the quality of hydrophilic DES extracted anthocyanin and polyphenol antioxidants from roselle. The DES was prepared in molar and molarity ratios. To assess the TPC, TFC, DPPH radical scavenging, total anthocyanin (TACN), and ferric reducing antioxidant power (FRAP) values of roselle, a naturally occurring hydrophilic DES composed of sodium acetate (hydrogen bond acceptor) and formic acid (hydrogen bond donor) was used. For comparison, standard solvents such as distilled water, 70% ethanol, and 80% methanol were utilized. The most efficient DES was determined to be the one made in molarity ratio. Anthocyanins were shown to be more stable, according to the stability tests. According to these results, the DES with molarity ratio is a useful green solvent for removing polyphenols from a variety of plants.

For ethno-medical and nutritional objectives, the extraction efficiency of phytochemicals and antioxidant capacity from two kinds of Roselle (*Hibiscus sabdariffa* var.) using aqueous and 80% methanolic solvent solutions was assessed (Chatepa et al., 2023). In comparison to water extracts, which ranged from 17.97 ± 0.08–258.06 ± 0.17 for dark red calyx leaf and methanolic red calyx calyces, respectively, methanolic extracts showed higher ($P < 0.05$) total phenolic compound in both red and dark red calyx *H. sabdariffa*. In contrast to aqueous extracts, which ranged from 4.1562 ± 0.0742–315.460 ± 0.428 for aqueous dark red calyx fruit and dark red calyx calyces, respectively, methanol had a higher anthocyanin concentration ($P < 0.05$). The quality and quantity of the extracts, as well as the phytochemicals and antioxidants of the extracts from the two *H. sabdariffa* kinds, were significantly impacted by the type and polarity of solvent used. Comparing methanolic extracts to aqueous extracts, the study found that the former had higher levels of anthocyanins, phytochemicals, and antioxidants.

In a recent study aimed at optimizing antioxidant activity, the following factors were meticulously examined using a Box-Behnken experimental design: the ethanol-to-water ratio, temperature, extraction duration, and solvent-to-solid ratio (Villalobos-Vega et al. 2023). The study comprised 27 experimental runs, including three repetitions at the central point. The results were analyzed using a second-degree polynomial equation. The response fluctuation can be explained by the model 87% of the time. Extraction of 1% solids in 35.5% ethanol at 60 °C for 33 minutes yields the highest level of antioxidant activity. Following laboratory scale optimization, Setyawan and Kartini (2023) achieved the following ideal conditions for stirring-assisted extraction (SAE) of anthocyanins from roselle: A 15% of crude drug weight to volume of solvent (S/L) ratio,

a 15-minute extraction time, and 50% ethanol acidified with 2% citric acid as the solvent (Setyawan & Kartini, 2023).

Mechanical Pressing

One of the simplest, oldest, and cheapest methods for extracting oil from seeds and other plant materials is mechanical pressing. To extract important components from roselle, especially anthocyanins, mechanical pressing is an essential approach. This technique is a top pick for both home and commercial settings since it uses pressure to improve production and quality. Applying pressure (using a screw press or hydraulic press) is the mechanical extraction method used to push oil out (Hashim et al., 2024). A compression step is used in the pressing phase to release fluid from the porous matrix that contains the target metabolites. Fruit and vegetable tissues have membranes all around their cells, which are sealed shut by a cell wall that is inserted into the middle lamella. The stiff wall's components limit the effectiveness of extraction by pushing since they shield the membranes from easy damage. The application of a uniaxial force on the material during hydraulic pressing causes the extract to separate from the matrix. For cocoa and olive oil, the pressure exerted on the raw material can reach levels of up to 100 MPa and 40 MPa, respectively (Schwartzberg, 1997).

A roselle anthocyanin extract and a technique for extracting anthocyanins from plants are provided in an invention (Honghui et al., 2020). To obtain the anthocyanin extract, the process entails fully drying a plant material containing anthocyanin, crushing the dried plant material into particles, adding water, performing pressurization extraction at least twice, concentrating the extracted solution, and spray drying the resultant mixture. The invention states that the high-quality roselle red pigment is used as a food additive and in health care products. The extract is obtained by combining superfine grinding, aqueous solvent pressurizing extraction, spray drying color protection, and other methods. The extract has the qualities of instant property, bright color, stable character, and other similar traits.

An investigation was conducted on the impact of the processing factors on the oil yield of roselle seed (Bamgboye & Adejumo, 2011). After being ground, the seeds were divided into two sizes of particles: fine and coarse. Using a hydraulic oil extractor, the samples were heated to various temperatures; 80, 90, 100, and 110° for 15, 20, 25, and 30 minutes. The samples were also expressed at 15, 22.5, 30, and 37.5 MPa for 10, 20, 30, and 40 minutes. When processing factors such as temperature and pressure are increased to a maximum of 100°C and 30 MPa, respectively, the oil yield increases by 5%-6%. The yield of finely ground samples was found to be higher than that of coarsely ground samples at various processing parameters. The yield of oil from roselle seed was discovered to be impacted by processing conditions. Homraruen and Chanpeng (2021) investigated the properties of roselle seed oil obtained through screw pressing. The study evaluated various characteristics including oil content, volatile matter, fixed carbon, ash content, and fatty acid composition from roselle seeds through frying and oven drying methods. The results indicated that roselle seeds had moisture contents ranging from 8% to 12%, volatile matter ranging from 1274 to 1323 ml per 0.0468 g of oil, fixed carbon content between 16.07% and 17.82%, and ash content ranging from 6.92% to 8.47%.

Hydraulic presses have gradually been replaced by screw presses. Pressing involves moving the raw material from the press's inlet to its outlet via a helical screw that is positioned in a barrel and directed toward a limit (Chemat et al., 2015). Shear pressures are created along the screw at the restriction area stage, allowing the oil in the seeds to express themselves. In the mechanical process, the oil is extracted by squeezing the substance seeds through a screw press. The seeds may be cracked or flaked before being let to reach the ideal temperature and moisture content. The oil is then extracted using a screw press. A screw press was used to extract oil from roselle seeds constantly, to achieve the best rotating speed, temperature, extraction time, and motor power for the extracted oil (Naeem et al., 2017). According to the findings, roselle seed oil

had a maximum production of 70.58%. The ideal temperature for screw pressing oil extraction was 45 °C, and the overall yield is proportionate to low velocity up to 30 rpm. The highest yield and the greatest oil quality were obtained at an extraction temperature of 45 °C and a motor speed of 30 rpm.

Applications of Roselle

Roselle is a Natural Dye in the Industry

A growing number of businesses are using Roselle extracts, which come from the calyxes of the *Hibiscus sabdariffa* plant, because of its unique qualities and possible health advantages. Using solvents or other extraction techniques, the active chemicals in the calyxes are extracted. The market for roselle extract is expanding due to the growing need for natural components in industries such as food & beverage, pharmaceuticals, and cosmetics (Sapuan et al., 2021). The extract's bright red hue, tart flavor, and possible health advantages make it extremely valuable (Mohd-Nasir et al., 2021). Meals are colored and flavored with roselle extract. The deep crimson color of this product enhances drinks, candies, baked goods, jams, and sauces. The acidic tang of the extract complements culinary tastes. The pharmaceutical and nutraceutical industry is recognizing the increasing potential health advantages of Roselle extract (Jamini & Islam, 2021).

The roselle market is anticipated to expand at a compound annual growth rate (CAGR) of 6.2% throughout the forecast period, from its estimated valuation of USD 1.35 billion in 2022 to USD 2.16 billion by 2029 as shown in Fig. 3 (MMR, 2023). Many important factors impact the growth and demand of the roselle industry. The market is seeing an increase in demand for natural and healthful items. A growing number of consumers are giving natural products priority since they are more conscious of their health and well-being. Roselle appeals to customers who are concerned about their health because it is natural and may have health benefits. The health advantages of roselle are becoming more well known.

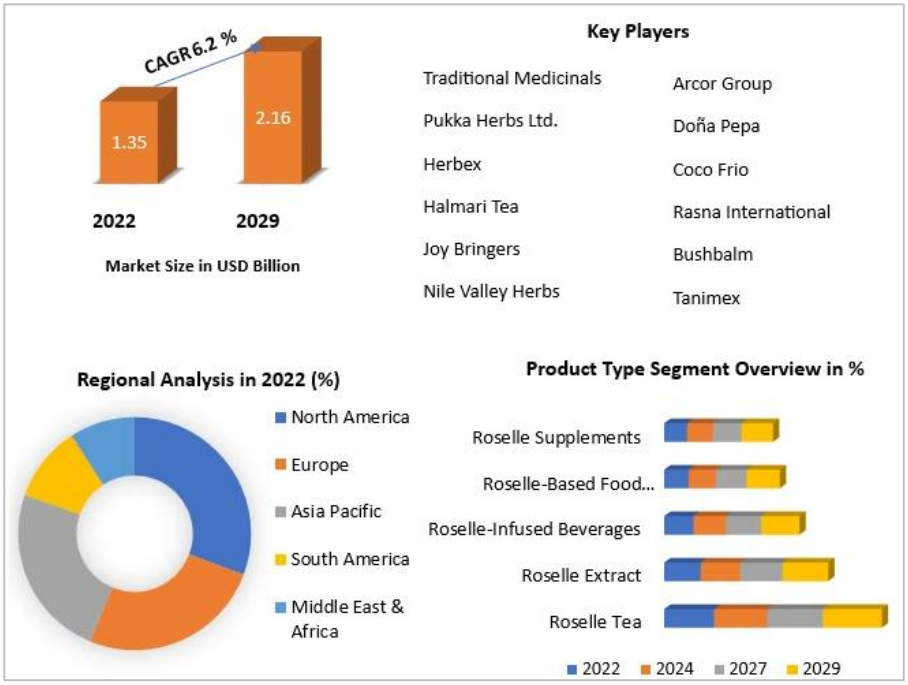


Figure 3: The value of the Roselle market from the year 2022 to 2029 (MMR, 2023)

Roselle in the Beauty Industry

Natural ingredients like roselle powder are frequently used in skincare products. This adaptable powder has grown in popularity in the beauty industry because of its extensive history and myriad skin advantages. Roselle powder is a beneficial addition to a wide range of skincare products, including face masks, cleansers, scrubs, serums, and creams. Roselle powder is well-known for minimizing fine lines and wrinkles, thereby promoting skin that looks younger (Islam et al., 2016). Its strong antioxidant content helps shield the skin from oxidative stress and environmental harm. Roselle powder's natural acids aid in skin exfoliation, exposing a more radiant and balanced complexion (Shruthi & Ramachandra, 2019). It keeps the skin moisturized and supple by assisting in moisture retention. Because of its calming qualities, roselle powder can help soothe irritated and inflamed skin. Its mild exfoliating action facilitates the removal of dead skin cells, clears clogged pores, and soothes the skin's texture.

An investigation into the clinical effects of roselle drink on blood pressure, skin condition, and antioxidant activity was the aim of a study conducted by (Chiu et al., 2022). The Roselle drink utilized in this study was rich in phenolics (1.96 g of gallic acid equivalent/100 ml) and anthocyanins (1.65 g of cyanidin-3-glucoside equivalent/100 ml). Participants who had roselle drinks showed a notable increase in both skin hydration and redness on their faces. Six months of oral roselle drink therapy resulted in a significant reduction in blood pressure, an increase in antioxidant capacity, and improved regulation of skin moisture and redness. The main possible causes of these health effects in roselle may be its phenols and anthocyanins. Vitamin C is present in roselle and helps reduce cholesterol and harmful fats.

Roselle in the Pharmaceutical Industry

The pharmaceutical and nutraceutical industry is recognizing the increasing potential health advantages of Roselle extract. Flavonoids and anthocyanins are examples of antioxidants that lower inflammation and safeguard the heart (Ullah et al., 2020). In numerous products, the extract supports heart health, blood pressure control, cholesterol level (Rason et al., 2018) and general well-being. The antioxidants in the extract are believed to protect the skin from oxidative damage and encourage a youthful appearance. Several factors, including the quality and availability of raw materials, extraction methods, product formulation, and consumer preferences, have an impact on the roselle extract market (Hoang et al., 2021).

Scientific research has demonstrated that Roselle possesses a range of beneficial effects, including the reduction of insulin resistance, cholesterol, obesity, anti-oxidant, antihypertensive, anti-aging, antinociceptive, antidiarrheal, anti-inflammatory, antiproliferative, anticarcinogenic, and chemopreventive effects on skin cancer (Jamini & Islam, 2021). The calyces of roselle are rich in calcium, iron, niacin, and riboflavin, according to a nutritional analysis (Islam et al., 2016). Consuming roselle products, such as fresh juice, tea, jam, jelly, or anthocyanin-rich capsules, protects the body from the damaging effects of free radicals through antioxidant activity. Researchers have investigated the potential role of roselle in assisting nerve growth factors, which are critical proteins involved in the formation of connections between brain neurons (Mishra et al., 2022). Eating roselle may help lessen the oxidative stress that free radicals cause to the brain, which is the main advantage. As an anti-inflammatory, it can also aid in reducing inflammation brought on by neurological illnesses including Parkinson's and Alzheimer's (El-Shiekh et al., 2020).

Furthermore, some studies indicate that roselle may enhance brain function and facilitate memory. According to research, consuming roselle tea or roselle extracts can help lessen inflammation brought on by chronic conditions like arthritis and asthma (Mardiah et al., 2015). The antibacterial qualities of roselle aid in the battle against oral microorganisms that can cause tooth decay and gum disease (Ray & Pattnaik, 2023). To maintain dental hygiene and possibly lower

the incidence of oral infections while encouraging healthier gums and teeth, roselle leaves are also utilized in a variety of forms and preparations (Imran et al., 2022). Roselle's anti-inflammatory qualities can also help to lessen gum inflammation, providing comfort to people who are uncomfortable with their gums. Stress, anxiety, and mood swings throughout the menstrual cycle can all be lessened by the vitamins and minerals in the roselle herb (Łagowska et al., 2014). It's also been suggested that it might help treat menstruation issues by helping to control the hormone balance in the body (Edo et al., 2023).

Additionally, studies have demonstrated that roselle extract enhances the absorption of fat-soluble vitamins and may contribute to the reduction of visceral belly fat (Morales-Luna et al., 2019). This demonstrates how roselle can help people lose weight by naturally accelerating their metabolism. Essential vitamins and minerals including iron, calcium, and vitamin C are abundant in the blossoms of the roselle plant. Vitamin C protects hair from oxidative damage caused by free radicals. Iron increases blood flow and calcium fortifies hair follicle roots, both of which promote healthy hair growth.

Roselle in the Food Industry

Several studies have shown that roselle and its extracts have useful qualities from which new goods with extra nutritive features could be developed that could enhance customers' health. Because of the high concentration of phytochemicals in Roselle food products, they are referred to as functional foods and may offer customers health advantages. To satisfy customer needs, developing new value-added products is one of the biggest difficulties facing businesses today. The edible, fleshy calyces and leaves of the roselle plant are widely used in salad dressings, tea, juices, jams, jellies, ice cream, and many other items. Fresh roselle calyces are gathered in various places to make pro-health drinks because of their high vitamin C and anthocyanin content. However, roselle leaves and calyces are consumed as vegetables in Bangladesh, and their fiber is substituted for jute (Islam et al., 2016). Table 1 displays the nutritional composition of 100 g of fresh roselle calyces, leaves, and seeds (Julia, 2013).

A study by Selim et al. (2008) found that incorporating encapsulated roselle pigments into hard candy (0.2%) and strawberry jam (0.1%) yielded products with color characteristics comparable to those of the control samples. A separate study by Dehankar et al. (2023) highlights the potential of these edible composite films for future applications in active food packaging.

Table 1. Nutritional composition of 100 g fresh roselle from different parts (Julia, 2013)

Constituents	Fresh Calyces	Fresh Leaves	Seeds
Moisture	9.20 g	85.60 g	8.2 g
Protein	1.15 g	3.30 g	19.6 g
Fat	2.61 g	0.30 g	16.00 g
Fiber	12.00 g	10.00 %	11.00 g
Energy	44 kcal	43 kcal	411 kcal
Ash	6.90 g	1.00 g	7.00 g
Calcium	12.63 mg	213.00 mg	356.00 mg
Phosphorus	273.20 mg	93.00 mg	462.00 mg
Iron	8.98 mg	4.80 mg	4.20 mg
Carotene	0.03 mg	4135 µg	-
Thiamine	0.12 mg	0.20 mg	0.10 mg

Riboflavin	0.28 mg	0.45 mg	0.15 mg
Niacine	3.77 mg	1.2 mg	1.40 mg
Ascorbic Acid	6.70 mg	54.00 mg	Trace
Carbohydrates	10.00 g	9.20 g	51.30 g

Conclusion

The health properties of Roselle are attributed to bioactive chemicals isolated from the plant. The plant is widely consumed worldwide and is reportedly safe and beneficial in several ways. Roselle is becoming more well-liked as an industrial, culinary, medicinal, and decorative plant. The calyx, leaf, seed, and stem of the roselle are generally used to make tea, oil, fibre, and drinks. A variable method for extraction of *H. sabdariffa* is developed to optimize the yield and maximize the use of the Roselle.

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