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REVIEW ARTICLE

## Roselle: A Functional Food with High Nutritional and Medicinal Values

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### ABSTRACT

Roselle (*Hibiscus sabdariffa* L.) is more than an eye-catching crop and has been used in number of dishes, beverages and conventional remedy of diseases for centuries. It is popular for its edible fleshy calyces and leaves that are used for making salads, tea, juices, jams, jellies, ice-cream, and many other products. In many countries of the world fresh calyces of roselle are harvested to produce pro-health drink due to its high vitamin C and anthocyanins contents. But in Bangladesh the roselle leaves and calyces are used as vegetables and its fibre is used as jute substitute. Roselle is also famous for its high nutritional and medicinal values. Nutritional analysis of the calyces of roselle showed that they are high in calcium, iron, niacin and riboflavin. It is also a source of antioxidants, anthocyanins which acts as free radical scavengers and inhibit lipid peroxidation. Consumption of roselle products such as fresh juice, tea, jam, jelly or in the form of capsule rich in anthocyanin protect human body from the harmful reaction of free radical by antioxidant activity. Roselle is a multipurpose crop and has great potential to increase the income of farmers, producers, processors of Bangladesh by fetching higher market price both from export and local market.

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### INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.) is popularly recognized as 'mesta' or 'chukur' in Indian subcontinent including Bangladesh (Halimatul et al. 2007; Rao 2008). Roselle is locally known by different names in different countries (Ismail et al. 2008). It belongs to the family of Malvaceae which is originated from West Africa (Shoosh 1993) and commonly available in the tropics especially in the African countries (Abu-Tarboush et al. 1997). It is widely cultivated in Tropical Africa, Sudan, Egypt, Ethiopia, Mali, Nigeria, Chad, India, Indonesia, the Phillipines, Malaysia, Brazil, Australia, Mexico, Hawaii and Florida of USA. The world largest producer is Thailand and China but the quality is the highest from Sudan (Food and Agriculture Organization). Roselle produced in Sudan fails to gain popularity due to its poor packaging and distribution. But in Sudan, it is a major crop of export. Roselle is an annual plant which requires around six months to complete its production cycle (**Figure 1**). Roselle is a miracle plant with various utilizations (Crane 1949). The leaves and calyx are used as vegetable in many countries of the tropics. There are three different color groups: green, red, dark red are available in the tropics (Purseglove 1977). The calyx of red and dark red types are used to extract juice for fresh drink after sweetened and the leaves of green types are used as vegetables (Babalola 2000).

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### ROSELLE PRODUCTION

Tropical warm and humid climate is suitable for roselle production. The temperature range within which roselle can grow in between 18 and 35°C with an optimum of 25°C (Ansari et al. 2013). Therefore, roselle can easily be grown in Bangladesh and used to promote nutraceutical and pharmaceutical industries. Superior quality roselle is produced by Sudan, Jamaica and Egypt. The best quality roselle produces in Sudan (Morton and Dowling 1987). The annual acreage of roselle in Sudan is fluctuating depending on the amount of rainfall and prices. Farmers are traditionally growing roselle in plots ranging from 0.25 ha to 2 ha, but some growers have up to 20 ha. Senegal and Mali are also produces roselle for their domestic use and are sold in local market. China and Thailand is the largest producers in Asia. Malaysia also started roselle cultivation as relatively a new crop to create industry (Mohammad et al. 2002). There is great market potential for roselle as a cash crop for farmers located in warmer climates where it grows well. The yield of fresh calyx range from 4–6.5 t ha<sup>-1</sup>, or about 800–1200 kg ha<sup>-1</sup> when dried to 12% moisture content. A single roselle plant may yield as many as 250 calyces, or 1–1.5 kg fresh weight depending on environmental conditions and management. Yield for leaves, is about 10 t ha<sup>-1</sup>.

## ROSELLE AS FUNCTIONAL FOOD

Generally roselle is considered as traditional medicine for the remedy of diuretic, mild laxative, cancer, cardiac and nerve diseases. Every fraction of roselle plants including leaves, fruits, roots, seeds are utilized in various foods. Among them, red fleshy calyces are employed for making fresh beverage tastes like Ribena, juice, jam, jelly, syrup, gelatin, pudding,

wine, cakes, ice-cream and flavors and also dried and brewed into tea (Rao 1996; Tsai et al. 2002). The bright red color coupled with exceptional flavor and other organoleptic attributes make them valuable food products (El-dawy and Khalil 1994) such as wine, syrup, ice cream, pies, snakes, tarts and other desserts (Duke and Atchley 1984; Eslaminejad and Zakaria 2011).



**Figure 1.** Roselle: *Hibiscus sabdariffa* L (a) field view (b) pot culture (c) calyx in the plant (d) calyces of HYV and local cultivar

The drink contains vitamin C and anthocyanins which act as an antioxidants. Anthocyanins present in roselle are delphinidin 3-sambubioside, cyanidin 3-sambubioside, delphinidin 3-glucoside and cyanidin 3-glucoside (Mgaya Kilima et al. 2014). Because of its commercial potential as a natural food and coloring agent roselle has drawn interest of manufacturers of food, beverage and pharmaceutical (Eslaminejad and Zakaria 2011). Roselle seeds are used to produce biodiesel and also used as animal feed as the seeds contain 17.8 to 21% non-edible oil (Ahmed 1980) and 20% protein (Ahmed and Nour 1981).

## NUTRITIONAL VALUE OF ROSELLE

Roselle contains high amount of vitamin C and anthocyanins which makes it unique for nutritional characteristics. Nutritionists have reported that roselle calyces are high in Ca, K, Mg, Na, niacin, riboflavin and iron. Nutritional composition of 100 g fresh roselle calyces, leaves and seeds are shown in Table 1.

**Table 1.** Nutritional composition of 100 g fresh roselle calyces, leaves and seeds

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	16.0 g
Fiber	12.00 g	10.00%	11.0 g
Energy	44 kcal	43 kcal	411 kcal
Ash	6.90 g	1.00 g	7.00g
Calcium	12.63 mg	213.00 mg	356 mg
Phosphorus	273.20 mg	93.00 mg	462 mg
Iron	8.98 mg	4.80 mg	4.2 mg
Carotene	0.03 mg	4135 µg	-
Thiamine	0.12 mg	0.2 mg	0.1 mg
Riboflavin	0.28 mg	0.45 mg	0.15 mg
Niacin	3.77 mg	1.2 mg	1.4 mg
Ascorbic Acid	6.70 mg	54 mg	trace
Carbohydrates	10.00 g	9.20 g	51.3 g

Sources: Leung et al. (1968); Duke and Atchley (1984); Morton (1987); Morton and Dowling (1987)

## USES OF DIFFERENT PARTS OF ROSELLE

Roselle is an underutilized multipurpose crop with enormous potential for medicinal and industrial use. It is used for numerous purposes from health to other uses in different

countries (Small 2011). The plant parts such as leaves, roots, fruits, seeds are used for different purposes:

### Leaves as Vegetables

In Bangladesh, roselle or mesta leaves are steamed with dried or fresh fish to make paste with garlic, onion, and chilies or cooked with fish. A popular soup or dish is also prepared from mesta leaves along with prawn stock. The young leaves of roselle are consumed as dal after steaming with lentils in India. Leaves are also used to make Pacchadi (pesto) by mixing with spices. In Assam (India), leaves of mesta are also cooked along with chicken or fish. The leaves are widely consumed as affordable vegetable in Myanmar for poor peoples (Dy Phon 2000).

### Calyx as Beverage

The production of a non- alcoholic beverage from red roselle calyces is very popular. It can be an option to the industrially produced soft drinks in terms of cost-effective choice. Either fresh or dried roselle calyces (Figure 2) are used to prepare drink. The calyces are first boiled to make dark red solution for 8-10 minutes and then sugar is added as sweetener. Before serving drinks are filtered and chilled into refrigerator for a while. The drink made from fresh fruits, juices or extracts are commonly consumed as cheap beverage in Mexico and Central America among several commonly consumed drinks. It is also a popular drink in many social events of African countries like Guyana, Antigua, Barbados, Diminica, Grenada, Jamaica, Trinidad, Tobago, Mali, Senegal, Gambia, Burkina Faso, Sudan and Benin. The dried calyces and readymade drinks are widely available in the groceries throughout the United Kingdom. It is also available in the health food stores in United States labeled as "Flor de Jamaica" (Fellows and Axtell 2014).

### Calyx as Tea

Tea prepared from roselle calyces have lots of health benefits and highly valued as organic product. It is a caffeine free herbal tea. Specifically, the tea is made out of the dried calyces (Figure 3). Roselle tea is a popular sugary herbal tea in Africa. It has also spread in Italy during the first decades of the 20<sup>th</sup> century and is quite common every where. In Thailand, roselle tea is believed to reduce cholesterol. Roselle tea is also produced in Jamaica by adding additional flavour from ginger. Roselle flowers are also widely used to make herbal tea (Mohamed et al. 2012).





**Figure 2.** Different roselle products (a) fruit bearing twigs (b) fresh calyces (c) dried calyces (d) fresh juice and (e) syrup



**Figure 3.** Roselle teabags (left), tea for serve (middle and right)

#### Yogurts with Roselle Flavour

Roselle juice can be used to prepare yogurts which have shown fabulous health benefits to improve gastrointestinal functions (Heyman 2000) which includes lactose digestion, lactose intolerance symptoms among the mal-digesters. It also lowered cholesterol level and reduce risk from hypertension (Taylor and Williams 1998) and helps to maintain the micro floral populations in the gastrointestinal (Boudraa et al. 1990; Iwalokun and Shittu 2007).

#### Calyx as Jam Preserves

One of the attractive and effective means of roselle utilization is jam processing (Desnosier 1970). Jam processing has been

known since the eighteenth century. Roselle jam is easy to make with only roselle calyces and sugar (Figure 4). The color of jams made from roselle calyces are red and tangy. Calyx of roselle is rich with various nutrients especially vitamins (B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub> and C), minerals and antioxidants. Antioxidants present in roselle calyces are good for our heart and health. Roselle jam has been made since Colonial period and still available in the community stalls of Australia. It is commonly sold as preserved fruits or jams in Myanmar. Roselle jam and jelly are also manufactured in different countries of the world and are available in supershops (Morton 1987; Mohamed et al. 2012).



**Figure 4.** Steps of processing of roselle jam (a) collect and clean fresh calyces (b) boil fresh calyces for 10-15 minutes (c) blend boiled calyces (d) heat blended calyces with sugar (e) ready jam preserve in jars

#### Roselle Seed

Roselle seeds contain 17% oil. The physical and chemical properties of roselle seed oil suggests that it could have several important industrial applications and justify its added value for cultivation (Mohamed et al. 2007). Roselle seed oil has a potential as vegetable oil that is low in cholesterol and rich in other phytosterols and tocopherols particularly  $\beta$ -sitosterol and  $\gamma$ -tocopherol. The seed oil can be used as an ingredient in cosmetics and paint industries. In addition, the seed oil is extracted and used for cooking and as an ingredient in paints. Seed oil can also be used to produce biodiesel (Nakpong and Wootthikanokkhan 2010).

#### MEDICINAL AND HEALTH BENEFITS

Roselle is a multipurpose plant and all above ground parts of roselle is used as traditional medicine for the treatment of several diseases in Africa, Senegal, India, Thailand and Mexico (Ngamjarus et al. 2010). Many medicinal applications of the plant parts of roselle have been reported in different countries of the world (Ageless 1999; Lin et al. 2011; Fullerton et al. 2011). Several reports listed which affirm the traditional health benefits of roselle extract:

- i. Roselle tea reduces the blood pressure in hypertensive and pre-hypertensive persons (Muhammad and Shakib 1995; Faraji and Tarkhani 1999).
- ii. Due to the presence of anthocyanins found in the extracts, roselle lowers bad cholesterol (LDL) levels in the blood

- (Hirunpanich et al. 2006; Lin et al. 2007; Kuriyan et al. 2010).
- iii. Roselle extracts shows anti-diabetic properties and induced sperm damage (Odigie et al. 2003).
  - iv. Roselle extracts is used to treat leukaemia, liver damage, hypertension, and pyrexia due to its high content of protocatechuic acid (Tseng et al. 2000).
  - v. The extracts of calyces reduce the deposits of calcium oxalate crystal on kidneys due to its uricosuric effect with no toxicity or negative side effects (Qi et al. 2005; Prasongwatana et al. 2008).
  - vi. It shows strong anti-cancer activities against prostate cancer cells (Duke 1983; Muhammad and Shakib 1995).
  - vii. The seed extracts of roselle inhibit growth of several fungus and bacteria (Olaleye 2007).
  - viii. Roselle extracts are perfectly safe for use in skin conditioning treatments (Ali et al. 2005).
  - ix. Roselle extracts has immune-protective effects which proved based on their ability to protect human cells against cadmium-induced damage such as tumor necrosis (Sulistiyani et al. 2016).
  - x. Calyx extracts act as a defensive means for liver diseases by destroying radicals and conserving enzymes responsible for medicine detoxification (Duh and Yen 1997; Furuta et al. 1998).
  - xi. Roselle extract's has anti-nociceptive, anti-inflammatory and anti-diarrheal qualities (Ali et al. 2005).
  - xii. Roselle extracts reduces extra fat from liver and abdomen (Cid-Ortega and Guerrero-Beltrá 2015).
  - xiii. Calyx extracts reduced body fat and body mass index (BMI) (Greenwood and Robinson 1999; Ghislain et al. 2011).
  - xiv. The boiled leaves help to remedy of cracks in the feet and speedup maturation of ulcers (Boudraa et al. 1990; Lin et al. 2007).
  - xv. Roselle juice with salt, pepper and molasses is used to relieve coughs and remedy of biliousness (Mohamed et al. 2012).
  - xvi. Helps to increase stamina and balance body electrolyte after sports ([www.onlinemlmcommunity.com](http://www.onlinemlmcommunity.com)).
  - xvii. Calyx extract also contain several amino acids those are important for our body (Al-Wandawi 2015).

#### PROCESSING OF CALYCES AND STORAGE

The edible parts of roselle are calyces and it can be easily peeled off from the center seed ball of the fruits after harvest. Sun drying is used to dry calyces during processing. On the other hand, many people use solar heaters which give sufficient aeration and limit excess exposure to heat, dust, insects and other pests (Miranda et al. 2014). Dehydrator is also used to dry fresh calyces. Dried calyces are stored in a cool place in to the glass jar out of direct sunlight. Refrigeration is not necessary to preserve dried calyces before use.

#### INTERNATIONAL TRADE OF ROSELLE

Worldwide business of roselle calyces is increasing day by day. The large importers of the world are Germany and the United States. Each year, the U.S. imports more than 5,000 metric tons of dried roselle calyces valued at \$22 million for use in making herbal teas. Egyptian and Sudanese roselle are highly paid, 1200-1700 US\$ per ton in United States and Germany as compared to the price of Chinese roselle ([www.usese.plantnet-project.org](http://www.usese.plantnet-project.org)). The quality of roselle of China and Thailand is low because of excessive precipitation during production due to that it prices is 4000 US\$ per ton. Other than China and Thailand, currently 18 companies of Malaysia are also engaged in the production, processing and marketing of roselle products for the local market. The current annual export value of fresh calyces to be RM2.5 million in Malaysia. The domestic market

consumes roselle calyces of around 500 tons per year, of which over 80% is used to process juice and drinks. In Malaysia, total market value of the roselle industry is to be RM10.0-15.0 million where about 65-80% of the value remains with the processor (Mohammad et al. 2002).

#### ROSELLE FOR FUTURE

Long-term consumption of diets rich in plant foods offers various defence against chronic diseases (Wallstrom et al. 2000; Odigie et al. 2003). Uncontrolled creation of free radicals is thought to be significantly concerned in the etiology of many chronic diseases (Guyton and Kensler 1993; Kehrer 1993; Stohs and Bagchi 1995). These observation spotlighted attention on the possible utilization of radical scavenging and radical suppressing nutrients from plant sources (Weisburger 1991). Fascinating research on antioxidant activity of roselle extract and their consumption can reduces or protect from many diseases.

#### PROSPECT OF ROSELLE IN BANGLADESH

Roselle is a multipurpose crop which can provide food and cash income as a vegetable and processing of domestic and industrial products. Dried calyces have high market potential for both export and local market. Demand for roselle products is increasing day by day due to the rising awareness in natural herbal products. The scope of exporting roselle calyces in United States and Europe are increasing gradually. Prospect of roselle in Bangladesh involves many socio-economic reasons influencing the choice of farmers. One of the main reasons is the market value of the crop. Farmers are not well aware of its versatile use and economic importance. Farmers prefer to grow cereals, pulses and other vegetables because they fetch higher market price compared to roselle or mesta. Farmers who are engaged in the production system are unaware about the versatility of roselle's and its products. They are growing it as a subsidiary crop, which is consumed at house level. None manufacturing units have come up with the production of edible products like concentrate, juice, tea, jam, jelly etc. made from roselle calyces which can enable to create more market niches. But it is becoming more and more popular because of the exports opportunities of the dried calyx and processed products. It has great potential to increase the income of farmers, producers and processors. However, few challenges should be taken into consideration in roselle production: (i) the price is determined by quality of calyx hence care should be taken during harvesting and when drying the calyces to avoid contamination by extraneous material, (ii) intensive labour is required for harvesting which increases the total cost of production. In addition, the following three points are advised to the growers:

- (i) roselle can be grown as a supplementary crop on the farm to boost income; it is drought tolerant and requires minimal attention and inputs once established.
- (ii) farmers are advised to grow and market the produce collectively in order to get better prices.
- (iii) value addition of the produce at farm level is also encouraged in order to get high returns.

#### CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this paper.

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