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An updated review on Malabar spinach (*Basella alba* and *Basella rubra*) and their importance

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Abstract

Recent studies have shown fruits from less-known and unexplored plants as an excellent source of nutrients and biologically active compounds for food and non-food applications (Khan *et al.* 2011, 2015). *Basella* plant is extremely heat tolerant and fast-growing perennial vine which is widely cultivated as a cool-season vegetable. *Basella alba* is also known as Malabar spinach, Indian spinach, Ceylon spinach, climber spinach and vine spinach. In India, it is commonly known as “Poi”. Red-violet colour of leaves, stalks, petioles and fruits are due to the presence of betalains (Palada *et al.* 1999). This crop is suitable for both home and market garden in the lowland tropics. This plant is full of nutrition like normal spinach. Also, the oil obtained from its seeds can become the source of safe vegetable oil. This plant is good for health due to the presence of mineral, protein, oil, carbohydrate, fibre, carotenoid, organic acid, vitamins. In the winter season, Malabar spinach can be used in place of normal spinach as it has similar Nutritional and medicinal value. *Basella* plant species contain betacyanin, carotenoids, bioflavonoids, β -sitosterol and lupeol which are reported to have antioxidant, antiproliferative, antimicrobial, anti-inflammatory activities etc. and help in curing various diseases, namely anticancer, antiviral, antioxidant, anti-inflammatory, anti-cholesterol, anti-ulcer, antimicrobial, anti-hypoglycemic, wound healing, androgenic from the ancient times. Leaf juice is used in to treat cataract and it is also an as safe laxative for children, pregnant women and in a urinary diseased patient. In Ayurveda Malabar spinach is called as “Upodika”, “Potaki”, “Malvaa”, “Amritvallari”, and in Siddha/Tamil as “Vaslakkirai” (Khare, 2004). It used as a vegetable in many countries like Philippines, Thailand China, Mongolia, India, Sri Lanka and many African countries. In India, In Andhra Pradesh curry of *Basella* and Yam is made popularly known as Kanda Bachali Koora, in Odisha, it is used to make Curries and *Saaga*.

Keywords: Malabar Spinach, *Basella*, Poi, Gomphrenin-I, Upodika

Introduction

Origin of *Basella alba* is India and Indonesia and it naturally has grown in tropical Asia and tropical Africa (Saroj *et al.* 2012) [65]. Malabar spinach is extremely heat tolerant and fast-growing perennial vine which is widely cultivated as a cool-season vegetable. Fruits are fleshy, stalkless, spherical and purple in colour. In India, it is commonly known as “Poi” found all over the country, except hills. The plant is a succulent, branched, smooth, twining and herbaceous vine reaching a length of several meters. The stems are green or purplish. The leaves are heart-shaped (cordate leaves), 5 to 12 cm in length, stalked with a pointed tip (Harold, 1963) [25].

Two species of *Basella* (*Basella rubra* L. and *Basella alba* L.) identified by Carl Linnaeus. Both two species *Basella rubra* L. and *Basella alba* L. are differentiated by their leaf characteristics and stem colours. Malabar spinach belongs to the *Basellaceae* family (Deshmukh, 2014) [15]. The stem of *Basella alba* is green in colour with bigger stem than the red-stemmed *Basella rubra*.

Malabar spinach has been used to cure various diseases, namely anticancer, antiviral, antioxidant, anti-inflammatory, anti-cholesterol, anti-ulcer, antimicrobial, anti-hypoglycemic, wound healing, androgenic from the ancient times (Shade *et al.* 2017) [68]. This plant is used for the cure of many skin problems, diarrhoea, dysentery and also used as a laxative. *Basella* plant show antioxidant, antiproliferative, antimicrobial, anti-inflammatory activities due to the presence of betacyanin, carotenoids, bioflavonoids, β -sitosterol and lupeol (Moutusi *et al.* 2019) [51]. Juice of leaves and stem are used as laxatives for children and pregnant women. In Ayurveda Malabar spinach is called as “Upodika”, “Potaki”, “Malvaa”, “Amritvallari”, and in Siddha/Tamil as “Vaslakkirai” (Khare, 2004) [31].

Malabar spinach is also rich in vitamins A, and C, Iron and Calcium (Haskell 2004) [26]. The leaves contain carotenoids, organic acids, water-soluble polysaccharides, bioflavonoid, betacyanin, and vitamin K. Fruit extract of *Basella alba* plant were used as an acid-base

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indicator, to detect the endpoint of acid-base titrations (Mitra *et al.* 2016) ^[49]. Many Indian states consumption of *Basella alba* as the vegetable is quite common. Consumption in Nigeria, India (Tongco *et al.* 2015) ^[73], Bangladesh (Haskell *et al.* 2004) ^[27] and so many other countries like China, Philippines, Thailand indicates that *Basella alba* does not possess any toxicity.

Taxonomy

Term “*Basella*” derived from Malayalam word, given by Linnaeus. Linnaeus first described two species of *Basella* L. i.e. *Basella rubra* and *Basella alba* in his book “*Species Plantarum*” in 1753 (Khare 2007) ^[32] based on their leaf character and stem colour. Roxburg (1832) was the first person who called all three name *Basella alba*, *Basella rubra* and *Basella lucida* are synonyms and adapt *Basella alba* as a correct name (Sidwell 1999) ^[69]. According to Echo plant information sheet, two colour forms of *Basella* are not separate species and the first species having a green stem and green leaf are identified as *Basella alba* L. while the second species having a red stem and red leaves are found, is identified as *Basella alba* L. var. *cordifolia* (Lamk.) Almeida (Almeida 2003) ^[6].

Basella alba is also known as Malabar spinach, Indian spinach, Ceylon spinach, climber spinach and vine spinach (Roy *et al.* 2010, Sen *et al.* 2010) ^[63, 67]. Name of *Basella alba* in a different language of the world is “Malabar spinach” in

English, “Lu luo kui” in Chinese, “Pazu” in Turkish, “Mong toi” in Vietnamese (Eland, S., 2008) ^[18], “*Espinaca blanca de Malabar*” in Spanish, “*Basella*” in French, “*Spinacio della cina*” in Italian “*indischer spinat*” in German (Eland, 2008 and Deshmukh *et al.* 2014) ^[18, 15], “Alugbati” in Filipino, Philippines (Tongco *et al.* 2015) ^[73] and “Amunututu” in the Yoruba language of Nigeria (Alakinde *et al.* 2014) ^[5].

Morphology

Malabar spinach is a perennial vine with fibrous roots. The stem of Malabar spinach is fleshy, succulent, thin, smooth, bright and leaves are distributed spirally. Side branching also observed in the stem. Stem length is about 8 to 10 m. The leaf stalk is short and leaf is oblong as the leaf length is longer than its width. Flowers of *Basella alba* are white, red or pink depending on the variety. Fruits colour is red or black. The surface of the seed is bright and rough with black and brown in colour. Thick testa is present around the seed. Seeds can remain viable for four years under optimum conditions. (Almeida, 2003, Mahr, 2014) ^[6, 41].

Cytological, pollen morphological and protein profile studies of both red and green stemmed *Basella* plant confirmed that both plant are generated from same *Basella alba* l. species (Roy *et al.* 2010) ^[63]. According to Echo plant information sheet, The plant with green stem and green petiole is *Basella alba* L. while the red stem and red petiole is *Basella alba* L. var. *cordifolia* (Lamk.) Almeida (Almeida 2003) ^[6].

Table 1: Characters of *Basella alba* l. and *Basella alba* l.var. *cordifolia* (lamk.) almeida (Almeida, 2003) ^[6]

S. No.	Character	<i>Basella alba</i> L.	<i>Basella alba</i> l.var. <i>cordifolia</i> (lamk.) almeida
1.	Stem	Fleshy, stout at the base with slender upper branches.	Very long, slender, succulent, glabrous and much-branched.
2.	Leaves	Auxiliary dark green, broadly ovate in shape and acute.	Broadly ovate, acute or acuminate, thick, apiculate with a cordate base.
3.	Flower	White, pink or red in colour and sub sessile.	White or red in colour, sessile in few lax pedunculate spikes.
4.	Bracts	Scaly and small.	Small and apiculate.
5.	Bracteoles	Acute.	Longer.
6.	Fruit	Black or dark purple in colour and enclosed within the persistent fleshy calyx.	Small and red or black in colour.
7.	Seed	Black, globose.	Black

Pigments of *Basella* spp.

Leaves and fruits contain Betacyanin and Flavonoid pigments. Major red pigments present in dye extract of *Basella alba* is gomphrenin-I, which is the compound of betalain family. Red-violet colour of leaves (Cyunel 1989) ^[13], stalks, petioles and fruits are due to the presence of betalains (Palada *et al.* 1999) ^[57]. Natural colour pigment anthocyanin is also present in stem, leaves and flowers (Glassgen *et al.* 1993) ^[21]. Betalains are the red or yellow coloured tyrosine derived pigments present in many plants such as Beetroot, bougainvillea, amaranthus and opuntia. Betalains content in leaves and fruits of *Basella* plant is less than the tubers of beet (Kumar *et al.* 2016) ^[36]. Betalains, extracted from *B. Vulgaris* and the prickly pear *Opuntia ficus-indica* are used in food (Delgado-Vargas *et al.* 2002) ^[14]. Betalains extracted from fruits of *Basella* plant are also used in food formulations (Kumar *et al.* 2015) ^[37]. It is considered as an alternative of synthetic colourants because of its positive effects on health (Lin *et al.* 2010, Khan *et al.* 2012) ^[39, 30] and also uses in the pharmaceutical and cosmetic industry (Khan *et al.* 2015) ^[28]. Due to the presence of pigments, fruit extract of *Basella alba* can be used as a natural colourant on fabrics (Mitra *et al.* 2015) ^[48].

Cultivation of Malabar spinach

Malabar spinach is a leafy vegetable, suitable for both home and market garden in the lowland tropics (Siemonsma *et al.* 1994) ^[70]. This perennial plant is native to countries of tropical Asia like India, Sri Lanka and Indonesia, and it can be easily grown as an annual crop during the summer and as ornamental foliage vine in gardens or park (Mahr, 2014) ^[41].

Cultivated lines: according to Malabar spinach – World Vegetable Center

(a). **VI047671-A1:** Vigorous growth, high yielding, thick green leaves with pink veins, Purple stems with short internode length, and late flowering line.

(b). **VI047914:** Vigorous growth, high yielding, thick dark green leaves, Green stems with short internode length and late-flowering line.

(c). **VI049472:** Vigorous growth, Narrow, thin, light green leaves, Light green, thin stems with long internode length and early flowering line.

(d.) VI051016: Vigorous growth, Narrow, thin, dark green leaves with pink veins, dark purple stems with long internode length and medium to the late flowering line.

Climatic requirement: Hot, sun-drenched climate is suitable for cultivation of Malabar spinach. 70 to 75 % relative humidity is needed for the cultivation and also humidity is essential to inhibit flowering that causes bitterness in the leaves. The plant growth is highest at the optimum temperature 32°C and as temperature drops to 26 °C the growth of plant slows down. Optimum 18-23 °C temperature is needed for seed germination. Direct sunlight and windproof areas are ideal for the cultivation (Mahr, 2014) [41].

Soil: Malabar spinach can be grown easily under proper soil and climate conditions (Palada *et al* 1999) [56]. Soil with high organic matter content, moisture and suitable drainage system is needed for cultivation. Optimum pH 6.5-6.8 is required for root development (Mahr, 2014) [41].

Fertilizer requirement: Before planting application of 100 t./ha organic manure complement with 250 kg./ha 10:10:20 nitrogen, phosphorus, and potassium. Straw mulching is useful particularly in the initial stages of development and during dry periods to preserve water. (Acikgoz *et al.* 2018) [2]. For good quality leaf application of 10 to 20 t/ha well-decomposed cow manure (Palada *et al* 1999) [56].

Sowing and Spacing: Cultivation of Malabar spinach done by both seed and seedling. A seed rate of 10-15 Kg requires for the one-hectare area. Recommended spacing for transplanted seedling is 100 cm between rows and 50 cm between plants (Palada *et al.* 1999) [57]. Natural (straw, sawdust, herbage and other materials) and synthetic (polyethene in different colours) both materials are used for mulching. These are well known for modifying the energy and water balance at the surface of soils mulches creating favourable conditions for plant growth by modifying soil temperature (Farias-Larios *et al.*, 1997) [19], decreasing the moisture loss from the soil, suppress weed growth (Borosis, *et al.*, 1998) [9], control of soil-borne pathogens, and reduce insect/pest populations (Farias-Larios *et al.* 1997) [19]. The yield of a mulched plant is higher than the unmulched plant. Silver plastic mulch gives the highest yield (Gonzaga *et al* 2014) [22].

Diseases: A total of 26 and 19 endophytic cultivable fungi were isolated from *B. alba* and *B. rubra* respectively. Majority of the endophytes belongs to the genus *Alternaria* and several genera in class Dothideomycetes. *Alternaria* is predominant in both the plants (Moutusi *et al.* 2019) [51]. Endophytic fungi can either complete or part of their life cycle inside the host tissue and colonize either in intercellular or intracellular spaces of leaves, stem, flowers, fruits, seeds and roots. The host plants show higher nutrient uptake, get immense resistance to herbivores, abiotic stresses (Mishra *et al.* 2014) [47].

Leaf Blight of *Basella alba* Caused by *Alternaria alternata* (Fr.) Keissler in India. In PDA media white to brown in coloured fungal colonies are formed. The fungus produces brown, short, simple, or sometimes branched conidiophores. Conidia are obclavate, obpyriform or ellipsoidal with a short conical beak with pale brown in colour. Conidia had three to eight transverse septa with one to two longitudinal septa (Sankar *et al* 2011) [64]. Leaf spot is elliptical to irregular oval, yellow-brown to dark brown, and concentrically zonate with

diffuse margins frequently surrounded by light-coloured haloes. Initially, the infection started from the leaf tips and reached to leaf base at a later stage. In severe infections, spots coalesce to cause necrosis, wilting, and ultimately death of leaves (Sankar *et al.* 2011) [64].

In Malabar spinach, Leaf spot disease is caused by *Colletotrichum*. This disease is more severe in *B. rubra* than *B. alba*. *Cercospora Basellae-albae* produces necrotic spot on leaves of *Basella alba*. This pathogen was first described from *Basella alba* in India (Srivastava *et al.* 1994) [72] and was reported recently in Thailand (Meeboon *et al.* 2007) [45], Philippines (Begum *et al.* 2010) [7]. Necrotic spots appear on both sides of young and mature leaves. Initially, spots are circular to subcircular, 1– 10mm wide with reddish-brown in colour. In a later stage, spots turn into black to brown in colour with grey centres and reddish-purple borders. Conidiophores are visible as minute black dots on the leaf spots. Conidiophores are unbranched, pale olivaceous brown, uniform in colour, straight or mildly geniculate with thickened conidial scars and sparingly septate. Conidia are hyaline, straight to slightly curved, indistinctly multiseptate, acute at the apex, truncate at the base with a thickened hilum. Crous and Braun (2003) [12] stated that *Collatotrichum Basellae-albae* was similar to *Collatotrichum apii s. lat.* but conidia of *C. apii s. lat.* is longer than *C. Basellae- albae* while conidiophores of *C. apii s. lat.* has narrower than *C. Basellae-albae*.

Yield: 1.5-2 kg fresh leaves are obtained per plant (Acikgoz *et al.* 2018) [2]. For seed production, dry fruits are selected. Total 1000-2000 kg/ha dry seed is obtained (Grubben *et al.* 2004) [23].

Importance

Use as an indicator: Fruit extract of *Basella alba* is used as a natural indicator in acid-base titration to detect endpoint because of the sharp colour of occurring with the change in pH value. The original colour of the dye is violet and their pH value is 4.9 (Mitra *et al.* 2015) [48]. Normally Synthetic colourants used for acid-base titration are hazardous to human beings and environment while natural indicators are economical, simple, easily available and eco-friendly. (Mitra *et al.* 2016) [49].

Medicinal uses: Natural foods have several health benefits (Schmidt 1974) [66]. The risk of cardiovascular diseases, stroke, and cancer can be reduced by adding fruit and vegetable in the daily diet (Rice-Evans *et al* 2003) [62]. *Basella* plant species contain betacyanin, carotenoids, bioflavonoids, β -sitosterol and lupeol which are reported to have antioxidant, antiproliferative, antimicrobial, anti-inflammatory activities etc. and help in curing various diseases, namely anticancer, antiviral, antioxidant, anti-inflammatory, anti-cholesterol, anti-ulcer, antimicrobial, anti-hypoglycemic, wound healing, androgenic from the ancient times (Shade *et al.* 2017) [68]. In Ayurveda Malabar spinach is called as “Upodika”, “Potaki”, “Malvaa”, “Amritvallari”, and in Siddha/Tamil as “Vaslakkirai” (Khare, 2004) [31].

Several different types of medicinal elements are found in the *Basella* plant which helps in fighting many diseases such as-

a) Saponins phytochemicals have anti-inflammatory, antimicrobial, vasodilatory actions, and antioxidant effects (Garcia *et al.* 2005) [20] and have the ability to fight against cancer and cardiovascular diseases (Kumar *et al.* 2013) [34].

- b) Kaempferol, the flavonoid is protective against cardiovascular diseases and cancer (Yang *et al.* 2008) [79].
- c) Red stemmed *Basella rubra* plant have wound-healing effect (Haneefa *et al.* 2012) [24], antibacterial activity (Oyewole *et al.* 2012) [55] and antiviral activity (Dong *et al.* 2012) [16], anti-inflammatory effect (Kumar *et al.* 2011) [38] and antiulcer effect (Venkatalakshmi *et al.* 2012) [75].
- d) Leaf juice is used in to treat catarrh (Nandkarni *et al.* 1908) [52].
- e) Leaf juice also used as safe laxatives for children, pregnant women and in the urinary diseased patient (Mishra *et al.* 2006) [46].
- f) Flowers are locally used as Antidote for poisons.
- g) Plant extract caused an increase in the WBC count which help in the management of anaemia and immunity-dependent disorders (Sonkar *et al.* 2012) [71].
- h) Plant leaves show amylase activity which helps in the diagnosis of acute pancreatitis. (Sonkar *et al.* 2012) [71].
- i) Boiled *Basella alba* is used to treat retained placenta in the cow (Adekilekun *et al.* 2012) [4] because it develops severe diarrhoea that causes the placenta to come out.
- j) Leaves are also used as anthelmintic, demulcent, anti-inflammatory, anti-malarial and analgesic (Yanadaiah *et al.* 2011) [78].

Table 2: The nutritional content of Malabar spinach (Yang *et al.* 2008 and USDA, 2018) [79]

S. No.	Nutrients	Quantity (per 100 g)
1.	Water	93g
2.	Energy	19 kcal
3.	Protein	1.8 g
4.	Fat	0.3 g
5.	Calcium	109 mg
6.	Phosphorus	52 mg
7.	Iron	1.2 g
8.	Magnesium	65 mg
9.	Potassium	510 mg
10.	Sodium	24 mg
11.	Zinc	0.43 mg
12.	Vitamin A	8000 IU
13.	Vitamin B1	0.05 mg
14.	Vitamin B2	0.16 mg
15.	Vitamin B3	0.50 mg
16.	Vitamin C	102 mg

Nutritional importance: *Basella rubra* is a good source of calcium, iron, and vitamins A and C. Seed contain fatty oils such as palmitic, oleic and linolenic acid (Anonymous, 2004). Carotenoids also found in the leaves of *Basella rubra* with major beta-carotene, small amounts of alpha-carotene and traces of other carotenoids (Panteado *et al.* 1987) [58].

This plant is good for health due to the presence of mineral, protein, oil, carbohydrate, fibre, carotenoid, organic acid, vitamins. According to Lyimo *et al.* 2003 [40], Malabar spinach contains 98.7 mg./100g vitamin C, 5% protein, 1.5%

fiber, 0.7% fat, 250.0 mg./100g Ca, 4.0 mg./100g Fe. It also contains 15.9 g./100g ash, 27.7 g./100g protein, 3.1 g./100g fat, 42.1 g./100g carbohydrate, 306.7 kcal./100g energy, 400.0 mg./100g Vitamin C, 48.7 mg./100g Ca, 21.5 mg./100g Fe and g./100g fiber (Maisuthisakul *et al.* 2008) [42].

Use in pest management: *Basella rubra* seeds contain two types of antifungal peptides α and β basubrins which are effective against some important fungi like *Botrytis cinerea*, *Mycosphaerella arachidicola* and *Fusarium oxysporum* (Wang *et al.* 2001) [76]. Antiviral glycoprotein effective against potato virus has been also found in *Basella* leaves.

Methanolic extract of leaves of *B. alba* contains two glycosides flavenoids vitexin, and vitexin-2''-O-arabinofuranoside which inhibit the growth of *Spodoptera litura*. These flavonoid glycosides act as deterrents to *S. litura* larvae (Aboshi *et al.* 2018) [1], green peach aphid, *Myzus persicae* (Dreyer *et al.* 1981) [17]. 50% population of aphid *Myzus persicae* is inhibited by 0.1% concentration of vitexin (Dreyer *et al.* 1981) [17]. The concentration of vitexin and vitexin-2''-O-arabinofuranoside glycosides flavenoid is higher in younger leaves than mature leaves (Rhoades 1979) [61]. *Basella* plant also acts as a trap crop against whitefly.

Intercropping of celery and *B. alba* with cucumber reduced whitefly on cucumber due to presence of Geranyl nitrile which reduces whitefly colonization (Zhao *et al.* 2014) [81].

Oil content in Malabar spinach: Malabar spinach oil can work as very good vegetable oil (Adedotun 2004). Saturated fatty acids like lauric acid, arachidic acid, behenic acid, lignocenic acid, palmitic acid, stearic acid and myristic acid while unsaturated fatty acids like oleic acid, eicosenoic acid, palmatoleic acid, erucic acid, docosahexanaenoic acid, arachidonic acid, linoleic acid and alpha-linolenic acid are present in the oil of both red and green species of Malabar spinach. In the oil of red Malabar spinach total amount of saturated and unsaturated fatty acid is about 22.19% and 50.7% respectively while in oil of green Malabar spinach oil total amount of saturated and unsaturated fatty acid is about 21.41% and 52.36% respectively (Adedotun 2017) [3]. That's why Malabar spinach oil can be used as a vegetable oil in homes.

Use as a vegetable: Malabar spinach is used to make many types of dishes in many countries like Philippines, Thailand China, Mongolia, India, Sri Lanka and many African countries. In the Philippines, a vegetable dish called utan which is cooked with sardines, onions, garlic, and parsley. In Mangalorean Tuluva cuisine, a coconut-based gravy called gassi is paired with the *Basella* plant, making a delicacy called Basale gassi to be eaten with rice dumplings called pundi soaked overnight in the gravy, or with red rice. Soup is made in Chinese cuisine and Vietnam cuisine, Malabar spinach is mixed with crab meat and jute (Grubben *et al.* 2004) [23].

Table 3: Malabar spinach dishes made in India (Wikipedia)

S. No.	State	Dishes
1.	West Bengal	In the vegetable dish, cooked with red pumpkin, and in non- vegetarian dishes, cooked with the bones of the Ilish fish
2.	Karnataka	Basalede kunhi Pindi
3.	Andhra Pradesh	curry of <i>Basella</i> and Yam were popularly known as Kanda Bachali Koora and snack item bachali koora bajji
4.	Odisha	Curries and Saaga
5.	Maharashtra	Daento or valchi bhaji
6.	Gujrat	Pakodas, popularly called "poi na bhajia".

Conflicts of Interest

The authors have no conflict of interest to declare.

References

- Aboshi T, Ishiguri S, Shiono Y, Murayama T. Flavonoid glycosides in Malabar spinach *Basella alba* inhibit the growth of *Spodoptera litura* larvae. *Bioscience, Biotechnology and Biochemistry* 2018;82(1):9-14.
- Acikgoz FE, Adiloglu S. A Review on a New Exotic Vegetable for Turkey: Malabar Spinach (*Basella alba* L. or *Basella rubra* L.). *J Hort* 2018;5:239.
- Adedotun I. Quality Assessment of Oil Extracted from Two Species of Malabar Spinach (*Basella alba*) American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS) 2017;28(1):88-98.
- Adekilekun TA, Adedayo AD, Olalekan OO, Oloruntoba AA. Some of the effects of aqueous leaf extract of Malabar nightshade on the kidney and liver of albino wistar rats. *European Journal of Experimental Biology* 2012;2:337-342.
- Alakinde TA, Adedeji O. Utilization of Indian Spinach (*Basella* Linn) in Ondo State, Nigeria. *Afr. J Plant Sci* 2014;8(6):278-284.
- Almeida MR. Flora of Maharashtra. *Blatter Herbarium*, St. Xavier's College, Mumbai 2003;4:278.
- Begum MM, Cumagun CJR. First record of *Cercospora Basellae-albae* from the Philippines. *Australasian Plant Disease Notes* 2010;5:15-116.
- Bendich A. Physiological role of antioxidants in the immune system. *J Dairy Sci* 1993;76:2789-2794.
- Borosic J, Romic D, Tomic F, Zutic I, Klacic Z. Effects of mulching and irrigation in bell pepper (*Capsicum annuum* L.) growing in Mediterranean part of Croatia. *Agriculturae Conspectus Scientificus* 1998;63:325-330.
- Chaitanya BK. Anti inflammatory activity of *Basella alba* Linn. in albino rats. *Journal of Applied Pharmaceutical Science* 2012;2:87-89.
- Chatterjee A, Chandra PS. The Treatise on Indian Medicinal Plants, New Delhi, Designed and printed by NISCAIR Press 1991.
- Crous PW, Braun U. *Mycosphaerella* and its anamorphs: 1. Names published in *Cercospora* and *Passalora* CBS Biodiversity Series 1. (Centraalbureau voor Schimmel cultures: Utrecht) 2003, 569pp.
- Cyunel E. *Basella alba* L. in vitro culture and the production of betalains. *Biotechnol Agric For* 1989;7:47-68.
- Delgado-Vargas F, Lopez OP. Betacyanins and phenolic compounds from *Beta vulgaris* L. roots. *Food Chem*, 2002;58:255-258.
- Deshmukh SA, Gaikwad DK. A review of the taxonomy, ethno botany, photochemistry and pharmacology of *Basella alba* (*Basellaceae*). *J Appl Pharm Sci* 2014;40:153-165.
- Dong C, Hayashi K, Mizukoshi Y, Lee J, Hayashi T. Structures of acidic polysaccharides from *Basella rubra* L. and their antiviral effects. *Int J Biol Macromol* 2012;50:245-259.
- Dreyer DL, Jones KC. Feeding deterrence of flavonoids and related phenolics towards *Schizaphis graminum* and *Myzus persicae*: aphid feeding deterrents in wheat. *Phytochemistry* 1981;20:2489-2493.
- Eland S. Plant biographies 2008.
- Farias-Larios J, Orozco-Santos M. Effect of polyethylene mulch color on aphid populations, soil temperature, fruit quality and yield of watermelon under tropical conditions. *New Zealand Journal of Crop and Horticultural Science* 1997;256:39-374.
- Garcia VV, Magpantay TO, Escobin LD. Antioxidant potential of selected Philippine vegetables and fruits. *The Philippine Agricultural Scientist* 2005;88(1):78-83.
- Glassgen WE, Metzger JW, Heuer S, Strack D. Betacyanins from fruits of *Basella rubra*. *Phytochemistry* 1993;33:1525-1527.
- Gonzaga ZC, Dimabuyu HB, Sumalinog RR, Capuno OB. Increasing productivity of Malabar Spinach (*Basella alba* L. and *Basella rubra* L.) Grown In The Marginal Upland Of Inopacan, Leyte Through Different Mulching Materials. *Annals of Tropical Research* 2014;36:166-178.
- Grubben GJ, Denton OA. Plant resources of tropical Africa 2. Vegetable. Wageningen, Leiden: PROTA Foundation, Backhuys, CTA 2004, 103-111.
- Haneefa MKP, Abraham A, Saraswathi R, Mohanta GP, Nayar C. Formulation and evaluation of herbal gel of *Basella alba* for wound healing activity. *Int J Pharm Sci Res* 2012;4:1642-1648.
- Harold FW. Ceylon Spinach (*Basella rubra*), *Economic Botany*, New York Botanical Garden Press 1963;17(3):195-199.
- Haskell MJ, Jamil KM, Hassan F, Peerson JM, Hassain MI, Fuchs GJ, et al. Daily consumption of Indian spinach (*B. alba*) or sweet potato has positive effect on total-body vitamin A store in Bangladeshi men. *Am. J Clin. Nutr* 2004;80(3):705-714.
- Haskell MJ, Jamil KM, Hassan F, Preerson JM, Hassain MI. Daily consumption of Indian Spinach (*Basella alba*) or sweet potatoes has positive effect on total body vitamin A store in Bangladeshi men. *Am J Clin Nutr* 2004;80:705-714.
- Khan MI, Harsha PSC, Chauhan AS, Vijayendra SVN, Asha MR, Giridhar P. Betalains rich *Rivina humilis* L. berry extract as natural colorant in product (fruit spread and RTS beverage) development. *J Food Sci Technol* 2015;52:1808-1813.
- Khan MI, Harsha PSC, Giridhar P, Ravishankar GA. Pigment identification, antioxidant activity and nutritional composition of *Tinospora cordifolia* (willd.) Mixers ex Hook.f & Thoms fruits. *Int J Food Sci Nutr* 2011;62:239-249.
- Khan MI, Harsha PSC, Giridhar P, Ravishankar GA. Pigment identification, nutritional composition, bioactivity and in vitro cell cytotoxicity of *Rivina humilis* L. berries, potential source of betalains. *LWT-Food Sci Technol* 2012;47:315-323.
- Khare CP. Encyclopedia of Indian Medicinal Plants. Heidelberg, Springer Verlag Berlin 2004.
- Khare CP. Indian medicinal plants: An Illustrated Dictionary. Springer-Verlag Berlin/Heidelberg 2007, 83.
- Kubitzki K, Rohwer JG, Bittrich V. The families and genera of vascular plants 1993;2:143-145.
- Kumar S, Prasad AK, Iyer SV, Vaidya SK. Systematic pharmacognostical, phytochemical and pharmacological review on an ethnomedicinal plant, *Basella alba* L. *Journal of Pharmacognosy and Phytotherapy* 2013;5(4):53-58.
- Kumar SS, Manoj P, Giridhar P. A method for red-violet pigments extraction from fruits of Malabar spinach (*Basella rubra*) with enhanced antioxidant potential under fermentation. *J Food Sci Technol* 2015;52:3037-3043.

36. Kumar SS, Manoj P, Nimisha G, Giridhar P. Phytoconstituents and stability of betalains in fruit extracts of Malabar spinach (*Basella rubra* L.). J Food Sci Technol 2016;53(11):4014-4022.
37. Kumar SS, Manoj P, Shetty NP, Prakash M, Giridhar P. Characterization of major betalain pigments-Gomphrenin, Betanin and Isobetanin from *Basella rubra* L. fruit and evaluation of efficacy as a natural colourant in product (ice cream) development. J Food Sci Technol 2015;52:4994-5002.
38. Kumar V, Bhat ZA, Kumar D, Bohra P, Sheela S. *In vitro* anti-inflammatory activity of leaf extracts of *Basella alba* Linn. Var. *alba*. Int J Drug Dev & Res 2011;3:176-179.
39. Lin SM, Lin BH, Hsieh NM, Ko HJ, Lin C, Chen LG. Structural identification of Bioactivities of red-violet pigments present in *Basella alba* fruits. J Agric Food Chem 2010;58:10364-10372.
40. Lyimo M, Temu RPC, Mugula JK. Identification and nutrient composition of indigenous vegetables of Tanzania. Plant Foods Hum Nutr 2003;58: 85-92.
41. Mahr S. *Malabar spinach, Basella alba*, Master Gardener Program, Division of Extension, 2014.
42. Maisuthisakul P, Pasuk S, Ritthiruangdej P. Relationship between antioxidant properties and chemical composition of some Thai plants. J Food Compos Anal 2008;21:229-240.
43. Mamary MA. Antioxidant activity of commonly consumed vegetables in Yemen. Mal J Nutr 2002;8:179-189.
44. Martin FW, Ruberte RM, Meitzner LS. *Edible Leaves of the Tropics*. Third Edition. ECHO, North Fort Myers, Florida 1998.
45. Meeboon J, Hidayat I, To-anun C. Cercosporoid fungi from Thailand 3. Two new species of *Passalora* and six new records of *Cercospora*. Mycotaxon, 2007;102:139-145.
46. Mishra S, Shrivastava RK, Sheikh M, Soni VK. Ethnomedicinal uses of certain plants by korku tribals of Khandawa District in M.P. (India). National Conference on Forest Biodiversity Resources: Exploitation Conservation and Management, 2006, 21-22.
47. Mishra Y, Singh A, Batra A, Sharma MM. Understanding the biodiversity and biological applications of endophytic fungi: A review. J of Microbial and Biochemical Technology 2014, 1-11. Doi: 10.4172/1948-5948.S8-004.
48. Mitra A, Das SK. Journal of Chemical and pharmaceutical Research 2015;7(12):1117.
49. Mitra A, Das SK. Use of *Basella alba* fruit extract as a potent natural acid-base indicator. Journal of Chemical and Pharmaceutical Research 2016;8(1):663-667.
50. Mittal AK, Chisti Y, Banerjee UC. Synthesis of metallic nanoparticles using plant extracts. Biotechnol Adv 2013;31(2):346-356.
51. Moutusi S, Parivallal BP, Prasannakumar MK, Kiranmayee P. Morphological and molecular characterization of culturable leaf endophytic fungi from Malabar Spinach, The first report. Studies in Fungi 2019;4(1):192-204.
52. Nandkarni KM, Nandkarni AK. *Indian Materia Medica*. Mumbai, India Popular Prakashan Private Ltd. 1908.
53. Olajire AA, Azeez L. Total antioxidant activity, phenolic, flavonoid and ascorbic acid contents of Nigerian vegetables. Afr J Food Sci Tech 2011;2:022-029.
54. Olgorite A. Genetic relationship between *Basella alba* and *Basella rubra*. WARA Newsletter 2006, 9-10.
55. Oyewole OA, Kalejaiye OA. The antimicrobial activities of ethanolic extracts of *Basella alba* on selected microorganisms. Scientific J Microbio 2012;1:113-118.
56. Palada MC, Crossman SMA. Evaluation of tropical leaf vegetables in the Virgin Islands. Perspectives on new crops and new uses, ASHS press, Alexandria, VA 1999, 388-393.
57. Palada MC, Davis AM, Crossman SMA. Growth and yield response of Malabar spinach to levels of dehydrated cow manure application. Proceedings of the Caribbean Food Crops Society 1999;35:178-143.
58. Panteado MDVC, Minazzi RS, Regina S, Bicuda DAL. Carotenoids and provitamin A activity of vegetable leaves consumed in northern Brazil. Chemical Abstract 1987;107:609.
59. Reshmi SK, Aravindhana KM, Suganya DP. Antioxidant analysis of betacyanin extracted from *Basella alba* fruit. Int J Pharm Tech Res 2012;4:900-913.
60. Reviews on Indian medicinal plants. Indian Council of Medical, New Delhi 2004;4:96-100.
61. Rhoades DF. Evolution of plant chemical defense against herbivores. In: Rosenthal GA, Janzen DH, editors., *Herbivores: their interaction with secondary plant metabolites*. 1st ed. New York (NY): Academic Press 1979, 1-54.
62. Rice-Evans CA, Packer L. *Flavonoids in Health and Disease*, New York: Marcel Dekker, Inc. 2003.
63. Roy SK, Gangopadhyay G, Mukherjee KK. Is stem twining form of *Basella alba* L. a naturally occurring variant? Current Science 2010;98:1370-1375.
64. Sankar NR, Sreeramulu A, Gopal DS, Bagyanarayana G. First Report of Leaf Blight of *Basella alba* Caused by *Alternaria alternata* in India. Plant Dis. 2011;95(11):1476.
65. Saroj V, Rao PS, Rao SK, Krupal S. Pharmacognostical study of *Basella alba* stem. Int J Pharm Biol Sci 2012;3:1093-1094.
66. Schmidt DR. Comparative yield and composition of eight tropical leafy vegetables grown at two soil fertility levels. Agronomy Journal 1974;63:559.
67. Sen K, Goel A, Rawal S, Mahajan N, Baboo S. Antimicrobial activity of *Basella rubra* leaves. Int J Pharm Sci Res 2010;1:88-91.
68. Shade A, Jacques MA, Barret M. Ecological patterns of seed microbiome diversity, transmission, and assembly. Current Opinion in Microbiology 2017;37:15-22. Doi: 10.1016/j.mib.2017.03.010
69. Sidwell K. Typification of two Linnaean names in the *Basellaceae*. Novon 1999;9:562-563.
70. Siemonsma JS, Piluek K. *Plant Resources of South-East Asia: Vegetables*. Prosea. Bogor. Indonesia 1994, 8.
71. Sonkar DS, Gupta R, Shubhini A. Effect of *Basella rubra* L. leaf extract on haematological parameters and amylase activity, Pharmacognosy Communications 2012;2(3).
72. Srivastava RK, Narayan S, Srivastava AK. New species of *Cercospora* from North-eastern Uttar Pradesh. Indian Phytopathology 1994;47:226-231.
73. Tongco JVV, Angustia DA, Tamayo JP. Nutritional Analysis, Phytochemical Screening, and Total Phenolic Content of *Basella alba* Leaves from the Philippines. International Journal of Pharmacognosy and Phytochemical Research 2015;7(5):1031-1033.

74. United States Department of Agriculture (USDA), Agricultural Research. Service National Nutrient Data base for Standard Reference Release, 2018.
75. Venkatalakshmi P, Senthamaraiselvi V. Antiulcer effect of *Basella alba* leaf extract in Aspirin induced Albino rats. Int J Pharm Sci Res 2012;3:2539-2542.
76. Wang H, Bun T. Novel antifungal peptides from Ceylon spinach seeds. Biochemical and Biophysical Research Communications 2001;288:765-770.
en.wikipedia.org/wiki/Basella_alba
77. Winters HF. Ceylon spinach (*Basella rubra*). Econ. Bot 1963;17(3):195-199.
78. Yanadaiah JP, Lakshmi SM, Jayveera KN, Sudhakar Y. Hepatoprotective activity of aqueous ethanolic extract of aerial parts of *Basella rubra* L. against carbon tetrachloride and paracetamol induced hepatotoxicity in rats. International Journal of Pharmacy and Pharmaceutical Sciences 2011;3:502-506.
79. Yang RY, Lin S, Kuo G. Content and distribution of flavonoids among 91 edible plant species. Asian Pacific J Clinical Nut 2008;17:275-279.
80. Zenaída C, Gonzaga Hubert BD, Richiêlda RS, Othello BC. Increasing Productivity of Malabar Spinach (*Basella alba* L. and *Basella rubra* L.) Grown in the Marginal Upland Area of Inopacan, Leyte through Different Mulching Materials. Annals of Tropical Research 2014;36:166-178.
81. Zhao Q, Zhu JJ, Qin Y. Reducing whiteflies on cucumber using intercropping with less preferred vegetables. Entomol Exp Appl 2014;150:19-27.