

Chapter 3

Review of Literature

3.1 The genus Basella

The genus *Basella* (Chenopodiaceae) containing about nine species is distributed in India (widely in Assam, Meghalaya, Manipur, Kolkata and Mumbai), tropical Africa and South-east Asia. *Basella rubra* Linn. is a traditional Indian folklore medicine used to treat bleeding piles, pimples, boils, tumour, hopping cough, urticaria, to cure irritations and itching, to heal ringworm, eczema, septic wounds, ulcers, anaemia, as an effective tooth powder that cures many diseases of gum and teeth, cure all evil effects of alcoholism, biliousness, leprosy, etc. (*Ghosh, 2000*)

The taxonomy of the genus is as follows

**Domain:** Eukaryota Whittaker & Margulis, 1978 - eukaryotes

**Kingdom:** Plantae Haeckel, 1866

**Subkingdom:** Viridaeplantae Cavalier-Smith, 1981 - Green Plants

**Phylum:** Tracheophyta Sinnott, 1935 Ex Cavalier-Smith, 1998 - Vascular Plants

**Subphylum:** Euphyllophytina

**Infrafylum:** Radiatopses Kenrick & Crane, 1997

**Superdivision** Spermatophyta – Seed plants

**Division** Magnoliophyta – Flowering plants

**Class:** Magnoliopsida Brongniart, 1843 - Dicotyledons

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Subclass: Caryophyllidae Takhtajan, 1967
Superorder: Caryophyllanae Takhtajan, 1967
Order: Caryophyllales Perleb, 1826
Suborder: Portulacineae
Family: Basellaceae (an-REE-der-uh) Moquin-Tandon, 1840
Subfamily: Ncpetoideae
Tribe: Salvieae

The Genus Basella is further organized into finer groupings including:

There are about 24 species, subspecies, varieties, forms, and cultivars in the Genus Basella: Basella alba (East-Indian Spinach) • Basella alba var. rubra • B. cananifolia • B. cordifolia • B. crassifolia • B. diffusa • B. excavata • B. filiformis • B. hookeriana • B. japonica • B. leandriana • B. lucida • B. madagascariensis • B. marginata • B. nigra • B. obovata • B. obtusifolia • B. paniculata • B. ramosa • Basella rubra • B. trifida • B. tuberosa • B. vesicaria • B. volubilis

3.2 Taxon Description

Twining subsucculent herbs with long much-branched stems. Leaves alternate; lamina ovate, entire. Flowers hermaphrodite, sessile, white or coloured, in axillary spikes or panicles of spikes. Bracteoles 2, united into a 2-lipped cup adnate to the perianth. Perianth urceolate or wide open, fleshy; lobes 5, short, incurved, or almost
free and spreading. Stamens 5, inserted near the top of the perianth-tube. Ovary ovoid, free; styles 3, or 1 deeply trifid or obsolete; stigmas 3, linear. Fruit membranous, one-seeded. Seed globose; embryo spiral; endosperm scanty (Berdcourt, 1968)

### 3.3 Taxon Range

A small genus of about five species, three very distinctive ones endemic in Madagascar, one endemic to eastern Africa and a polymorphic one widespread in Africa and Asia and also cultivated in America; the latter is widely cultivated as a spinach-like vegetable (Berdcourt, 1968; Stannard, 1988)

Recent molecular systematic studies using plastid DNA data indicate that the traditional families Basellaceae, Cactaceae, Didieraceae, and Portulacaceae form a distinct and well-supported clade within Caryophyllales (Manhart and Rettig, 1994; Applequist and Wallace, 2001; Cuénoud et al., 2002). These four families were first grouped together by Thorne (Thorne, 1976) as suborder Portulacineae; more recently the terms portulacaceous alliance (Hershkovitz, 1993), portulacaceous cohort (Applequist and Wallace, 2001), and higher core Caryophyllales II (Hilu et al., 2003) were used to refer to this same clade. Evidence is available that Halophytaceae and Hectorellaceae are also part of Portulacineae (Bittrich, 1993; Philipson, 1993; Müller and Borsch, 2005).

Overall, the suborder Portulacineae comprises some 2000 to 2200 species in 160 genera, of which about 80% are Cactaceae (estimates based on Kubitzki et al., 1993). Except for a few taxa that have a cosmopolitan distribution [e.g., *Basella alba* L., *Portulaca oleracea* L., *Talinum paniculatum* (Jacq.) Gaertn.], most species of Portulacineae inhabit dry areas of North and South America, Africa, and, to a lesser extent, Australia. Common characteristics of this group of families are (1) the
presence of a fleshy or succulent tissue in either stems, leaves, or underground parts,

(2) Crassulacean acid metabolism (CAM) photosynthesis, (3) normal secondary
growth (i.e., absence of internal phloem), (4) mucilage idioblasts in stems and leaves,
and (5) calcium oxalate crystals in the stem epidermis (Stevens, 2001).

Morphological and molecular studies that included several genera and species
of Portulacaceae (Hershkovitz, 1993; Hershkovitz and Zimmer, 1997; Applequist
and Wallace, 2001) indicate that this family is paraphyletic, with Basellaceae,
Cactaceae, and Didieraceae nested in it. Furthermore, evidence is accumulating that
the suborder Portulacineae consists of three major subclades: (1) ACPT clade (from
Anacampseroteae G. D. Rowley, Cactaceae, Portulaca L., Talinum Adans.), (2) CDP
clade (from Ceraria H. Pearson & Stephens, Didieraceae, Portulacaria Jacq.), and (3)
PAW clade (Nyffeler, 2007; Hershkovitz, 1993). The relationships among these
three major groups and between Basellaceae, Halophytaceae, and Hectorellaceae are
not yet resolved.

![Figure 3.1: Hypotheses of relationships among selected taxa of the ACPT clade.](image_url)

Hershkovitz (1993) based on a cladistical analysis of morphological data (strict
consensus tree) (Basellaceae as part of the polytomy with Talinum and A+C+P
not shown).
Available evidence suggests that a revised family classification of Portulacineae that reflects inferred phylogenetic relationships might consist of five major taxa: Basellaceae (as traditionally circumscribed), Didieraceae (including Calyp- trotheca, Ceraria, and Portulacaria (Applequist and Wallace, 2003), Halophytaceae (Cuenoud et al., 2002; Muller and Borsch, 2005), Montiaceae (corresponding to the PAW clade of Hershkovitz and Zimmer [Hershkovitz and Zimmer, 2000]), and Cactariae (a superfamily not yet formally described) to include Cactaceae, and the genera Anacampseros, Portulaca, and Talinum, which are either referred to their individual monogeneric families or are included in a paraphyletic family Portulacaceae (Nyffeler, 2007)

Basella has thick leaf, thick stem short-lived perennial with tendency to climb. The flowers are small and develop in groups in the leafy axis. When mature, the trilobed fruits are round and succulent containing only one seed in the middle. **Two varieties of Basella are usually identified in Nigeria** (i) Basella alba or the group type which has white flowers, (ii) Basella rubra or the red Indian spinach which has red (dark purple) stems, petioles and leaves and pale pink flowers. Both varieties are tolerant to heavy rainfall and are common in the southern part of the country. Both varieties have high water content (Ukpong Sunny, 2005)
3.4 Review of Reports on *Basella rubra*

According to Rig Veda hymn no. 6/46/14, *Basella rubra* is described as a non-vegetarian food. According to another legend, it is called “ketabas” or abode of worms. It is said that it carried viruses and bacteria but Charaka Samhita suggested that in case of diarrhea and dyspepsia, this creeper, *Basella rubra*, boiled with curd and juice of Dadimba (*P. graticum*). Susruta Samhita suggested its use to treat filariasis by taking the juice. Eminent physician of ancient India, Bangasen suggested its juice was useful for cold in case of children to be given after warming and to cure constipation of pregnant women after fifth or sixth months. It is also used in catarrh of bronchial and genitor-urinary tracts, and extremely in headache and insomnia (*Ghosh, 2000*)

Modern science also made research on it. Scholars of Phillipino and Germany identified vitamin A and B in this herb. Scholars of India found protein, calcium and iron. It is reported that its juice is soothing, diuretic and used for treating gonorrhoea. Ash of the plant if used as tooth powder is useful for teeth and gum (*Ghosh, 2000*).

Hosotani *et al.*, revealed both α- and β-carotenes as pro-vitamin A in *Basella rubra* with the help of HPLC (*Hosotani et al., 1989*)

Absolute stereo-structures of spinocoside with a navel type substituent from *Spinacia obracea* (spinach) and *Basella rubra* (Indian spinach) have been isolated by Yoshikawa *et al.*, (*Yoshikawa et al., 1998*)

*Basella rubra* had also been used as natural dye. Mell had reported the isolation of a purple dye from the plant (*Mell, 1937*). Cao *et al.*, (*Cao et al., 1991*) have extracted a red pigment from the fruit of *Basella rubra*. It is a new pigment for food. The ability for colouring is good. It is bright purple at pH 3-7. It is
decomposed under the effect of light, heat and metal ions such as Fe$^{2+}$, Fe$^{3+}$, Cu$^{2+}$, etc. The stability of the pigment to UV rays could be improved on adding an appropriate amount of ascorbic acid into the solution of the colourant. It is a good additive and non-poisonous colourant. It showed as identical peak to that of betanin on UV-Visible spectrum and IR spectrum of purified Basella red pigment also gave the characteristic absorption of betacyanins.

Nishimato and Hirose isolated a red colouring material resistant to heat induced discolouration for food, feeds, pharmaceuticals, cosmetics, etc. using the fruit juice of Basella rubra (Nishimoto, 1991)

Carotenoids were detected in leaves of Basella rubra and the corresponding vitamin A values were calculated. The major carotenoids detected in all the species were β-carotene, small amounts of α-carotene and traces of other carotenoids (Penteado, 1987)

It was reported that the effect of different cooking methods on β-carotene contents of twelve raw vegetables by column chromatography and spectrophotometry, and investigated by calculating the percentage less in the cooked preparations. The extent of loss was lower when processing/heating was kept to a minimum and prolonged cooking resulted in progressive losses of β-carotene. Deep frying resulted in twice the loss that occurred during shallow-frying (Padmavati et al., 1992)

Culturally important vegetables were analyzed for proximate and mineral composition by Bhardwaj (Bhardwaj et al., ISHS Acta Horticulturae 806). Composition studies showed that some species such as poi (Basella rubra), dhekia (Diplazium esculentum), oyik (Pouzolzia bennettiana) and gaam oying (Glochidion multiloculare) are richer in minerals and energy compared with common vegetables such as spinach, amaranth, and cabbage. Results from the work indicate that these
vegetables could be further promoted for greater commercialization in order to strengthen nutrition security in the region.

Qin (Qin et al., 2010) extracted the red pigment from natural mulberry. They found that because of its non-poisonous nature and good stability to light and heat this pigment can be used as an additive in candy, beverages, fruit wine, jelly, ice cream etc.

Lui, Wei and Sheng extracted the yellow pigment of Gardenia from the fruit of *G. tamonoxide* by water soaking and drying. They found that it is bright, stable, safe and has a strong odouring ability. It is thus a desirable colouring agent for the food industry (Liu et al., 1991).

3-Oxo-α-ionol vomofoliol and dehydrovomofoliol were identified for the first time from the fruits of *V. vinifera* by Strauses, William and Wilson (Strauss et al., 1987)

Raj Kumar et al., investigate the moisture content in *Basella rubra* was 92%, Ca – 0.2831%, Fe – 0.006162% and Zn – 0.1394% respectively (Rajkumar et al., 1973)

She and Kheng (She and Kheng, 1992) identified As contents in 41 common Malaysian vegetables including *Basella rubra* and analyzed by hydride generation inductively coupled plasma emission spectrometry. None of the sample showed levels >2.00 μg/g, the highest was found in bean. Sprouts (*Phaseolus radiactus*) (2.00 μg/g) and the lowest in sengkuang (*Pachyrhizus erosus*) (0.20 μg/g). Boiling causes a loss of 17-60% of the As in the plants.

Total oxalate, sol oxalate and nitrate were detected by Schmidt et al., for leaves of *Amaranthus cruentus* (*amaranth*), *Basella alba* Brassica abracia ver acephala(Kala) and *Ipomoea aquatica* (morning glory) grown on
soils of medium and high fertility. Difference among species were much greater than differenced due to fertility. Average total oxalate content on dry weight basis were Basella 10.62, Amaranthus 8.86, Ipomoea 2.81 and Brassica<1.50%. Higher soil fertility resulted in increased total oxalate of about 25% in Amaranthus and Basella but no increase in Brasica and Ipomoea. Soluble oxalate ranged from 4.14% for Basella to 0.20% for Brassica. Average nitrate contents were: Brassica 2.80, Amaranthus 0.67% Basella 0.61 and Ipomoea 0.39%. Leaves grown on high fertility soil had an average of 125% more nitrate than those from medium fertility (Schmidt et al., 1971).

Appalanaidu and Murti studied the influence of gibberellic acid on growth habit of Basella alba and Jasminum sambac. Gibberellic acid was sprayed uniformly on Basella alba and J. sambac at various concentrations and time intervals. A few drops of tween 20 used as wetting agent. Gibberellic acid modified the dwarf bushy habit of both plants to that of tall twining habit of its naturally existing corresponding alleles. The probable reasons for causing the twining habit in some species and not in others, in spite of hyperelongation caused by gibberellic acid are proposed in the light of the information available. Jasmine and spinach sprayed with gibberellic acid showed hyperelongation of shoot associated with charateristic twining habit. The leaves were reduced in weight and size, the shoots were thinner and had longer internodes than those of controls (Appalanaidu and Murty, 1963).

Cyunel and Czygan found that the formation of a red pigment particularly found in Basella alba liquid tissue cultures, was observed in samples exposed to fluorescent light. In preliminary chemical investigation, 3 betacyanins were detected by TLC their highest accumulation (76mg crude pigment/g dry tissue) was found in a 3
Leafy vegetables [Basella rubra L., Peucedanum sowa Roxb., Moringa oleifera, Lam., Trigonella foenum-graecum L., Spinacia oleracea L., Sesbania grandiflora (L.) Poir., and Raphanus sativus L. that are commonly used by the rural population in India were evaluated in terms of their main carotenoid pattern. The extracted carotenoids were purified by open column chromatography (OCC) on a neutral alumina column to verify their identity by their characteristic UV-visible absorption spectra. Reverse phase high performance liquid chromatography (HPLC) on a C18 column with UV-visible photodiode array detection under isocratic conditions was used for quantification of isolated carotenoids. Acetonitrile/methanol/dichloromethane (60:20:20 v/v/v) containing 0.1% ammonium acetate was used as a mobile phase. The major carotenoids identified by both methods were lutein, beta-carotene, violaxanthin, neoxanthin, and zeaxanthin. Among the carotenoids identified, lutein and beta-carotene levels were found to be higher in these leafy vegetables. Results show that P. sowa and S. oleracea are rich sources of lutein (77-92 mg/100 g of dry wt) and beta-carotene (36-44 mg/100 g of dry wt) compared with other leafy vegetables (Lakshminarayana, 2005).

Toshiyuki Murakami, Kazubiro Hirako and Massayuki Yoshikawa (Murakami, 2001) found that to evaluate the anti ulcer activity of Basella rubra (Basella alba) aqueous extract the methodology is that aqueous extract of the leaves of Basella rubra was prepared and anti ulcer activity was studied on ethanol and pylorus ligated induced gastric ulcer in rats. The ultimate result is that the leaf extracts (10 and 20mg/kg P.O.) showed significant and dose dependent anti ulcer activity
against ethanol and pylorus ligated-induced ulcer in rats. The study was compared with ranitidine (50mg/kg P.O.) as the control. The results indicate the potential of *Basella rubra* leaf extracts in the treatment of gastric ulcers.

Sattler and Lacroix (*Sattler and Lacroix, 1988*) found that in angiosperms placentae or ovules are formed on carpels as the floral apex. Hence, in a developmental sense, there are carpellate and acarpellate gynocia. The latter occur in about 11% of all Angiosperm families. *Basella rubra* is an example of the noncarpellate condition. Its single basal ovule is formed directly from the floral apex. In young developmental stages it even retains the tunica corpus organization of the floral apex. In later development stages, three septa arises only at the base of the ovule. The single vascular strand of the ovule is symmetrically derived from the bases of all six strands that supply the ovary wall, i.e., it is not associated with the vascular strand of only one of the three gynoecial appendages. Hence neither development nor vascularization support a carpellate interpretation of the *Basella gynoeicum* with regard to the evolution of basal placentation in Basella and other taxa of Angiosperms.

Three possibilities exist: (1) It is derived from the carpellate condition, (2) It is primitive and the carpellate condition is derived, (3) Both carpellate and noncarpellate organizations have co-existed during the evolution of Angiosperms which may have been monophyletic as polyphyletic.

Nirmala and co-workers (*Nirmala et al., 2009*) found that great efforts are on going in understanding and management of diabeties, the disease and disease related complications are increasingly unabated. In spite of the presence of known anti diabetic medicine in the pharmaceutical market, remedies from medicinal plants are used with success to treat this disease. In the present investigations an attempt is made to study the beneficial effects of *Basella rubra* in streptozotocin induced diabetic rats.
and validate its traditional claim. The diabetes induced rats were fed with *Basella rubra* (400mg/100g body weight orally through a gavage), when tested after ingestion the fasting blood glucose levels were remarkably reduced to normal and liver glycogen content was remarkably increased. In pancreatic sections of diabetic rats fed with *Basella rubra*, the islets were normal comparable to diabetic controlled rats (insulitis was observed). In liver, the changes caused after induction to diabetes was global microvascular steatosis. The portal traits appeared normal and central veins appeared congested, which was brought back to normal after feeding with *Basella rubra* while in the kidney sections, of diabetic control rats fed with *Basella rubra* no histopathological changes were noticed. The results demonstrate that the leaf pulp of *Basella rubra* possesses a strong hypoglycemic effect in streptozotocin-induced diabetic rats, thus supporting its traditional use in diabetes mellitus control.

Eliana Ferrira Ozela, Paulo Cesar stringheta and Milton Cano Chauca (Ferreira Ozela et al., 2007) found the stability of anthocyanin in spinach vine (*Basella rubra*) fruits. The stability of anthocyanin in the extract of spinach vine fruit (*Basella rubra* L.) was studied in relation to degradative factors such as light, temperature and pH acting alone as in combination. In this work, the possible use of spinach vine fruit as a source of natural pigments for use in food coloring was evaluated. Extraction of the pigment was carried out with 99.9% methanol at pH 2.0. The stability of the antocyanine extract was estimated. From these values, reaction velocity constants (K) as well as the half-life time (t1/2) were calculated at pH 4.0, 5.0 and 6.0 in the presence and absence of light both at 40 and 60°C. Results indicate that independent of pH values, spinach vine extract suffered an interference of light in its anthocyanin degradation kinetics with the mean t1/2 being greater in samples place in darkness (654.5±66.6h) compared to exposed to light (280±60.62h). In the presence
of light, degradation of the anthocyanin pigment increased with increased temperature and had an average half life time of 280±60.62h, 6.88 ± 0.76h and 2.42±0.31 h at room temperature (25±1°C), 40° and 60°C, respectively. Spinach vine extract was more stable at pH 5.0 and 6.0 than at pH 4.0 both in the presence and absence of light. This characteristic differs from other anthocyanins. This property could facilitate its application as a natural food colorant.

Sen et al., found the anti microbial activities of the aqueous, ethanolic and petroleum ether extract of leaves of Basella rubra were evaluated in the present study by measuring the inhabitation zones using cup plate definition method. The inhabitation zones were significantly different (P<0.001) in each plant extract. The ethanolic extract showed maximum activity with zone of inhabitation (14.3±1.82mm) against E. coli, followed by aqueous extract (13.4±1.2mm) and petroleum ether (5.6±0.62mm) at the concentration of 50μg/ml. Ciprofloxacin was used as the standard drug having zones of inhibition (17±0.34mm) against E. coli and 19±0.18mm against A. niger. Microbial inhabitation was in the order E. coli (12.57±0.99) A. niger (11.68±0.71), V. cholera (11.42±0.60), S. aureus (10.71±0.46), S. typhi (9.80±0.90) respectively with all the extracts. The extracts were not able to inhibit the growth of P. aerugnosa (Sen et al., 2010)

Pumchaosuan and Wongroung showed that the pigments found in plants play important roles in plant metabolism and visual attraction in nature. Anthocyanins, a major group of plant pigments, have been revealed to have strong antioxidant activity with potential use as chemotherapeutic. In this report, in vitro culture of Ceylon spinach (Basella rubra L.) was preliminary studied for anthocyanin production. Two types of explants including stem and leaf were used for callus induction. The method for sterilization by 7%(v/v) Clorox for 15 min and placed on Murashige and Skoog
(MS) medium containing 0.1 µg L⁻¹, 2,4-D and 5 µg L⁻¹ BA gave result of 100% callus production the stem type explant. The callus was also subjected to cell culture study. The effect of sucrose concentration on cell culture of Ceylon spinach was investigated and it was found that 0.5070g L⁻¹ d⁻¹ growth rate can be obtained at 3% sucrose. Anthocyanin production of the callus was induced by exposing Ceylon spinach callus to uv light for 0, 5, 10, 20 and 30 min and culturing on LS medium with 2,4-D and BA at 3 µg L⁻¹ for 2 weeks. The showed that callus treated with uv for 20 min and 30 min produces anthocyanin from the control callus was found at 1.001 mg/100g fresh cell weight (Pumphao Suan and Wongroung, 2009)

Oladele and Aberisada (Oladele and Aborisade, 2009) found the influence of different drying methods and storage on the quantity of Indian spinach (Basella rubra L.). This study reports the effect of drying methods on nutrient retention in a leaf vegetables during storage. The leaves of Indian spinach were dried to 3.50 – 4.00% moisture content in the sun (35°C), shade (28°C) and oven (45°C) and stored in polyethylene. There was minimal moisture gain during the twelve week storage period being less than 1% in all three drying methods. Ascorbic acid decreased by 43 – 48% as a result of drying but storage for twelve weeks did not result into much further loss. Shade dried leaves retained ascorbic acid in the least. Chlorophyll minerals contain also decreased slightly with drying and storage. Shade dried leaves were lowest in Ca, Mg, K, Na, Fe, Mn and Zn. The amount of Ca and Mg in shade dried leaves increased in storage while K, Mn and Zn decreased. Manganese was the most critically reduced element by both drying and storage with shade drying. Sun drying resulted into more nutrient retention while there was only marginal difference in ascorbic acid content by the three techniques. Chlorophyll contents were not much
affected by both drying and storage and shade dried leaves retained chlorophyll more than those dried in the sun and oven.

Glaessgen et al., have isolated Betacyanins from fruits of *Basella rubra*. They have reported the presence of betanidin monoglucoside as the major betacyanin and its 4-coumaroyl and feruloyl derivatives as minor components by Ion spray mass spectrometry and tandem mass spectrometry of the fresh juice from the fruits of *Basella rubra* (Glaessgen, 1993).

According to Shimizu and Mori *Basella rubra* contained crude lipids – 0.55%, total carotenoids – 8.3% and pro-vitamin – 3.2% (Shimizu and Mori, 1980). The carotenoids found were α-carotene, β-carotene and violaxanthin, lutein, phytoene, and three unidentified carotenoids.

Kittur et al., found that the seeds of *Basella rubra* contained oils (36.9%), fatty acids (50.3%), linoleic acid (19.1%) and protein (23.1%) (Kittur et al., 1983).

Jain and Garg found that the proteins hydrolyzed from whole *Basella rubra* contained thirteen amino acids and 62.92% of the hydrolyzate consisted of eight essential amino acids (Jain and Garg, 1987).

Vasi and Kalintha determined the amino acids by paper chromatography. Powdered defatted dried leaves of *Basella rubra* were hydrolyzed with 6N HCl and 5N NaOH, and the amino acids were identified by paper chromatography (Vasi and Kalintha, 1980).

It was found that the moisture contained in *Basella rubra* was 92%, Calcium – 0.2831%, iron – 0.00616% and zinc – 0.1394%. Ascorbic acid, total carboxylic acid and iron were also determined and the overall values were 19-125, 0.54-1.00 and 0.89-2.76 mg/kg, respectively (Iwai et al., 1986).
Oshodi (Oshodi, 1993) carried out proximate analysis for proteins, minerals, and vitamin C contents in twelve different dried leaf vegetables including *Basella rubra*.

It has also been known that the extracts from various parts of plants such as leaves, stems and roots and especially from their fruits are used as colouring agents. Some dyes are non-edible being toxic in nature whereas some other are non-toxic and hence edible. Thus the plant world contributed lot towards development of dye segment.

Kameoka et al., identified a couple of volatile flavor components of *Basella rubra* L. by infrared spectra and chromatography-mass spectrometry. Major components identified from volatile oil were 1-methoxypropane, (Z)-3-hexen-1-ol, 3-methoxyphenyl acetate, acetophenone, 4-vinylguaiacol, isophytol, and phytol. The major headspace components were ethyl acetate, benzene, 3-heptanone, 2-heptene, ethylbenzene, o-xylene, and limonene (Kameoka et al., 1991)

![4-vinylguaiacol](https://example.com/4-vinylguaiacol.png)

![Isophytol](https://example.com/isophytol.png)
Colours have always fascinated mankind since ages and have always been regarded as one of life’s greatest mystery. Ever since primitive people could create, they have been endeavoring to add colour to the world around them. Every civilization has its myth and association with colour. Aristotle, the great philosopher in the fourth century BC, considered blue and yellow to be the true primary colours relating as they do to life’s polarities. Artists universally adopted his principles of association of colour with the four elements fire, water, earth and air and applied them for two thousand years, until Newton’s discoveries in the seventeenth and eighteenth centuries replaced them in general colour theory (http://www.colour-affects.co.uk/history-of-colour).

Ferreira Ozela \textit{et al.}, studied the stability of anthocyanin in the extract of spinach vine fruit (\textit{Basella rubra} L.) was studied in relation to degradative factors such as light, temperature and pH acting alone or in combination. They studied the possible use of spinach vine fruit as a source of natural pigments for use in food coloring was evaluated. Spinach vine extract was more stable at pH 5.0 and 6.0 than at pH 4.0 both in the presence and absence of light. This characteristic differs from other anthocyanins. They commented that this property could facilitate its application as a natural food colorant (Ferreira Ozela \textit{et al.}, 2007).
Different colours obtained from the leaves, and stems are used for dyeing fabrics and in painting. Betacyanins—isogomphrenin I, isogomphrenin II, gomphrenin I, gomphrenin II, and gomphrenin III were isolated from fruits. Ion spray mass spectrometry and tandem mass spectrometry of the fresh juice from *Basella rubra* fruits revealed the presence of betanidin monoglucoside as the major betacyanin and its 4-coumaroyl and feruloyl derivatives as minor components (*Glassgen et al.*, 1993; *Potsangbam et al.*, 2008; *Cai, et al.*, 2003).

Oladele (*Oladele, and Aborisade, 2009*) discussed the influence of different drying methods and storage on the quality of Indian Spinach (*Basella rubra* L.). Drying and storage caused a reduction in Ca, Mg, Na, K, Fe, Mn and Zn. Shade dried sample was lowest in Ca, Mg, K, Na, Fe, Mn and Zn immediately after drying. Sun drying technique retained Ca more than the other two techniques. Usually however,
the vegetable is not cooked alone but with other ingredients which may provide additional quantities of nutrients required.

Chlorine is one of the most abundant elements on the surface of the earth. Until recently, it was widely believed that all chlorinated organic compounds were xenobiotic, that chlorine does not participate in biological processes and that it is present in the environment only as chloride (Cl\(^-\)). In a mini-review, Oberg, discussed the ability of *Basella rubra* to convert chloride to organic chlorine (Öberg, 2002).

Hypoglycemic effect of *Basella rubra* in streptozotocin – induced diabetic albino rats was studied by Nirmala and co-workers (Nirmala et al., 2009). The result of their study showed that *Basella rubra* brings back the blood glucose and body weight to normal in diabetes-induced rats. After treatment with *Basella rubra*, liver section of diabetic rat’s hepatocytes, portal tracts and central veins appeared normal. In the pancreas, no insulinitis was observed. From the above results it is shown that it has (*Basella rubra*) hypoglycemic activity. Hypoglycemic action of the herbal plant (*Basella rubra*) in diabetic rats may be possible through the insulinomimetic action or by other mechanism such as stimulation of glucose uptake by peripheral tissue, inhibition of endogenous glucose production, or activation of gluconeogenesis in liver and muscle. It may prevent the hepatic injury and pancreas and suppressing the oxidative stress associated with diabetes. Although the exact chemical compounds responsible for the hypoglycemic effects of *Basella rubra* still remain speculative, experimental evidence obtained from this study indicates that *Basella rubra* possess hypoglycemic property, which also is confirmed by histopathological examination.
3.5 Review of Reports on Basella alba

Penteado, Marilene de Vuono Camargo, Minazzi, Ragina Sorrentino; Bicudo de Almeida, Ligia determined the carotenoids present in leaves of vegetables and the corresponding vitamin A values were calculated. Species examined were purslane (Pastulaca halimoids), Malabar spinach (Basella rubra), cariru (Talinum sp.), Chocory (Cichorium intybus), Chinese mustard (Brassica chinensis), Indian and African spinach (Amaranthus spp.), Siplanthes acmella, cassava (Manihot esculenta), Mexicantea (Chenodium ambrosioides), monkey ear (Alternanthera sp.), okra (Hibiscus esculenthus), taro (Colocasia esculent), tomato (Lycopersicum esculentum), and roselle (Hibiscus sabdariffa and H. acetosella).

Recently Basella alba has received lot of interest from the researchers in phytochemistry and related fields. Plots of numbers of papers mentioning Basella alba (filled column histogram and left hand axis scale) and line of best fit, 1926 to 2006 (complete line, with equation and % variation accounted for, in box on the left hand side) is presented below:

Figure 3.2: Plots of numbers of papers mentioning Basella alba

(http://www.newcrops.uq.edu.au/listing/species_pages_B/Basella_alba.htm)
Moundipa and co-workers found that *Hibiscus macranthus* and *Basella alba* leaves are mixed in a remedy given, is western Cameroon, to the new king for some weeks during initiation period to sustain his sexual performance. This plant extracts enhanced blood testosterone level in male rats. There were further studied for androgenic activity since they could be used to alleviate male infertility as to treat androgen deficiency in ageing male. Using rat testis slices, methanol extract of both plants significantly induced testosterone synthesis. In primary Leydig cell cultures of bull and rat, extracts from *Basella alba* significantly enhanced testosterone levels in a dose dependent manner. *H. macranthus* showed no androgenic activity. Phytochemical screening and HPLC study of *Basella alba* extracts revealed presence of terpenoids, Lemonoides and coumarins. This extract also modulated aromatase gene activity in leydig cell cultures. In vivo, methanol extract (1mg/kg) given to adult male rats significantly increased serum testosterone level after 30 days (*Moundipa et al.*, 2008)

Haskell and his co-workers (*Haskell et al.*, 2004) found that daily consumption of Indian spinach (*Basella alba*) has a positive effect on total body vitamin A stores in Bangladeshi man. Recent evidence suggests that the vitamin A equivalency of β-carotene from plant sources is lower than previously estimated. They assessed the effect of daily supplementation with 750 μg retinol equivalents (RE) of either cooked, pureed sweet potatoes; cooked pureed Indian spinach (*Basella alba*); as synthetic sources of vitamin A as β-carotene on total body vitamin A stores in Bangladeshi men. Total body vitamin A stores in Bangladeshi men (n=14/group) were estimated by using the deuterated retinol dilution technique before and after 60d of supplementation with either 0μg RE/d (white vegetables) as 750 μg RE/d as sweet
potatoes, Indian spinach, retinyl palmitate, as β-carotene (RE-1µg) retinol as 6µg β-carotene in addition to a low-vitamin A diet providing ≤ 200µg RE/d. Mean changes in vitamin A stores in the vegetables and β-carotene groups were compared with the mean change the relative equivalency of these vitamin A sources. The ultimate result is that overall geometric mean (+SD) initial vitamin A stores were 0.108±0.067 mmol. Relative to the low-vitamin A control, the estimated mean changes in vitamin A stores were 0.29 mmol for sweet potato (P=0.21), 0.041 mmol for Indian spinach (P=0.033), 0.065 mmol for retinyl palmitate (P<0.001), and 0.062 mmol for β-carotene : retinol, wt : wt) were estimated as ≥ 13.1 for sweet potato, ≥ 10:1 for Indian spinach, and ≥ 6.1 for synthetic β-carotene.

Shanta and group (Shantha et al., 2005) studied the morphology and pharmacognostical aspects of Bassella alba fresh leaf samples, including phytochemical, UV and TLC studies for quantity control and prevention of alternation of medicinal formulations. The leaves exhibited several important diagnostic characteristics presence of succulent mucilaginous leaf with cordate leaf base without any trichomes; presence of rubiaceous type of stomata on both sides of the leaf presence of one to 2 large median vascular bundle in the midrib region of the leaf, enclosed by 2 to 3 layers of collenchymatous bundle sheath; and presence of collateral conjoint and closed vascular bundle in the leaf as well as in the petiole. The results of pharmacognostical and phytochemical studies are also presented.

It is important to note that some medicinal plants that were commonly used for the treatments of DM are linked to male infertility, such as Azadirachta indica (Meliaceae) and Quassia amara (Simaroubaceae). By contrast, administration of Hibiscus macrocanthus (Malvaceae) and Basella alba (Basellaceae) extracts caused
an increase in the serum levels of testosterone and in the weight of the rat testis (Irshaid and Mansi, 2009). Moundipa et al., determine the androgenic effects of Basella alba and Hibiscus macranthus extracts in the rat and the bull. Basella alba extracts significantly enhanced testosterone production in bull and rat Leydig cells in a concentration-dependent manner. Hibiscus macranthus showed no androgenic effect but was shown to inhibit testosterone production at higher concentrations (Moundipa, 2005)

On the basis of the above surveyed literature, known therapeutic uses and as folk-lore medicinal properties, we intended to carry out the phytochemical and biological study of some of the compounds present in the Basella rubra L. and Basella alba L. using different solvents and also to propose a tentative structure.