



Roselle (*Hibiscus sabdariffa* L.) in Sudan, Cultivation and Their Uses

Bahaeldeen Babiker Mohamed^{1*}, Abdelatif Ahmed Sulaiman² and Abdelhafiz Adam Dahab³

¹National Centre for Research (NCR), Dept. of Crop Production and Biodiversity, Khartoum, Sudan.

*Corresponding author E-mail: bbr.2009@gmail.com

²Agricultural Research Corporation (A.R.C), El Obeid Research Station, Sudan.

³National Centre for Research (NCR), Env. & Natural Resources Research Institute (ENRRI), Sudan.

ABSTRACT

More than 300 species of *Hibiscus* are grown over the world. It is an annual herbaceous shrub belonging to the family Malvaceae. Sudan is considered as the country in which Roselle originated, particularly in the Kordofan and Darfur areas. Roselle is known as karkade in the Sudan and other Arab countries. It is mainly grown for its fleshy calyx (sepals), which is the commercially valuable part of the plant. The color of the calyx plays an important role in determining the quality of karkade. The plant has some medicinal uses; in Europe, it is used in food preparation in sauces, jams, juices, jellies, syrups and flavoring, and as coloring agent for food and drinks. This paper is a review of the applications and production of roselle plants, and points out that roselle is a promising crop for medicinal uses, which is an aspect that has not been widely studied to date.

INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.) belongs to the family Malvaceae, locally called “karkade”, is an important annual crop grown successfully in tropical and sub-tropical climates [1]. The commercially important part of the plant is the fleshy calyx (sepals) surrounding the fruit (capsules). The whole plant can be used as beverage, or the dried calyces can be soaked in water to prepare a colorful cold drink, or may be boiled in water and taken as a hot drink. It also has some medicinal properties [2]. The seeds contain 17.8–21% non-edible oil [3] and 20% protein, and are sometimes used for animal feed [4]. Roselle is a flexible plant with a number of uses. It is intercropped with crop staples such as sorghum and sesame, or planted along field margins. It requires little care. Its leaves, seeds, capsules and stems are used in traditional medicines.

In rural areas women are usually responsible for growing roselle. They add value to the crop by developing products for market [5] Mclean [6] and Wilson and Menzel [7] reported that *Hibiscus sabdariffa* is a tetraploid ($2n = 4x = 72$), whose chromosomes are related to the diploid ($2n = 2x = 36$) *Hibiscus cannabinus*. The two botanical types of roselle are *Hibiscus sabdariffa* var. *sabdariffa*, grown for its fleshy, shiny-red calyx, and *Hibiscus sabdariffa* var. *altissima* [8] grown for its phloem fiber. Despite its potential economic importance, karkadi has received little attention and there is a lack of information regarding its genetics, breeding and production, particularly under rain-fed conditions.

Origin

Roselle may have been domesticated in western Sudan before 4000 BC; [23] it was first recorded in Europe in AD 1576. It seems to have been carried from Africa to the New World by slaves for use as a food plant. Roselle was called Jamaican sorrel in 1707 in Jamaica, where the regular use of the calyces as food seems to have been first practiced [24]. The use of the plant as “greens” was known in Java as early as 1658 [24,25]. Taken to the New World, roselle was cultivated in Mexico, parts of Central America, the West Indies, and in southern Florida, Texas and California in the late 19th century. It is now grown for culinary purposes in much of the tropical world. The use of *H. sabdariffa* for fiber seems to have developed in regions other than Africa [23].

Most breeding of roselle has been for its fiber yield [26]. Sudan is presently the major producer of roselle; however, farmers regard it as a famine food. When drought is expected, farmers prefer to cultivate roselle rather than cereals because of its hardiness under adverse conditions [12].

Roselle is grown for its calyces, which are exported from the Sudan, China and Thailand, and it is also grown for its calyces in Mexico. In the Sudan it is collected by goat-herding nomadic tribes, but the product is frequently inferior because of poor processing conditions. Nevertheless, the Sudanese product is attractively bright red, very acidic, and it is extremely popular in Germany, which imports most of the crop. Export prices for the 1992–93 season for Sudanese, Chinese and Thai roselle was of the order of \$US1700.00/t [27].

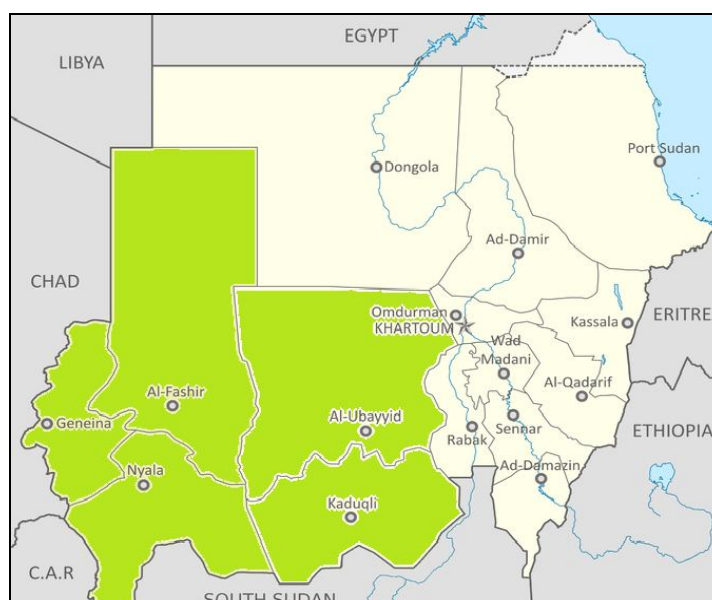
Karkade is grown in various parts of the Sudan, particularly Kordofan and Darfur. It is one of the cash crops cultivated by traditional farmers in Kordofan and Darfur States under rain-fed conditions, where large quantities are produced both for local consumption and for export. The total area under cultivation was estimated at 290,000 feddans (approximately 121,800 ha) in the 2000/2001 season, compared with 22,300 to 78,444 feddans (approx. 9370–32,950 ha) in the 1970s and 47998 to 59882 feddans (approx. 20,160–25,160 ha) in the 1980s. The increased area raised production from 454 tons in the 1960s to 26,000 tons in the 1999/2000 season [19].

Roselle is an important cash crop and a source of income for small farmers in western Sudan, especially in North Kordofan State. The crop is grown mainly by traditional farming methods, exclusively under rain-fed conditions [20].

China and Thailand are also major producers, and control much of the world’s supply. Thailand has invested heavily in roselle production and their product is of superior quality, whereas China’s product, with less stringent quality control practices, is less reliable and reputable. The world’s best roselle comes from the Sudan, but the quantity is low, and poor processing hampers quality. Mexico, Egypt, Senegal, Tanzania, Mali and Jamaica are also important suppliers but production is mostly used domestically [12].

Roselle names

Roselle (*Hibiscus sabdariffa* L.) is known in different countries by various common names, including roselle, razelle, sorrel, red sorrel, Jamaican sorrel, Indian sorrel, Guinea sorrel, sour-sour, and Queensland jelly plant [9,10]. In English-speaking countries it is known as roselle, Jamaican sorrel, red sorrel, Indian sorrel, rozelle hemp, natal sorrel and rosella. The Japanese name is rohzelu; also sabdriqa or lalambari in Urdu; and lal-ambari, patwa or laalambaar in Hindi [28]. In French, *roselle* also is the word for the red-winged thrush. In Switzerland, the edible calyx is called karkadé. The roselle fiber is called India rosella hemp, rosella fiber, rosella hemp or Pusa hemp. Vernacular names for roselle include rozelle, jelly okra, lemon bush, and Florida cranberry [29].



Map of Sudan showing the areas of roselle cultivation (colored green)

Uses

Roselle is a multi-use plant, whose outer leaves (calyx), also known as natal sorrel,[13] shown in Fig. 1, is frequently used in the production of jelly, jam, juice, wine, syrup, gelatin, pudding, cake, ice cream and flavoring. Its brilliant red color and unique flavor make it a valuable food product [11].

Roselle is an annual crop used in food, animal feed, nutraceuticals, cosmeceuticals and pharmaceuticals. The calyces, stems and leaves are acid in flavor. The juice from the calyces is claimed to be a health-enhancing drink due to its high content of vitamin C, anthocyanins and other antioxidants [12].



Fig.1. Roselle fruit branch (prepared by Bahaeldeen B.)



Fig.2. Roselle Drink (prepared by Bahaeldeen B.)

In Sudan, the dry calyx is used to produce a flavorsome and healthy drink (see Fig. 2) and dried calyces are used for tea, jelly, marmalade, ices, ice cream, sorbets, butter, pies, sauces, tarts, and other desserts[30]. The seeds have also been used as an aphrodisiac coffee substitute.

Roselle tea:

Sudanese roselle tea is well known as an organic product and is highly valued for its beneficial effects (see Table 1). Tea made from roselle flowers is widely exported for use in making a sweet herbal tea, and is also commonly sold on the domestic market. The dried flowers are common in all countries: see Fig. 3.



Fig.3. (left) Hibiscus teabags <http://www.elnasrltd.com> (right) Hibiscus flower tea <<http://www.gumarabic.sd>>

Table 1: Chemical composition of roselle (hibiscus) flower tea

Product type	Flavored tea
Type	Flower tea
Variety	Hibiscus flowers
Style	Flowering tea
Processing type	Fresh, raw
Specialty	Health tea, organic tea
Packaging	Bulk
Certification	SSMO
Grade	Flower
Place of origin	Sudan
Brand name	Hibiscus Flower Tea
Model number	KR-1
Moisture content	15% max
Extract content	41% min.
Protein content	5% max.
Ash and mineral salts	7% max
Impurities	2% max
Vitamins C (ascorbic acid)	80-100mg/100gm
Natural pigment	> 1.5 mg/100 g
Reducing sugar	12% max.
Fiber	15% min.
Total acids	25-30%

Medicinal and industrial applications

Many medicinal applications of the roselle plant have been developed around the world. In China it is used to treat hypertension, pyrexia and liver damage, and in ayurvedic medicine [16]. Recently the sepal extract has been used as an effective treatment against leukemia due to its high content in polyphenols, particularly protocatechuic acid [17]. Roselle seeds, which until now have not had any commercial applications, are a source of a vegetable oil that is low in cholesterol and rich in other phytosterols and tocopherols, particularly β -sitosterol and γ -tocopherol. The overall characteristics of roselle seed oil allow for important industrial applications and represent added value for its cultivation [18]. Roselle also has certain therapeutic properties; the reported benefits of taking it internally in the form of herbal tea include: soothing colds, clearing a blocked nose, clearing mucous, as an astringent, promoting kidney function, aiding digestion, as a general tonic, as a diuretic, and helping to reduce fever [13]. Taken as a drink made from the calyx, it is a mild diuretic and purgative, among many other effects. The drink is said to be a folk remedy for cancer. Restored roselle drink has no bacterial isolate [15].

Phytochemicals content

Roselle is rich in anthocyanins and protocatechuic acid. The dried calyces contain the flavonoids gossypetine, hibiscetine and sabdaretine. The major pigment, formerly reported as hibiscine, has been identified as daphniphylline. Small amounts of myrtillin (delphinidin 3-monoglucoside), chrysanthenin (cyanidin 3-monoglucoside), and delphinidin are also present. Roselle seeds are a good source of lipid-soluble antioxidants, particularly γ -tocopherol [18].

Table 2: Chemical analysis of dried karkade calyces (red and white) [22]

Component	Red karkadi (%)	White karkadi (%)
Moisture	11.00	9.30
Crude protein	7.88	7.53
Crude fiber	13.20	12.00
Crude fat	0.16	0.12
Ash	10.60	9.50
Total carbohydrates	57.16	61.55
Ascorbic acid (mg/100 g)	11.00	15.50
Titration acidity (mg/100 g)	9.00	11.00
Total soluble solids (%)	5.00	5.50
Calcium (mg/100 g)	60.00	50.00
Iron (mg/100 g)	25.00	20.00

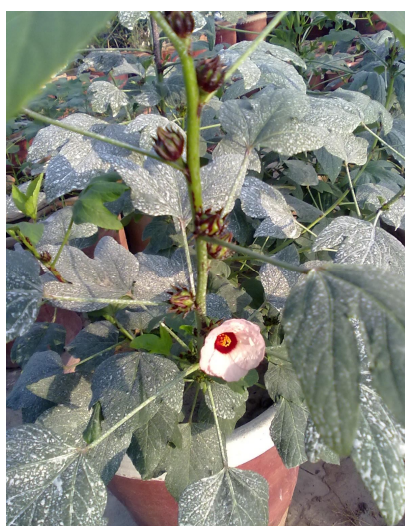
Roselle description

Roselle is an annual erect shrub that takes five months from planting to harvesting; it can also be regarded as a perennial [31]. Species grown for their fiber are tall, with fewer branches, sometimes growing to more than 3–5 m in height. Culinary varieties are many-branched, bushy, and generally 1–2 m tall [32]. Stems may be green or red, depending on the seed source. Roselle has a strong taproot. The young plants have leaves that are unlobed, but as the plant grows the later-developing leaves are shallowly to deeply palmate, 3- or 5-parted (sometimes 7-parted); see Fig. 4. The large flowers have pale yellow petals (sometimes suffused with pink or red) and a dark red eye [33].



Fig 4. Leaves of two roselle varieties: Abu Shankal (l) and Rahad mix (r)

The flowers are usually borne singly in the leaf axils. The sepals at the base of the large flowers and fruit vary from dark purple to bright red (sometimes white) at maturity, and are quite fleshy. The calyx increases from 1 to 2 cm in length before the flower is fertilized, then to about 5.5 cm (occasionally longer) at maturity. Some forms of roselle contain a pigment that gives a brilliant red color to culinary products made from the plant; other forms are completely green. Edible types of roselle are usually succulent, have well-developed lateral branches, and lack a hairy covering [23]. Flowering is induced as the days become shorter and the light intensity decreases, beginning in September or later depending on the country. Flowers are red to yellow, with a dark center containing short peduncles (Fig. 5), and have both male and female organs. The seed pods begin ripening near the bottom and proceed to the top (Fig. 6). In Sudan, growers sometimes allow the seed to completely ripen and let the leaves drop prior to harvest [21].



Figs. 5. Roselle flowering branch and seed pods (prepared by Bahaeldeen B.)

Climate

Roselle requires a monthly rainfall ranging from 130–250 mm in the first three to four months of growth. Dry weather is well tolerated, and is desirable in the latter months of growth. Rain or high humidity at harvest and drying times can downgrade the quality of the calyces and reduce the yield.

Planting

Roselle is very sensitive to changes in the length of day. This photoperiodism requires the planting time to be set according to the length of the day rather than rainfall requirements. It is a deep-rooted crop, therefore deep plowing is recommended in preparing the seedbed. Seeds are planted at a rate of 6–8 kg/ha and approximately 2.5 cm deep. Seeds are usually planted at the beginning of the rainy season, 60 cm – 1 m between rows and 45–60 cm apart. The reduced planting rate produces a larger calyx. Sowing is done by hand or using a modern grain drill. A good alternative tool would be a corn planter small enough to accommodate the hibiscus seeds. Thinning is also done by hand.

There are over 100 cultivars or seed varieties of *H. sabdariffa*. The major commercial varieties are those grown in China, Thailand, Mexico and Africa—principally Sudan, Senegal and Mali [21].

Harvest and storage

H. sabdariffa is harvested from late November onwards. The harvest is timed according to the ripeness of the seed. The fleshy calyces are harvested after the flower has dropped but before the seed pod has dried and opened. The longer the capsule remains on the plant after the seeds begin to ripen, the more susceptible the calyx is to disease and sun cracking [21].

The calyces ripen about three weeks after the start of flowering, which is 100–160 days after the plants are transplanted outdoors [27]. The fruit ripens progressively from the bottom of the plant to the top. Harvesting is carried out by intensive hand labor, the calyces being picked singly at the appropriate stage. The fruit may be harvested when fully grown but still tender, when they can be easily snapped off by hand; later harvesting requires clippers [34]. The fruit is easier to break off in the morning than at the end of the day. On average, each fruit yields about 7–10 g of sepals [25].

Drying is the traditional method for preserving foods. Roselle drying is done in one of two ways: by harvesting the fresh fruit and then sun-drying the calyces, or by leaving the fruit to partially dry on the plants and harvesting the dried fruit, keeping the crop well protected during the process. Dehydration depends on the two fundamental processes of heat transfer (heat is transferred into the fruit) and mass transfer (subsequent removal of moisture from it)[14].

In Sudan, the fully developed fleshy calyx is peeled from the fruit by hand and dried naturally in shade.

Pest control and weeds

Major diseases of hibiscus are stem rot and root rot. Prevention techniques include monitoring the water content in an irrigated field, and avoiding the planting of other crops that are also prone to these diseases. Insect damage is minor, but it does exist; pests include stem borer, flea beetles, abutilon moth, cotton bollworm and cutworm. Mealy bugs and leafhoppers are minor concerns, as is the cotton stainer. Plant enemies usually do not compete in a cultivated field [21].

Weeding can increase yield and calyx size. Roselle fields are generally weeded if necessary, and there are many weeds species observed in Sudan (Table 3).

Table 3: Species, classification and common names of weeds observed with roselle during the growing season in the Sudan.

Scientific name	Classification	Common name
<i>Zornia glochidiata</i>	Dicot	Sheilini
<i>Cenchrus biflorus</i>	Monocot	Alhuskaneet
<i>Trienemara pentanture</i>	Dicot	Alraba
<i>Sesamum alatum</i>	Dicot	Simsim elgumal
<i>Ocimum basilicum</i>	Dicot	Elryhan
<i>Allium spp</i>	Bulb	Bureaj
<i>Echinochloa colonum</i>	Monocot	Aldiffera
<i>Ruella patula</i>	Dicot	Tagtaga
<i>Corchorus olitorius</i>	Dicot	Almlukhia
<i>Tribulus terrestris</i>	Dicot	Aldraisa
<i>Ipomea cordofana</i>	Dicot	Eltabar
<i>Solanum dobium</i>	Dicot	Aljubain
<i>Abutilon figarinum</i>	Dicot	Alniada
<i>Ipomea sinensis</i>	Dicot	Elhantoot

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