



An Overview of the Roselle Plant with Particular Reference to Its Cultivation, Diseases and Usages

Mehdi Ansari¹, Touba Eslaminejad^{1*}, Zarrin Sarhadynejad²
and Tahereh Eslaminejad³

¹Pharmaceutics Research Centre (PRC), University of Medical Sciences, Kerman, IRAN.

²Herbal and Traditional Medicines Research Centre (HTMRC), University of Medical Sciences, Kerman, IRAN.

³Medical Education Development Centre (EDC), University of Medical Sciences, Kerman, IRAN.

Authors' contributions

This work was carried out in collaboration between all authors. Author Touba E designed the study, managed the literature searches and wrote the first draft of the manuscript. Authors MA and ZS, Tahereh E managed the analyses of the study and wrote the paper. All authors read and approved the final manuscript.

Research Article

Received 25th July 2012
Accepted 11th October 2012
Published 27th February 2013

ABSTRACT

Aims: This paper is a review of the applications, production and uses 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.

Study Design and Methodology: A review of the literature from the pioneering study of 1929 until 2012.

Place and Duration of Study: School of Biological Sciences, Universiti Sains Malaysia (USM), Penang, Malaysia, between June 2008 and July 2010.

Results: Our review of the studies mentioned in the literature was performed on the effects on Cultivation, Diseases and Usages of (*Hibiscus sabdariffa* L.) Roselle.

Conclusion: Roselle has been used as an herbal medicine in phytotherapy and nutritional plant in many years. According to the medical potential of this plant, need further work to validate reliability.

*Corresponding author: Email: tslaminejad@yahoo.com;

Keywords: Roselle; hibiscus; cultivation; Sudanese red tea; medicinal usages.

1. INTRODUCTION

There are more than 300 tropical and sub-tropical Hibiscus species [1]. Roselle, or Jamaica sorrel (*Hibiscus sabdariffa*) is a unique species cultivated in many tropical regions for its leaves, seeds, stem and calyces which, the dried calyces are used to prepare tea, syrup, jams and jellies as beverages [2]. Roselle is an annual plant which takes about six months to mature. Morphological characteristics of Roselle are illustrated in Fig. 1. The leaves of Roselle plants are divided into three to five lobes and they are arranged on the stem alternately. Each calyx lobe of the Roselle flower has a prominent central rib and two marginal ribs. These characteristics place the plant in the section of Furcaria [3]. Flowers are white to pale yellow in colour, with fleshy and soft calyces. The colour of the petals may vary from white to pink, red, orange, purple or yellow. The mature fruits are bright red [4-6].

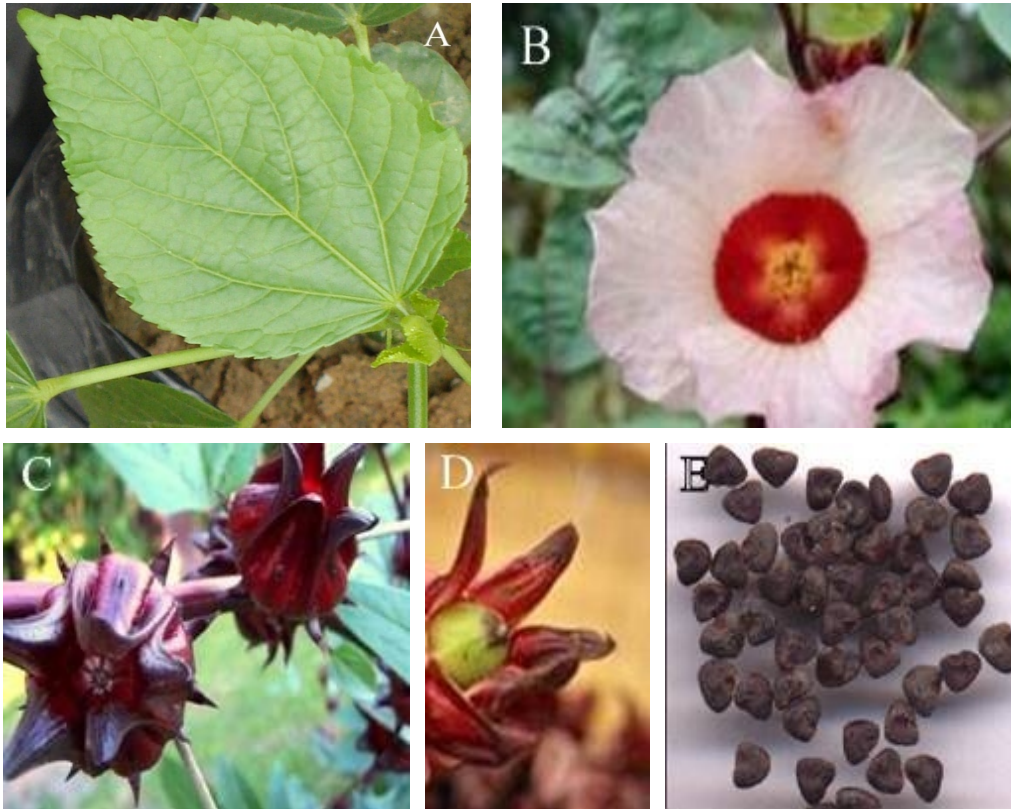


Fig. 1. Morphology of Roselle plant. (A) Leaves; (B) pink or yellow flower; (C) Red fresh calyces; (D) Fruit; (E) Dark brown seeds.

Source; (E) [7].

Roselle is locally known as 'Mesta' or 'Meshta' on the Indian Subcontinent [5,8]. Roselle is locally known by different names in different countries (Table 1). Roselle has drawn the attention of food, beverage and pharmaceutical manufacturers because of its commercial potential as a natural food and colouring agent that can replace some synthetic products [9].

Table 1. Names of Roselle in different regions

Regions	Vernacular names	Source
Caribbean	Sorrel	[5]
Egypt, Saudi Arabia, and Sudan	Karkade	[10]
Florida	Cranberry	[5]
Gambia	Wonjo	[11]
Indian Subcontinent	Mesta, Meshta	[5, 8]
Indonesia	Rosela	[5]
Latin America	Jamaica	[5]
Malaysia	Assam paya, Asam susur	[5,12]
Mali	Dah, Dah bleni	[11]
Myanmar	Chin baung	[11]
Namibia	Omutete	[5]
Nigeria	Zoborodo	[11]
Panama	Saril	[5]
Senegal, Congo and France	Bissap	[11]
Thailand	Krajeab	[11]

2. ORIGIN, DISTRIBUTION AND ECOLOGY

Roselle, which originated from Africa, was planted in Sudan about 6000 years ago [7]. Sudan is currently the major producer of Roselle as a source of Sudanese tea [13]. It was introduced to India and South America as a vegetable in the 17th century and was domesticated in Asia for use in fibre production [7]. There were reports of its cultivation, in India, Sri Lanka, Thailand, Malaysia and Indonesia at the beginning of the 20th century. According to [14], the extensive cultivation of this plant under a government subsidized programme was established to obtain fibre for sugar-sack manufacturing in the Dutch East Indies (now Indonesia) in the 1920s. Nowadays, it is found throughout the tropics especially in the Savannah region of West and Central Africa [7].

The warm and humid tropical climate is suitable for Roselle plants as it is exceptionally susceptible to frost and mist [4,6]. The temperature range within which Roselle thrives is between 18 and 35°C, with an optimum of 25°C. Growth of the plant ceases at 14°C [7]. In tropical and subtropical regions, an altitude 3000 ft. (900 m) above sea level is suitable for growing this plant [7]. Annual rainfall between 400 and 500 mm is necessary throughout the Roselle growing season [15]. Roselle is a short-day plant that is very sensitive to the photoperiod. In the first 4-5 months of its growth, Roselle requires a daily light phase of 13 hours [7]. According to [16], flowers would not appear if there were more than 13 hours of sunlight in a day, while [7] reported that flowering of Roselle plants was excellent when daylight was shorter than 12 hours. According to [16], Roselle plants prefer well-drained humus and rich-fertile soils with a pH of 4.5 to 8.0. It tolerates floods and heavy winds.

3. PROPAGATION

Roselle is commonly propagated by seeds, but it is also readily grown from cuttings [17]. Sowing is at the beginning of the rainy season in India. There are two approaches for sowing: sowing directly in the field and sowing in seed beds [15].

4. HARVESTING AND POST-HARVEST HANDLING

The fruits should be gathered sufficiently early before any woody matter forms in the pods, or in the calyxes [17]. Harvested stems are steeped in water for two weeks, followed by stripping of the bark and subsequently the stems are beaten to discrete their fibres. The beaten stems are washed, dried and sorted according to length, colour and stiffness to produce fibre [15]. The seed capsules are removed from the calyxes by round and sharpened metal tubes.

5. DISEASES OF ROSELLE

The expansion of Roselle planting has increased the threat of disease outbreak. As with other plants in the Malvaceae family, Roselle is at risk of diseases that affect the cotton crop. The symptoms of Roselle diseases caused by fungi, nematodes, bacteria and virus are illustrated in Fig. 2. In Malaysia cultivation of Roselle is subjected to a number of diseases outbreaks some of the common diseases of Roselle reported were root rots, stem rot, leaf spot and Fusarium wilt caused by, *Rhizoctonia solani*, *Sclerotium rolfsii*, *Cercospora hibisci* and *Fusarium oxysporum* [18]. According to [7] the most important diseases of Roselle are stale rots caused by *Phytophthora parasitica*, leaf fleck caused by *Phoma sabdariffa*, blackleg and stalk base rots caused by *Macrophomina phaseolina*, seed rots caused by *Rhizoctonia solani*, stem rots caused by *Sclerotium rolfsii*, leaf spot caused by *Cercospora hibisci*; and powdery mildew caused by *Oidium abelmoschii*. Root rots can be caused by *Botrytis cinerea*, *Phytophthora parasitica*, *Macrophomina phaseolina* and *R. solani*. In addition, vascular wilt of Roselle caused by *F. oxysporum* was reported in Malaysia by [19,20]. Fungal pathogens associated with Roselle diseases namely *Phoma exigua*, *Fusarium nygamai*, *Fusarium camptoceras* and *R. solani* were identified and characterised by [9]. According to [7], Roselle plants are also prone to attack by several virus diseases such as leaf curl, cotton leaf curl and yellow vein mosaic. A hard-cracking leaves disease caused by virus has been reported in Nigeria on Roselle plants. A bacterial disease has been reported on Roselle plants caused by *Bacillus solanacearum* [7]. Roselle plants have been seriously attacked by root-knot nematodes such as *Meloidogyne arenaria*, *M. incognita* and *M. javanica*. Another nematode, *Heterodera rudicicola*, has been recognized as a major pest affecting the roots of Roselle plants [7,21].

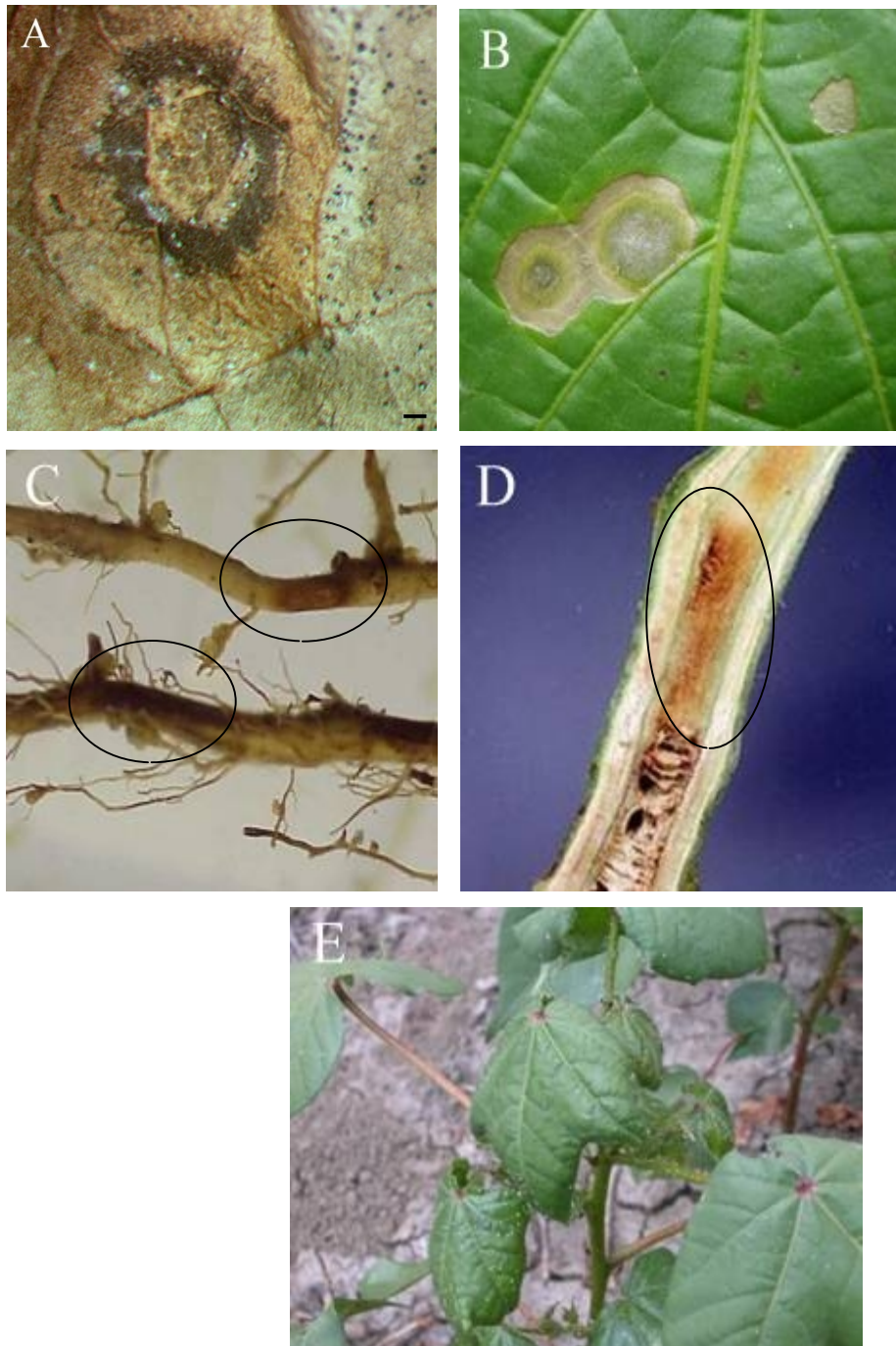


Fig. 2. Symptoms of Roselle diseases caused by fungi, nematodes, bacteria and virus. (A and B) Fungi diseases, *Phoma* sp. and *Fusarium* sp. respectively; (C) Nematode attack of roots; (D) Bacterial disease of stem; (E) Virus disease. Scale bar; A=1000 μ m. Source; (C) (*Nematode Diseases of Pearl Millet*, 2011)], (D) ("*Ralstonia solanacearum*," 2011)[23].

5.1 Fungal Diseases of Roselle

Vascular wilt of Roselle is caused by *F. oxysporum* that comes from plant debris and infected soil. Infected plants in the field show wilting of the whole shoot with necrotic lesions seen at the stem base and extending upward to the branches [24]. In addition, young and mature plants are flaccid with the stem tissues showing discolouration on the wood. [25], investigated this disease on Roselle plants in south-western Nigeria. [19], also observed this disease in Malaysia while [26], reported a similar disease for the first time on Roselle plants in the United States. Foliar blight of Roselle plants caused by *Phyllosticta hibisci* was reported by [25]. This fungus produces round black pycnidia in culture. Field symptoms of the disease include water-soaked necrotic spots on the young foliage. Pycnidia are often formed on the upper segment of the leaf spot in a ring around the centre of the lesion. According to [27], this disease is common in several tropical and sub-tropical areas. Leaf spot and stem canker diseases of Roselle caused by *Coniella musaiaensis* were first reported by [28] in Trinidad and Tobago. [29], also reported *Cercospora hibisci* as the causal agent of leaf spots. Small irregular and light blight lesions were observed on the lower leaves, young growing tips and mature stems. Pycnidia were produced on both surfaces of the leaves and severely infected leaves defoliated [28]. According to (30), root rots and collar rots of Roselle in Trinidad are caused by *Phytophthora nicotianae*. [31], have suggested that *Rhizoctonia bataticola* alone, or in combination with *F. oxysporum*, causes root rots and collar rots in Roselle plants. Powdery mildew of Roselle plants arising from infection by *Microsphaera euphorbiae* was reported by [32]. *Oidium* sp. and *Phytophthora sabdariffa* to be associated with mildew in Florida and the Philippines respectively found by [4]. In South Africa, botrytis blight of Roselle caused by *B. cinerea* was reported by [33]. The pathogen was isolated from affected stems and flower stalk tissues. It produced abundant conidia and mycelial on the surface of dead and infected tissues. This disease has significant impact on the yield of Roselle plants under cool and wet growing conditions. [33], observed foot and stem rots caused by *Phytophthora parasitica* var. *Sabdariffa*, a soil or water-borne fungus. Infection often occurs when there is stagnant water in the fields. Symptoms of the disease include black stems which result ultimately in the death of the infected plant. A list of fungi that cause diseases on Roselle is shown in Table 2.

6. NUTRITIONAL VALUES AND USAGES

The young shoots, leaves and calyces of Roselle are used as a cooked vegetable or cut and used as vegetable sauce [24]. According to [34], the dried red calyces have been used to prepare tea, syrup, jams and jellies as beverages. Leaves and young shoots of Roselle are eaten raw in salads, and the red fleshy calyx lobes are chopped and used in fruit salads in the United States [35]. [7], observe that the calyces are harvested as fodder for livestock in West Africa and Roselle seed oil is used in soap and cosmetics industries. In addition, the seed oil is extracted and used for cooking and as an ingredient in paints [5]. Roselle seeds are pounded into meal, added to cereals, or roasted and boiled as a coffee replacement in some parts of Africa, [15]. The seeds are also eaten roasted as snacks or ground into meal to make cakes. Nutrient compositions of different parts of Roselle are presented in Table 3. Roselle is an attractive garden plant. The cut flowers and also the decorative red stalks with ripe red fruits have been exported to Europe [36]. Besides that, the bast fibres, and sometimes the whole stem, have been used in the paper industry in the United States and Asia, [7].

Table 2. Fungi-causing diseases in Roselle

Host	Fungi species
Roselle	<i>Aecidium garckeanum</i> <i>A. hibiscisurattense</i> <i>Alternaria macrospora</i> <i>Cercospora abelmoschii</i> <i>C. malaysensis</i> <i>Corynespora cassiicola</i> <i>Cylindrocladium scoparium</i> <i>Diplodia hibiscina</i> <i>Fusarium decemcellulare</i> <i>F. sarcochroum</i> <i>F. solani</i> <i>F. vasinfectum</i> <i>Guignardia hibisci sabdariffa</i> <i>Irenopsis molleriana</i> <i>Leveillula taurica</i> <i>Microsphaera euphorbiae</i> <i>Phoma sabdariffae</i> <i>Phymatotrichum omnivorum</i> <i>Phytophthora parasitica</i> <i>Phytophthora terretris</i> <i>Pythium perniciosum</i> <i>Rhizoctonia solani</i> <i>Sclerotinia fuckeliana</i> <i>S. sclerotiorum</i> <i>Sclerotium rolfsii</i>

Source: (37).

7. TRADITIONAL MEDICINES OF ROSELLE

More importantly, Roselle is cultivated in the tropical and subtropical countries. It is considered as one of the important medicinal plant in some parts of the world (38). Roselle tea is used to control high blood pressure and its leaves are used as a source of mucilage in pharmacy and cosmetics [7]. According to [7], extractions of Roselle have been used medicinally to treat colds, toothaches, urinary tract infections and hangovers. In Senegal, the juice from Roselle leaves has been used to treat conjunctivitis. Roselle leaves have also been applied as a poultice to treat sores and ulcers, besides being used as an antiscorbutic for the treatment of scurvy, a refrigerant to relieve fevers, an emollient, a diuretic, and a sedative [16]. The leaves are not the only Roselle part that is useful for the treatment of scurvy. [39] reported that a root decoction of Roselle has also been used for a similar application. Ethno botanical information of Roselle plant revealed diuretic, diaphoretic, uricosuric, antibacterial, antifungal agent, mild laxative, sedative, antihypertensive, antitussive, gastrointestinal disorder treatment, hypercholesterolemia treatment, kidney stone treatment, liver damage treatment, agent for decreasing the viscosity of the blood, and agent for treating the after effects of drunkenness [40,41]. Roselle is consumed as hot and cold drinks to its uses in folk medicine. The drinks are widely used as diuretic, for treating gastrointestinal disorders, liver diseases, fever, hypercholesterolemia and hypertension [42]. The ripe calyces are used for hot and cold beverages and medicinally it is used as

antispasmodic, hypotensive and antimicrobial agent and for relaxation of the uterine muscle [43]. Roselle is a popular health drink among Malaysians who consume it for its high vitamin C and anthocyanin contents [2]. Anthocyanins and proanthocyanidins compounds of the Roselle calyces, could be the bioactive compounds responsible for lowering the blood pressure [44]. Quercetin of Roselle has an effect on the vascular endothelium, [41]. They mentioned oxide nitric increasing renal vasodilatation and kidney filtration.

Table 3. Nutritional information from different parts of Roselle

Nutritional value (unit/100g)	Flowers	Red Calyces	Green Calyces	Seeds
Ash Content (g)	9.75±0.59	12.24	6.83	6.89
Fat Content (g)	0.59±0.06	2.01	2.17	21.60
Crude Fibre (g)	33.9±3.59	4.69	6.75	4.12
Protein Content (g)	9.87±0.28	4.71	6.45	31.02
Moisture content (g)	4.38±0.05	7.60	6.24	9.25
Carbohydrate (g)	4.38 ±0.05	68.75	71.56	36.37
Sodium (mg)	ND	96.66	48.1	ND
Potassium (mg)	ND	49.35	49.59	ND
Calcium (mg)	ND	12.65	21.58	6.6
Magnesium (mg)	ND	38.65	47.54	ND
Iron (mg)	ND	3.22	3.37	ND
Zinc (mg)	ND	12.22	16.28	ND
Manganese (mg)	ND	2.39	5.61	ND
Nickel (mg)	ND	1.78	3.57	ND
Phosphorus (mg)	ND	36.30	15.05	6.8
Ascorbic acid (mg)	ND	16.67	12.50	ND

Sources: ((45); (46); (47)).
 ND: Non Determinate

8. CONCLUSION

The main conclusion that can be drawn is that Roselle has been used as an herbal medicine in phytotherapy and nutritional plant in many years. According to the medical potential of this plant, need further work to validate reliability.

CONSENT

Not applicable.

ETHICAL APPROVAL

Not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anderson NO, editor. Flower Breeding and Genetics: Issues, Challenges and Opportunities for the 21st Century. California: Springer; 2006.
2. Eslaminejad T, Zakaria M. Morphological characteristics and pathogenicity of fungi associated with Roselle (*Hibiscus Sabdariffa*) diseases in Penang, Malaysia. *Microbial Pathogenesis*. 2011;51(5):325-37.
3. Wilson F. *Hibiscus* section *Furcaria* (Malvaceae) in islands of the Pacific Basin. *Brittonia*. 1993;45(4):275-85.
4. Morton JF. Roselle. Fruits of warm climates: Julia F. Morton, Miami; 1987. p. 281-6.
5. Halimatul SMN, Amin I, Mohd.-Esa N, Nawalyah AG, Siti Muskinah M. Protein quality of Roselle (*Hibiscus sabdariffa* L.) seeds. *ASEAN Food Journal* 2007;14(2):131-40
6. Qi Y, Chin KL, Malekian F, Berhame M, Gager J. Biological characteristics, nutritional and medicinal value of Roselle (*Hibiscus sabdariffa*). *Circular- Urban Forestry Natural Resources and Environment* 2005. p. 1-2.
7. McClintock NC, Tahir IME. *Hibiscus sabdariffa* L. In: Grubben GJH, Denton OA, editors. *Vegetables/Legumes*. Wageningen, Netherlands: PROTA; 2004.
8. Rao P. Nutrient composition and biological evaluation of mesta (*Hibiscus sabdariffa*) seeds. *Plant Foods for Human Nutrition* [Internet]. 1996 October 11, 2008; 49(1):[27-34 pp.]. Available from: <http://www.springerlink.com/content/?k=10.1007%2fBF01092519+>.
9. Eslaminejad T, Zakaria M. Morphological characteristics and pathogenicity of fungi associated with Roselle (*Hibiscus Sabdariffa*) diseases in Penang, Malaysia. *Microbial Pathogenesis*. 2011;51(5):325-37. Epub 2011/08/16.
10. Abu-Tarboush HM, Ahmed SAB. Studies on karkade (*Hibiscus sabdariffa*): protease inhibitors, phytate, in vitro protein digestibility and gossypol content. *Food Chemistry*. 1996;56(1):15-9.
11. Omemu AM, Edema MO, Atayese AO, Obadina AO. A survey of the microflora of *Hibiscus sabdariffa* (Roselle) and the resulting "Zobo" juice. *African Journal of Biotechnology*. 2006;5(3):254-9.
12. Tee P, Yusof S, Mohamed S. Antioxidative properties of roselle (*Hibiscus sabdariffa* L.) in linoleic acid model system. *Nutrition & Food Science*. 2002 32 (1):190-6. MCB UP Ltd.
13. Mohammad O, Mohd. Nazir B, Abdul Rahman M, Herman S, editors. Roselle: A new crop in Malaysia. A grand international biotechnology event; 2002; Kuala Lumpur: BioMalaysia.
14. Appell SD. Red Sorrel, *Hibiscus sabdariffa* the other "Cranberry". *Plants & Gardens News*. 2003;18(2).
15. Augstburger F, Berger J, Censkowsky U, Heid P, Milz J, Streit. C. *Organic Farming in the Tropics and Subtropics, Exemplary Description of 20 Crops*. Vanilla: Grafelfing, Naturland; 2000.
16. Duke JA. *Hibiscus sabdariffa* 1983 [cited 2009 August 29]; Available from: http://www.hort.purdue.edu/newcrop/duke_energy/Gliricidia_sepium.html.
17. Rolfs pH. *Subtropical vegetable-Gardening*. New York: The Macmillan company; 1929. 360 p.
18. Eslaminejad T, Zakaria M, Tahereh E. Anti-fungal activity of cold and hot water extracts of spices against fungal pathogens of Roselle (*Hibiscus sabdariffa*) in vitro. *Microbial Pathogenesis*. 2012;52(2):125-9.
19. Ooi KH, Salleh B. Vegetative compatibility groups of *Fusarium oxysporum*, the causal organism of vascular wilt on Roselle in Malaysia. *Biotropia*. 1999;12:31-41.

20. Ooi KH, Salleh B, Hafiza MH, Zainal AAA. Interaction of *Fusarium oxysporum* with *Meloidogyne incognita* on Rosella. *Journal Indonesia Plant Protection*. 1999; 5:83-90.
21. McCaleb R. Roselle production manual (*Hibiscus sabdariffa*). 1996; Available from: <http://www.herbs.org/africa/hibiscus.html>.
22. Nematode Diseases of Pearl Millet. 2011 [cited 2011 February 20]; Available from: <http://www.tifton.uga.edu/fat/disnem.htm>.
23. *Ralstonia solanacearum*. 2011 [cited 2011 20 February]; Available from: http://www.ask.com/wiki/Ralstonia_solanacearum.
24. Amusa NA. Foliar blight of Roselle and its effect on yield in tropical forest region of southwestern Nigeria. *Mycopathologia*. 2004;157(3):327-31. Epub 2004/06/08.
25. Amusa NA, Adegbite AA, Oladapo MO. Vascular Wilt of Roselle (*Hibiscus sabdariffa* L. var. *sabdaeiffa*) in the Humid Forest Region of South-western Nigeria. *Plant Pathology*. 2005;4(2):122-5.
26. Ploetz RC, Palmateer AJ, Geiser DM, Juba JH. First Report of *Fusarium* Wilt Caused by *Fusarium oxysporum* on Roselle in the United States. *Plant Disease*. 2007;91(5):639-.
27. Amusa NA, Kogbe JOS, Ajibade SR. Stem and foliar blight in Roselle in the tropical forest region of South Western Nigeria. *Biotechnology*. 2001;76:681-4.
28. Persad C, Fortune M. A new disease of sorrel (*Hibiscus sabdariffa* var. *sabdariffa*) caused by *Coniella musaiaensis* var. *hibisci* from Trinidad and Tobago. *Plant Pathology* [Internet]. 1989 November 12, 2009; 38(4):[615-7 pp.]. Available from: <http://www3.interscience.wiley.com/cgi-bin/fulltext/119434036/PDFSTART>.
29. Westcott C, Horst RK. *Westcott's plant disease handbook*: springer; 2008. 512 p.
30. Jeavons R. *Studies in the etiology of collar rot of Hibiscus sabdariffa var. sabdariffa* L. MSc. Trinidad: University of the West Indies; 1975.
31. Horst RK, Westcott C, Horst CRK. *Westcott's Plant Disease Handbook*. 7 ed. New York: Springer 2008. 2008. 512 p.
32. Westcott C, Horst RK. *Westcott's plant disease handbook*. 6 ed: Kluwer Academic Publishers, Norwell, Massachusetts; 2001. 832 p.
33. Swart L, Langenhoven P. First Report of *Botrytis* Blight, Caused by *Botrytis cinerea*, on *Hibiscus* in South Africa. *Plant Disease*. 2000;84:487.
34. Fasoyiro SB, Babalola SO, Owosibo T. Chemical Composition and Sensory Quality of fruit-Flavored Roselle (*Hibiscus sabdariffa*) drinks. *World Journal of Agricultural Sciences*. 2005;1(2):161-4.
35. Facciola SC. *Cornucopia. A source book of edible plants*. : Kampong Publications, Vista, CA.; 1990.
36. Grubben GJH, Denton OA, Messiaen GM, Schippers RR, Lemmens RHMJ, Oyen LPA, editors. *Plant Resources of Tropical Africa*. Wageningen, Netherlands: Backhuys publishers; 2004.
37. Orwa C, Mutua A, Kindt R, Jamnadass R, Simons A. *Agroforestry Database: a tree reference and selection guide version 4.0*. ; 2009 [cited 2011 February 20]. Available from: <http://www.worldagroforestry.org/af/treedb/>.
38. Eslaminejad T, Ansari M, Elaminejad T. Evaluation of the potential of *Trichoderma viride* in the control of fungal pathogens of Roselle (*Hibiscus sabdariffa* L.) in vitro. *Microbial Pathogenesis*. 2012;52(4):201-5.
39. Gallaher RN, Gallaher K, Marshall AJ, Marshall AC. Mineral analysis of ten types of commercially available tea. *Journal of Food Composition and Analysis*. 2006;19(Supplement 1):S53-S7.
40. Alarcon-Aguilar FJ, Zamilpa A, Perez-Garcia MD, Almanza-Perez JC, Romero-Nunez E, Campos-Sepulveda EA, et al. Effect of *Hibiscus sabdariffa* on obesity in MSG mice. *Ethnopharmacology*. 2007;114:66-71.

41. Alarcón-Alonso J, Zamilpa A, Aguilar FA, Herrera-Ruiz M, Tortoriello J, Jimenez-Ferrer E, et al. Pharmacological characterization of the diuretic effect of *Hibiscus sabdariffa* Linn (Malvaceae) extract. Journal of Ethnopharmacology. 2012;139(3):751-6.
42. Ojeda D, Jiménez-Ferrer E, Zamilpa A, Herrera-Arellano A, Tortoriello J, Alvarez L. Inhibition of angiotensin convertin enzyme (ACE) activity by the anthocyanins delphinidin- and cyanidin-3-O-sambubiosides from *Hibiscus sabdariffa*. Ethnopharmacology. 2010;127:7-10.
43. Khalid H, Abdalla WE, Abdelgadir H, Opatz T, Efferth T. Gems from traditional north-African medicine: medicinal and aromatic plants from Sudan. Nat Prod Bioprospect. 2012;2:92-103.
44. Wahabi HA, Alansary LA, Al-Sabban AH, Glasziuo P. The effectiveness of *Hibiscus sabdariffa* in the treatment of hypertension: A systematic review. phytomedicine. 2010;17:83-6.
45. Sayago-ayerdi SG, Arranz S, Serrano J, Goni I. Dietary Fiber Content and Associated Antioxidant Compounds in Roselle Flower (*Hibiscus sabdariffa* L.) Beverage. Journal of Agricultural and Food Chemistry. 2007;55(19):7886–90.
46. Hainida E, Ismail A, Hashim N, Mohd.-Esa N, Zakiah A. Effects of defatted dried roselle (*Hibiscus sabdariffa*) seed powder on lipid profiles of hypercholesterolemia rats. Science of Food and Agriculture. 2007;88(6):1043 - 50. Society of Chemical Industry.
47. Adanlawo IG, Ajibade VA. Nutritive Value of the Two Varieties of Roselle (*Hibiscus sabdariffa*) Calyces Soaked with Wood Ash. Pakistan Journal of Nutrition. 2006;5(6):555-7.

© 2013 Ansari et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/3.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:
<http://www.sciencedomain.org/review-history.php?iid=159&id=13&aid=1002>