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A review of the taxonomy, ethnobotany, phytochemistry and pharmacology of *Basella alba* (Basellaceae)

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ABSTRACT

Basella alba L. is an important green leafy vegetables found commonly in the tropical regions of the world. The plant is used as a substitute for true spinach (i. e. *Spinacea oleracea L.*) and also has great ethnomedicinal importance. Different studies have proved that the plant is rich in vitamin A and vitamin C along with flavonoids, saponins, carotenoids, many amino acids and organic acids. Various *in vivo* and *in vitro* studies revealed that the plants is enriched with active substances/principles having medicinal potential. Major biological activities exhibited by *Basella alba* is androgenic, antidiabetic, anti-inflammatory, antimicrobial, antioxidant, antiulcer, antiviral, CNS depressant, hepatoprotective and wound healing, properties. Besides these all the plant possess a valuable ethnomedicinal importance and are used to cure digestive disorders, skin diseases, bleeding piles, pimples, urticaria, irritation, anemia, whooping cough, leprosy, aphthae, insomnia, cancer, gonorrhea, burns, headache, ulcers, diarrhea, liver disorders, bilious vomiting, sexual asthenia.

INTRODUCTION

Basella alba L. (Synonym: *Basella rubra* Roxb.) is an extremely heat tolerant (Grubben and Denton, 2004), fast growing perennial vine which belongs to family Basellaceae (Rathee *et al.,* 2010). It is commonly known as Malabar spinach, Indian spinach, Ceylon spinach, vine spinach (Roy *et al.,* 2010), climbing spinach (Sen *et al.,* 2010), East-Indian spinach, Chinese spinach (Bamidele *et al.,* 2010) and cyclone spinach (Nirmala *et al.,* 2011). *Basella* is native to tropical Southern Asia, probably originated from India or Indonesia (Saroj *et al.,* 2012). *Basella alba* is particularly abundant in Malaysia, Philippines, tropical Africa, the Caribbean and tropical South America (Palada and Crossman, 1999), Southeast of Brazil (Echo plant information sheet, 2006). Due to easy adaptation to a variety of soils and climates *Basella alba* is considered one of the best tropical spinach throughout the tropical world (Palada and Crossman, 1999). *Basella alba* is one of the wild leafy vegetables, which is rare in its natural habitat (Wambugu and Muthamia, 2009) but nowadays it is an important leafy vegetable grown for its nutritive value (Varalakshmi and Devaraju, 2010) throughout the temperate regions as an annual and the tropics as a perennial (Bamidele *et al.,* 2010, Echo plant information sheet, 2006). Almost in every part of India, *Basella* is grown as a pot herb (Khare, 2007).

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TAXONOMY

Taxonomical Conflicts

The generic name *Basella* given by Linnaeus was derived from Malayalam. Later he cited *Hortus Malabaricum* in the synonymy for *Basella rubra* L. = *Basella alba* L. (Cook, 2010). *Basella* has generated much attention due to some conflicting reports from the classical taxonomists (Ray and Roy, 2007). According to Sperling, (1987), the genus consists of five species; one is pantropical and remaining four are widely distributed in East and Southeast Africa and Madagascar.

Linnaeus first described two species of *Basella* L. in *Species Plantarum*. These species were *Basella rubra* and *Basella alba* which were separated from each other on the basis of leaf character and stem colour. Roxburgh (1832) first treated *Basella alba, Basella rubra* and *Basella lucida* in synonymy and adapted

Basella alba as a correct name according to the article 11.5 of the code (Sidwell, 1999). Smitinand (1992) agrees with the Roxburgh. These findings also have been supported by the facts that the anatomical differences in between these two taxa are negligible (Busuioc *et al.,* 2004). As per the Echo plant information sheet (2006), most authors agreed that the two colour forms of *Basella* are not separate species. Cytological, pollen morphological and protein profile studies of the red and green stem forms of *Basella* proved that both the stem forms belong to one single species and that is nothing but *Basella alba* (Roy *et al.,* 2010). Almeida (2003), in 'Flora of Maharashtra' has mentioned that, the plant with green stem and green petiole is *Basella alba* L. and the other with red stem and red petiole is *Basella alba* L. var. *cordifolia* (Lamk.) Almeida.

Common names/ Vernacular names

Arabic

Malabar spinach, Chinese: lu luo kui, Danish: indisk spinat, Dutch: ceylonspinazie, Filipino: Alugbati, French: baselle, German: indischer spinat, Gujarati: poi-mopal, Indonesian: gondola, Italian: spinacio della cina, Javanese: jingga, Kikuyu: murerema, Nepalese: poi sagg, Portuguese: bacela, Spanish: espinaca blanca de Malabar, Swedish: indisk spenat, Tamil: pasali, Tamil: vaslak-kirai Telugu: baccali, Thai: phak plang, Turkish: pazu, Vietnamese: mong toi, (Eland, S., 2008). Bengali: puishak, Hindi: lalbachlu, Kannada: baselesoppu, Konkani: valchibhaji, Marathi: bhajyacha vel, velbondi, mayalu; Oriya: poi saga, Sanskirt: upodika, Tamil: kodippasali, Telugu: bachhali (Adhikari *et al.,* 2012).

Morphology

***Basella alba* L.**

The plant is a perennial twining herb. Stem is fleshy, stout at the base with slender upper branches. Leaves are axillary dark green, broadly ovate in shape and acute. Flowers are sub sessile, white, pink or red coloured and closed at anthesis. Bracts are scaly and small.

Bracteoles are acute. Stamens are included with short filaments and cordate anthers. Ovary is unilocular. Fruit is black or dark purple coloured and enclosed within the persistent fleshy calyx. Seeds are black, globose and indehiscent. (Cooke, 1902; Yadav and Sardesai, 2002; Almeida, 2003).

***Basella alba* L.var. *cordifolia* (Lamk.) Almeida**

The plant is a perennial herb. Stem is very long, slender, succulent, glabrous and much branched. Leaves are broadly ovate, acute or acuminate, thick, apiculate, entire with cordate base. Flowers are white or red in colour, sessile in few lax pendunculate spikes. Bracts are small and apiculate. Bracteoles are rather longer than the perianth, oblong and obtuse. The perianth is divided about halfway down; segments are elliptic and obtuse. The fruit is small and red or black in color. Seeds are black. (Almeida, 2003).

ETHNOBOTANY

Basella alba is an underutilized plant with great potential (Olgorite, 2006). The plant is often grown as an ornamental. *Basella alba* is a very popular vegetable in many coastal communities of Southern Nigeria and is one of the chief sources of the major ingredients in the Northern and Northeastern foods. (Izonfuo *et al.,* 2006; Pareek *et al.,* 2010). The medicinal importance of *Basella alba* had earlier reviewed by Adhikari *et al.,* (2012), Kumar *et al.,* (2013). A precise summary of ethnobotanical applications is given in Table 1.

PHYTOCHEMISTRY

Nutritional and Anti Nutritional Composition

Basella alba is good source of vitamin A, vitamin C, vitamin B9 (folic acid), calcium, magnesium, iron and several vital anti oxidants in the plant. (Duke and Ayenshu, 1985; Palada and Crossman, 1999); also has proteins, fats, carbohydrates, fiber, ash, calcium, vitamins, thiamine, riboflavin and niacin (Grubben and Denton, 2004). According to Khare (2007) the plant consists the essential amino acids such as arginine, isoleucine, leucine, lysine, threonine and tryptophan alongwith several vitamins, minerals and a low percentage of soluble oxalates. Sheela *et al.,* (2004) have analyzed macronutrients composition of *Basella rubra* on dry weight basis and mentioned that the plant contains carbohydrate = 0.4g., energy = 31kcal., fat = 1.9g, fiber = 0.3g., moisture = 93% and protein = 3.3 g, while the micronutrient composition and oxalic acid content were ascorbic acid = 15mg., calcium = 187mg., iron = 5.45mg., and oxalic acid = 60 to 84mg. per 100g of edible portion. Lola A. (2009) has studied the fat content of raw *Basella rubra* which was about 0.30%. Oladele and Aborisade (2009) have evaluated the influence of different drying methods and storage on the quality of *Basella rubra.* They observed significant reduction in Ca, Mg, Na, Fe, Mn and Zn during drying and storage. Werner and Raus (2006) have stated that the leaves are rich in β carotene and vitamin A. Killur *et al.,* (1983) studied characteristics and composition seeds which contain oils (36.9%), fatty acids (50.3%), linoleic acid (49.1%) and protein (23.1%).

Basella alba contains basellasaponins (Toshiyuki, 2001) and peptide, phenolic compounds (Maisuthisakul *et al.,* 2008). In South East of Nigeria the leafy vegetable *Basella alba* contains cyanide in the range of 5.04±0.20 mg HCN/ kg. (Uhegbu *et al.,* 2011). Olagire and Azeez (2011) have reported that *Basella alba* yields about 42% and contains flavonoids, ascorbic acid, phenolic compounds and possessed DPPH antioxidant activity. The leaves also contain carotenoids, organic acids and water soluble polysaccharides, bioflavonoid and vitamin K (Khare 2007). Rothman *et al.,* (2009) stated that, *Basella alba* leaves has n = 13, acid detergent fibre = 14 ± 2.4, acid detergent lignin = 4.6 ± 3, crude protein = 29 ± 4 and neutral detergent fibre = 24.3 ± 2.7. In aerial parts of *Basella rubra*, Glassgen *et al.,* (1993) and Hebbar *et al.,* (2004) have reported the presence of betacyanins, carotenoids and organic acids; Toshiyuki (2001) has isolated triterpene oligoglycosides basellasaponins A, B, C and D; Murakami *et al.,*

(1999) have reported the presence of betavulgaroside I and Iwamoto *et al.,* (1985) have isolated momordins IIb and IIc. Gupta *et al.,* (2008) and Saleem *et al.,* (2001) have reported the anticancer, antioxidant and anti inflammatory activities due to presence of β sitosterol and lupeol in the plant. Paul and Singha (2010) have identified and isolated two important sterols, β-sitosterol and stigmasterol glucoside in good yield from the leaves of *Basella rubra*. Arangasamy and Munusamy (2008) have investigated the efficiency of *Basella alba* leaves for the reduction of silver ions as well as the formation of silver nanoparticles. They noted significant development in the intensity of reaction mixture colour. Babalola *et al.,* (2008) have reported the importance of *Basella alba* as an effective biosorbent for the removal of lead (II) and chromium (III) from aqueous solutions. Pumchausuan and Wongroung (2009) have preliminary studied *in vitro* culture of Ceylon spinach (*Basella rubra*) and obtained highest anthocyanin production in calluses treated with 20 min. UV- illumination.

***Basella* fruit dye**

Mell (1937) isolated the purple dye from the *Basella* plant. Cao *et al.,* (1991) extracted a red pigment from the fruit of *Basella rubra.*

Izonfuo *et al.,* (2006) studied acid base indicator properties of aqueous and ethanol extracts of ripened fruits of *Basella alba.* They determined that the dye obtained from the fruits is photo chemically unstable and can be used in the strong acid and strong base titrimetric reactions as an indicator. Mundo *et al.,* (1995-96) reported that the stain obtained from *Basella rubra* fruit pulp can be used as a substitute for crystal violet or safranin in the Gram staining and as a biological stain for plant nuclei and organelles. Lin *et al.,* (2010) studied structural identification and bioactivities of red violet pigments present in *Basella alba* fruits. They subjected 80 % methanol extract of fresh fruit flesh to solid phase extraction, semipreparative HPLC isolation, structure elucidation and mass spectrophotometric analysis. Observations made by them clarified that fruit possessed gomphrenin-I as major red pigment (360 mg/100g), along with betanidin dihexose, betalins and isobetanidin dihexose. They reported anti oxidant properties and anti inflammatory function of gomphrenin I and mentioned the potential use of fruit in the development of food colorants and nutraceuticals. By ion spray mass spectroscopy and tandem mass spectroscopy Glassgen *et al.,* (1993) reported that the *Basella rubra* fruits possessed betanidin monoglucoside as major betacyanin along with its derivatives i.e. 4-coumaroyl and feruloyl as minor compounds. They performed TLC and HPLC analysis and concluded that betacyanin in the fruits are gomphrenin I (15S-betanidin 6-O-β-glucoside), gomphrenin II (15S-betanidin 6-O-[6'-O-(4-coumaroyl)- β-glucoside]) and gomphrenin III (15S-betanidin 6-O-[6'-O-feruloyl-β-glucoside]) alongwith small fractions of isogomphrenin I and II. Reshmi *et al.,* (2012,a) studied the effect of light, temperature and pH on the stability of betacyanin pigments from *Basella alba* fruits and reported that the betacyanins are strong or moderately resistance to pH, temperature and light therefore can be widely used in food colorant. Nishimato and Hirose, (1991) isolated a red coloring material from the fruit juice of *Basella rubra* which showed resistance to heat induced discoloration for food, feeds, pharmaceuticals and cosmetics. *Basella* red pigment also gave the characteristic absorption of betacyanins and decomposed under the effect of light, heat and metal ions such as Fe^{++}, Fe^{+++} and Cu^{++} hence can be widely used as a good additive and non poisonous colorant (Paul and Singha, 2010). *Basella rubra* fruit pulp pigment had good stability in between pH 3 to 7 and hence can be widely used in the food industry and cosmetic industry. They also reported the stability nature of the pigment which gets influenced by the light, temperature, oxidants, reducing agents and citric acid (Zhang *et al.,* 2010). Amon *et al.,* (2012) studied *Basella rubra* fruit extracts for their potentiality as a food colorant. They mentioned that the extract showed the presence of anthocyanin and also exhibited DPPH radical scavenging activity. They summarized that the extract is non toxic and can also be implied in foods coloring industries to impart reddish colour.

***Basella* - Plant Mucilage**

Guang and Quing – Gang (2009) employed paraffin sectioning technique to study the distribution and developmental structures of mucilage cells of *Basella alba* L. During this study they concluded that the mucilage cells exist in the aerial plant parts except seed, anther and ovary; in leaf tissue, spongy tissue consist more mucilage cells than the palisade tissue and in the petiole, mucilage cells are distributed in 'U' type cortex. They reported that four different developmental stages (viz. stage of initial mucilage cells, stage of vacuolation, stage of maturation and stage of integration) are involved in developmental process of mucilage cells. Pareek *et al.,* (2010) isolated and evaluated physicochemical characterization of *Basella alba* leaf mucilage. They isolated mucilage by defatting sun dried leaf powder with petroleum ether and performed various phytochemical tests. The isolated mucilage from *Basella alba*, occurs as off white, odorless, amorphous powder. The total particle size of the mucilage was 114 nm; melting range was above 240^0C and IR spectrum of mucilage showed the presence of hydroxyl group, carboxyl group, keto group, an aldehyde group and phenol group. The phytochemical screening results concluded that total yield of mucilage was about 14.8% with moisture content about 2.63% and total carbohydrate content was found to be 84.05%. The reports by Pareek *et al.,* (2010) also mentioned that the mucilage showed the presence of water insoluble ash (0.54%), acid insoluble ash (0.36%), sulphated ash (1.35%) along with chloride and uronic acid. Kumar *et al.,* (2011,a) reported strong suspending ability along with high viscosity of *Basella alba* mucilage and mentioned its role as a good thickening agent in pharmaceutical industries. Preliminary investigations of *Basella alba* mucilage as a tablet binder in model drug paracetamol reported that, the mucilage exhibits good binding properties for uncoated tablets with small retardation in drug release from the tablet (Ramu *et al.,* 2012). Physical and biological properties of *Basella alba* stem mucilage has studied by Chatchawal *et al.,* (2010). They reported that mucilage is mainly a

polysaccharide with pH ranging between 5.3 to 5.4, contains D-galactose as a major monosaccharide and exhibits slow swelling capacity, mild antioxidant activity and no tyrosinase inhibiting activity.

BIOLOGICAL ACTIVITIES

Wound healing activity

Mohammed *et al.,* (2012) studied wound healing capacity of *Basella alba*, in male albino rats. They created burn wounds on the back of rats and treated them with *Basella alba* leaf extract in glycerin for about 20 days. Their results concluded that, rats treated with aqueous leaf extracts showed a maximum wound healing capacity with significant wound closure and indicated wound healing capacity of *Basella alba.*

Antimicrobial activity

Oyewole and Kalejaiye (2012) used agar cup method for the determination of antimicrobial effects of *Basella alba* ethanolic extracts against *Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli and Candida albicans*. Their findings reported that *Basella alba* ethanol extracts showed inhibitory activities against all the above bacteria except *Candida albicans.* Sen *et al.,* (2010) examined the antibacterial activity of the *Basella rubra* leaves by cup plate diffusion method and reported that aqueous, ethanol and petroleum ether extracts of the *Basella rubra* leaves exhibited antibacterial activity against *E. coli, Vibrio cholera, Staphylococcus aureus and Staphylococcus typhi.*

Antiviral activity

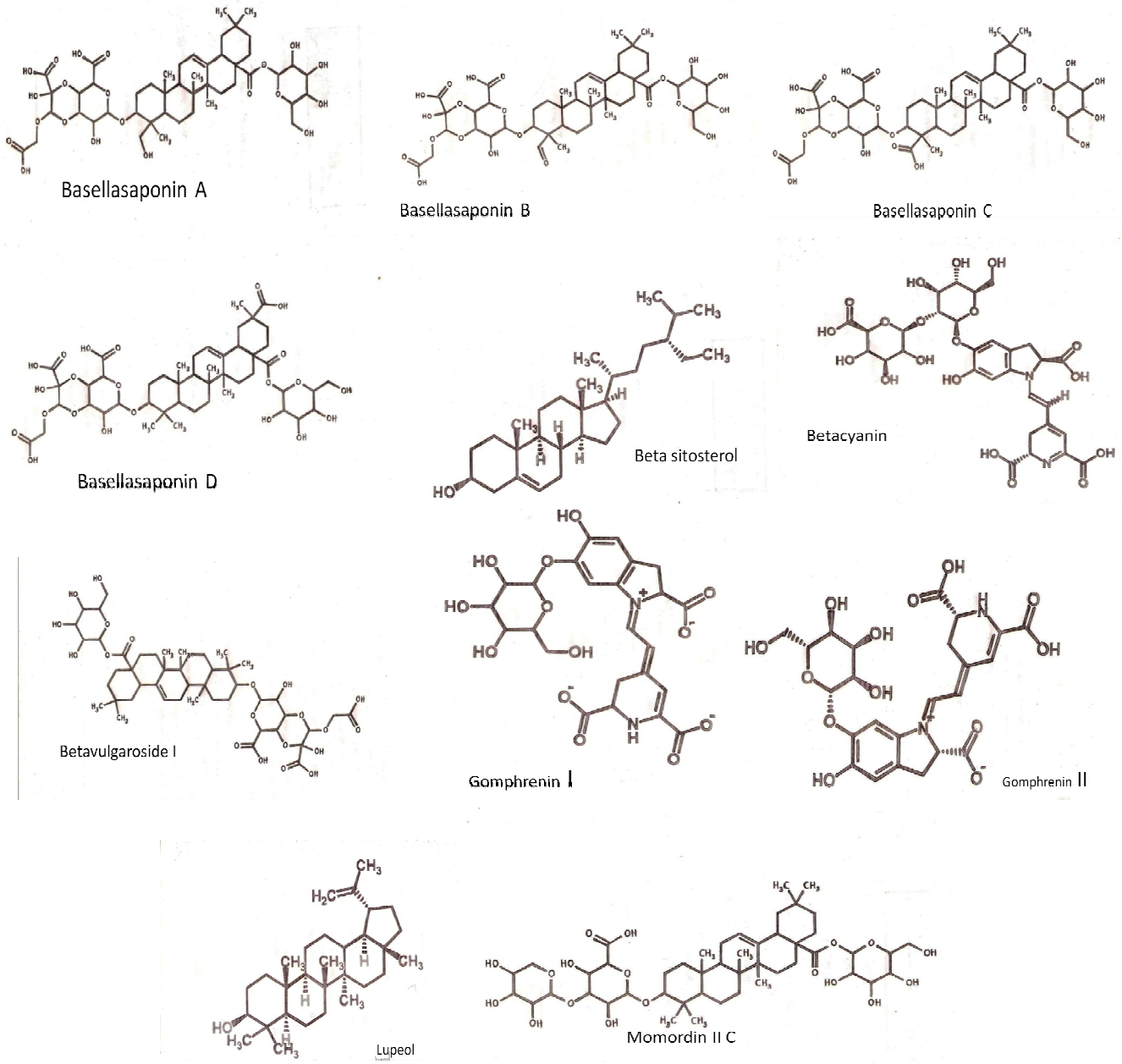
Verma *et al.,* (1995) reviewed antiviral activity of many plant tissues. This property is due to the presence of ribosome inactivating proteins (RIPs) present in the extracts of plant tissue (Barbieri *et al.,* 1993). All RIPs are with single chain (type I) or two chains (type II). Bolognesi (1997) isolated single chain (type I) ribosome inactivating proteins from the seeds of *Basella rubra* and tested them for antiviral activity and inhibited infection of *Nicotiana benthamiana* by AMVC (Bolognesi, 1997). Liu *et al.,* (2006) studied that the early inoculation of *Basella rubra* extract on tobacco plant showed inhibitory effects against tobacco mosaic virus. Dong *et al.,* (2012) reported structures of acidic polysaccharides from *Basella rubra* and their effects on herpes simplex virus type 2.

Anti inflammatory activity

Kachchhava (2006) have performed anti inflammatory activities of *Basella alba* extract on rats. He used two different phlogistic agents viz. carageeneen (1%) and formaldehyde (3, 5%) to carry out the activity on two inflammatory models. Phenylbutazone was used as a standard anti inflammatory drug. Aqueous extract of *Basella alba* at the dose of 500mg/kg and 100mg/kg significantly reduced the inflammation. In the carageeneen induced inflammatory method they noted that, the pre ether extract of *Basella alba* did not exhibit significant anti inflammatory activity. Krishna (2012) employed cotton pellet induced granuloma method while Rodda *et al.,* (2012) employed carageeneen along with cotton pellet granuloma induced inflammatory methods in rats, to study the activity on inflammatory models. In both the above studies phenylbutazone was used as a standard. They treated experimental rats with oral suspension of cold macerated 50% ethanol extract of *Basella alba* leaves and resulted that the plant had significant anti inflammatory activity. In another study, Kumar *et al.,* (2011 b) investigated in vitro anti inflammatory activity of *Basella alba* as per human blood cell membrane stabilization method. They noted that, both the aqueous and methanol extracts of *Basella alba* leaves exhibited significant membrane stabilization property as compared with the standard drug diclofenac.

Anti ulcer activity

The effect of *Basella alba* as an anti ulcer agent has studied by Venkatalakshmi and Senthamaraiselvi (2012). They treated 7-8 weeks old female albino Wistar rats with aspirin suspended in 1% carboxyl methyl cellulose at a dose of 150 mg/kg to induce the ulcer. The studies resulted that, aspirin altered parameters like ulcer index, percentage of ulcer inhibition, gastric pH, pepsin content, thiobarbituric acid reactive substances, lipid hydro peroxidases, SOD, GPx, CAT, GSH, vitamin C, and vitamin E were restored by the treatment of *Basella alba* leaf extract and indicated its anti ulcer activity. Kumar *et al.,* (2012) evaluated the effects of aqueous and ethanol extracts of *Basella alba* leaves on antiulcer activity in the rats subjected to pylorus ligation and ethanol induced ulcer models. They prepared plant extracts by cold maceration of shade dried powered leaves with ethanol and distilled water separately. A solid mass was obtained after filtration and evaporation which was used as an animal feed. They made six groups of albino wistar rats of either sexes and gave various treatments as follows. The group I was treated as control and served with distilled water. 200 mg/kg and 400mg/kg AEBA were given to the animals in group II and III while group IV and V animals were orally supplemented with 200 mg/kg and 400mg/kg EEBA respectively. Fomotidine was used as a standard drug and administered orally to the animals of group VI in the ratio of 20mg/kg. The animals treated with AEBA and EEBA showed a dose dependant protection against the action of ethanol and pylorus ligation on gastric mucosa of animals. Kumar *et al.,* (2012) also concluded that, both the extracts increased the mucosal defense and decreased the gastric acidity very significantly, indicating that the *Basella alba* has gastroprotective activity as well as statistically significant antiulcerogenic activity due to improvement in gastric cytoprotection and inhibition of acid secretion. Deshpande *et al.,* (2003) induced gastric ulcers in the rats by the treatment of ethanol and pyrolous and then the treated animals were fed with aqueous extracts of *Basella rubra* leaves. They found that, the treatment of *Basella rubra* aqueous leaf extract in the ratio of 10mg/kg and 20mg/kg had significant and dose dependent antiulcer activity.



Chemical structures redrawn from: ChemDraw – (www.cambridgesoft.com), *Chemspider*-(chemspider.com) and pubchem.ncbi.nlm.nih.gov).

CNS Depressant activity

Anandrajagopal *et al.,* (2011) evaluated the CNS depressant activity of various solvent extracts of *Basella alba* aerial parts on Swiss albino mice of either sex. They concluded that, the methanol extract exhibited CNS depressant activity which is due to the presence of some psychoactive substances like terpenoids in the plant.

Androgenic potential

Moundipa *et al.,* (1999) evaluated the effects of aqueous plant extracts on male reproductive function in mature male albino Wistar rats. In these studies, they concluded that the weight of seminal vesicles, serum level of testosterone, in vitro testosterone production, the activity of prostatic acid phosphatase and concentration of spermatozoa in the lumen of the seminiferous tubules significantly increased after treatment of both the fresh and dried leaves extracts to the rats. Thus the work done by they concluded that the aqueous extract of leaves has anabolizing and virilizing effects. Moundipa *et al.,* (2005) isolated Leydig cells from the rats and the bulls and treated them with the methanol extract of *Basella alba*, to evaluate the androgenic effects on testosterone production. They concluded that the testosterone production was significantly increased in a concentration dependant manner, owing that the *Basella alba* has androgenic

potential. Nantia *et al.,* (2011) treated seventy days old Sprague-Dowley rats with the methanol extract of *Basella alba* (MEBA) fresh leaves to evaluate the effects on Leydig cell viability, on steroid production and aromatase mRNA level. They found that the percentage of viable Leydig cells was more than 95% and purity was higher than 85%. MEBA also stimulated the production of steroid and aromatase mRNA. From these studies they concluded that the *Basella alba* has the capacity to stimulate not only androgen production but also estrogen level, hence it has been used in traditional practices in the treatment of male infertility and sexual asthenia. Another study by Nantia *et al.,* (2012) have further demonstrated that the MEBA has the effect in the enhancement of fecundity/ fertility in rats exposed to the antiandrogen flutamide during their foetal life as well as in normal rats. Methanol extracts from fresh leaves of *Basella alba* has been reported to possess active components that have a significant effect on the masculinization of *Poecilia reticulata* (Chakraborty *et al.,* 2012). Moundipa *et al.,* (2006) *in vitro* studied effects of extracts from *Hibiscus macranthus* and *Basella alba* mixture on testosterone production in adult rat testes slices. Their study resulted that the methylene chloride and methanol extracts application induced an increase in testosterone production in testes slices.

Hepatoprotective activity

Adekilekun *et al.,* (2012) studied the effects of *Basella rubra* aqueous leaf extract in Wistar albino rats and evaluated various parameters of kidney and liver. They grouped Wistar albino rats of either sex into four groups. The first group was treated as control and fed with PBS (phosphate buffer saline) while second, third and fourth groups animals were orally administered with 300 mg/kg, 200 mg/kg and 100 mg/kg of aqueous leaf extracts respectively. All the animals were fed with a particular dose once a day for about fourteen successive days. After that they scarified the animals using cervical dislocation, excised kidney and liver from animals and used for further studies. They observed that all the parts of the liver and kidney were well preserved indicating that plant extracts had no adverse effects on the histology of kidney and liver in Wistar albino rats. Sonkar *et al.,* (2012) analyzed the effects of aqueous and ethanol extracts of *Basella rubra* leaf extracts for the determination of haematological parameters of normal Swiss mice and amylase activity in Wistar rats. They revealed that the haematological parameters like WBC, RBC, Hb and PCV were significantly increased in the animals treated with the 100 mg/kg body weight (bw) of ethanolic extract. They also determined biochemical parameters of serum for estimation of total bilrubin content and reported that the animals treated with 200 (mg/kg body weight) aqueous extract and ethanolic extract of *Basella rubra* leaf showed a considerable increase in the bilrubin content. They also determined the amylase activity in experimental animals with three different extracts i. e. aqueous, ethanol and hexane in the ratio of 200 mg/kg body weight. After the proper treatment/dose they scarified the animals and analyzed urine samples for determination of amylase activity which was found more in the animals treated with hexane extract. Bamidele *et al.,* (2010) performed the haematological/ hepatoprotective activity in Wistar albino rats. The rats were administered orally with 10mg/kg of normal saline as control and 60; 80 and 100 mg/kg of aqueous leaf extract as different treatments for two weeks and biochemical and haematological parameters were determined at the end of the experiment. They reported that the haematological parameters like red blood cell count, platelet count, white blood cell count, packed cell volume and haemoglobin concentration were increased while the activity of liver enzymes like alkaline phosphatase (ALP), alanine aminotransaminase (ALT) and aspartate aminotransaminase (AST) was reduced. Thus their study strongly supported the view that the *Basella alba* leaves, traditionally are used in the treatment of anaemia and has hepatoprotective potential. Yanadaiah *et al.,* (2011) studied hepatoprotective activity of aqueous ethanol extracts of *Basella rubra* aerial parts against carbon tetrachloride and paracetamol induced hepatotoxicity in rats. The Wistar rats fed with carbon tetrachloride and paracetamol exhibited increased activities of AST, ALT, and ALP along with increase in level of serum bilrubin which are indicators of development of hepatic injury. They reported that the increased activities like ALT, AST, ALP and level of bilrubin were significantly decreased and bought to the normal conditions when the rats intoxicated with paracetamol and carbon tetrachloride were fed with ethanol extract of *Basella rubra*. Depending on this study they resulted that the *Basella rubra* ethanol extract has a protective effect on improvement of the functional integrity of liver cells.

Antidiabetic activity in relationship with the Antioxidant property

Nirmala *et al*., (2009) studied the hypoglycemic effect of aqueous leaf extract of *Basella rubra* with that of streptozotocin (STZ) in two months old male albino rats. After a month of proper treatment they scarified all the experimented animals and analyzed the antidiabetic properties. Their results concluded that the rats treated with *Basella rubra* pulp significantly bought back the blood glucose level. Nirmala *et al.,* (2011) studied the antioxidant properties of plant leaf extract and found that the levels of liver enzymatic antioxidants such as catalase, superoxide dismutase, glutathione peroxidases and non enzymatic antioxidants like vitamin C, vitamin E and reduced glutathione greatly increased in the animals treated with the *Basella rubra* pulp. Thus their findings suggested that the plant has hypoglycemic and antioxidant properties.

Antioxidant activity

Reshmi et al., (2012b) evaluated the antioxidant properties of *Basella alba* fruit extracts using 1,1- diphenyl 2-picrylhydroxyl (DPPH), hydroxide and superoxide, reducing power, hydrogen peroxide, metal chelating, anti ferric chloride hydrogen peroxide system and deoxyribose degradations. All these activities increased with an increase in the concentration. They extracted betacyanin from the fruits with 10 ml. acidified methanol

and reported following observations. The extract showed the presence of flavonoids and betacyanins. Evaluated total flavonoids were 350mg/g, total phenolic content was 750mg/g and total betacyanin content was 15µg/g respectively. Experimental studies by them indicated that, fruit betacyanin had the hydrogen donating capacity along with high concentration of phenolic and hydroxyl group by the activity of which DPPH radicals are scavenged effectively. Depending on the above studies they concluded that fruit possesses strong antioxidant activity and can be used in food additives as an antioxidant material. Anusuya *et al.*, (2012) lypolized and homogenized the aerial plant parts of *Basella rubra* into powder. They employed various in vitro assays, such as DPPH, ABTS, reducing power, hydroxyl radical scavenging activity, superoxide radical scavenging activity and nitric oxide radical scavenging activity, metal ion chelating ability and peroxidation inhibition activity to evaluate an antioxidant and free radical scavenging activities for aqueous, methanol and acetone extracts. They noticed that all the extracts exhibited reducing power and effectively inhibited hydroxyl radicals, nitric oxide radical and superoxide radical. Research summarized by them explained that almost all the extracts exhibited a considerable amount of total phenolic content and vitamin C ranging from 31.1-34.5 mg TAE/g and 39.5 – 42.8 mg AAE/g respectively. They also concluded that aqueous extract showed total tannins about 10.3±4.7 mg TAE/g, while the flavonoids in maximum quantity were obtained in acetone extract about 16.9±1.6 mg RE/g.

Table. 1: Ethnobotanical uses of *Basella laba* L.

Sr. No.	Plant part used	Applications/ uses	Places/Tribes/ Community/Country	References.
1.	Whole plant	Used in ethnovetrrinary for treatment of retained afterbirth, anaplasmosis, gonorrhea and balanitis. The aerial parts such as the leaves, stems and young shoots with buds are consumed as a vegetable and health food.	India	Kirtikar and Basu, 1975. Larkcom, 1991.
		Decoction is used as safe aperients for pregnant women to alleviate labour.	China	Duke and Ayensu, 1985.
		Maceration is used to cure prolapsed, hernia (invagination of the rectum).	Kenya	Chifundera, 1998. Abukutsa-Onyango et al., 2005.
		Dishes made are regularly eaten at the end of pregnancy to reinforce the contractions and to facilitate delievery.	Buea, Cameroon	Palada and Crossman, 1999.
		Cures mouth ulcers.	North Karnataka, India	Rajasab and Mahamad Isaq, 2004.
		Daily consumption of pureed leafy vegetable has a positive effect on Vitamin A stores in populations at risk of vitamin A deficiency.	Bangladesh	Haskell et al., 2004.
		Basella alba is said to cure skin diseases and diarrhea.	Central Kenya	Njoroge et al., 2004. Abukutsa-Onyango et al., 2005.
		Reported analgesic, androgenic, anticonvulsant, antifungal, anti- inflammatory activity and used in the treatment of anemia.	Nigeria	Moundipa et al., 2005. Kachchhava, 2006. Premakumari, et al., 2010. Bamidele et al., 2010. Anandarajagopal, et al., 2011.
		Demulcent, diuretic and laxative activities and can be used as a cooling medicine in digestive disorders.	India	Khare, 2007.
		The plant sap is used to anoint any part of the body affected by acne in order to diminish the irritation and in the treatment of aphthae.	NR	Rathee et al., 2010.
		Mucilage has been used in Thai traditional medicine as tropical application for irritant, bruise, ringworm, laboring, carminative and dwarf tonic. The sticky properties of mucilage can be used as medicine and cosmetic purposes for skin diseases.	Thailand	Chatchawal et al., 2010.
		Used to cure cancer, indigestion, insomnia, stomachache, insecticide, tonic, tumor, burn, stop bleeding. The whole plant is prescribed to increase weight in under-weight children and adults.	The Kavirajes in villages of Kurigram district of Bangladesh	Rahmatullah et al., 2011.
		Used in traditional medicine to treat sexual asthenia and infertility in man.	West Cameroon	Nantia et al., 2011.
		Used for fertility enhancement in women, burn wounds etc.	Nigeria	Mohammed et al., 2012.
2.	Leaves	*Basella rubra (B. alba var. cordifolia)* is a traditional Indian folklore medicine used to treat bleeding piles, pimples, boils, tumour, whooping cough, urticaria, to cure irritations and itching, to heal ringworm, eczema, septic wounds, ulcers, anemia, as an effective tooth powder that cures many diseases of gum and teeth, cure all evil effects of alcoholism, biliousness, leprosy etc.	India	Ghose, G. K., 2000. Paul and Singha, 2010.
		Leaf juice is prescribed in case of constipation particularly in children and pregnant women and in urinary diseases.	Malaya Peninsula	Burkill, 1935. Rajasab and Mahamad Isaq, 2004. Mishra et al., 2006. Roy et al., 2010. Varalakshmi and Devaraju, 2010.
		The mucilaginous liquid obtained from the leaves and tender stalks is a popular remedy for habitual headaches. A decoction of the leaves is a good laxative for pregnant women and children.	India	Kirtikar and Basu, 1975. Rathee et al., 2010.
		Ground leaves with fruits of *Solanum sysymbrifolium* along with fruits of *Phoenix reclinata* are used to promote pregnancy, sexual impulse and fertility in domestic animals.	Bushi area, Democratic republic of Congo.	Chifundera, K. 1998. Jiwajinda et al., 2002.

		Leaf juice is used to treat catarrh and is applied externally to treat boils.	Nepal	Manadhar, 2002.
		Leaves are given as enema followed by manual removal of the hard faeces in ehnoveternary medicine. It is also used as either oral drench or as feeds to boost milk production in cows. *Basella alba* is boiled and administered to the cow with a retained placenta, it develops severe diarrhea that also causes the placenta to come out.	Southwest Uganda	Katunguka-Rwakishaya et al., 2004.
		In ayurveda system of medicine it is recommended that application of leaves to head about half an hour before bathing brings sound refreshing sleep.	India	Panda, 2004. Anandarajagopal et al., 2011.
		Delicious bread called roti is prepared by mixing boiled leaves with flour of *Sorghum*. The extract taken from the boiling of leaves is mixed with the spices and soup can be prepared.	North Karnataka, India	Rajasab and Mahamad Isaq, 2004.
		Used as vegetable.	Pare people of Shengena forest reserve Tanzania.	Hugo et al., 2005.
		The leaves are consumed in stew and soups.	Nigeria	Olgorite, 2006.
		Leaf juice is used in balanitis and catarrhal affections, externally applied in urticaria, burns, vomiting and in intestinal complaints, used as a poultice to reduce local swellings and in acne.	India	Khare, 2007. Roy et al., 2010.
		Used for the treatment of malaria	Cameroon	Vincent et al., 2008.
		Has laxative property.	Nigeria	Odungbemi, 2008.
		Used for preparation of a curry with pulse or other greens.	Many parts of Asia	Harriet, K., 2009.
		Used to cure constipation and gonorrhea.	India	Singh et al., 2010.
		Used for the treatment of hypertension	Nigerians in Logos	Olowokudejo et al., 2010.
		Decoction is used internally for removal of after birth stomach pains, increase milk production.	South Nandi district of Kenya.	Pascaline et al., 2010.
		Used to cure burns, sore throat, liver diseases, scabies, as a blood producer and to increase weight,	People of Talbunia village, Bangladesh	Paul et al., 2011.
		Boiled leaves along with *Sorghum* flour is an effective antiulcer agent.	India	Dixit and Goyal, 2011.
		Basella rubra (B. alba var. cordifolia) leaves are ground with sour buttermilk with salt for preparation of a poultice and indicated for arbuda.	India	Bhishashagratha, 1991. Balachandran and Govindarajan, 2005.
		The leaves or aerial parts have been used for the treatment of constipation and also as a diuretic, toxicide and anti- inflammatory.	China	Toshiyuki et al., 2001.
		Used in catarrhal affection and to hasten suppuration. In general leaves contain several active components including flavonoids exhibits antioxidative, antiproliferative and anti inflammatory properties in biological systems. Leaves are used as anthelmintic, demulcent, anti-inflammatory, ant malarial and analgesic.	India	Yanadaiah et al., 2011
3.	Stem	Mucilaginous cooked shoots are used in intestinal disorders.	Bogra district, Bangladesh	Rahmatullah et al., 2010(a).
		Used externally to cure fungal disease like Eczema, ringworm and general skin infections.	Rural areas of Delta state of Nigeria.	Okungbowa and Okpako, 2011.
4.	Leaves and stem	Cooked leaves and stems have diuretic and febrifuge activity.	China	Duke and Ayensu 1985. Larkcom, 1991. Phillips and Rix, 1995.
		Used in constipation, as a diuretic, in urticaria, as a demulcent, antiulcer and as cooling application for burn and toothache.	India	Vaidratanams, 2002. Pareek et al., 2010.
		Used in culinary practice.	Southern parts of India	Palada and Chang, 2003. Prance and Nesbitt, 2005.
		Applied for anticancer treatment such as melanoma, leukemia and oral cancer.	India	Balachandran and Govindarajan, 2005. Chatchawal et al., 2010.
		Excellent hot weather spinach substitute and may be eaten raw in salads.	India, china, Bangladesh	Echo plant information sheet (2006, ECHO, Inc). www.echonet.org. Smith and Ojo, 2007. Pareek et al., 2010. Ajesh et al., 2012.
		Used for antipruritis and burn.	India	Saikia et al., 2006.
		Used for acne and freckle treatment.	Bangladesh	Akhter et al., 2008.
		Colours obtained from the leaves and stems are used for dying fabrics and in paintings.	Manipur, India	Potasangbam et al., 2008.
		A paste of leaves and stem of is applied to cure acne, abscess, and skin diseases.	Kavirajes in Pirojpur district Bangladesh	Rahmatullah et al., 2010.
		Both stem and leaves of are used in Syphilis, intestinal disorders, tumour, acne, leucorrhoea.	Bangladesh	Paul et al., 2011. Rahmatullah et al., 2011.
5.	Flower	Useful for removal of kidney stone, gonorrhea and headache.	India	Nadkarni, 1976.
		Used as an antidote for poisons.	China	Duke and Ayensu, 1985.
6.	Fruit	A purple dye from the ripened fruits has been extracted and used to colour or dye the 100% cotton and polyester fibers.	Nigeria	Odilora et al., 2002, Olgorite, 2006.
		Deep colouring matter obtained from the ripened fruits is used for colouring the food, to colour pastries or sweets.	North India	Rajasab and Mahamad Isaq, 2004. Echo plant information sheet (2006, ECHO, Inc). www.echonet.org

		Fresh ripened fruits mixed with alum produces maroon colour which is used to colour the silk and cotton.	Assam, India	Kar and Borthakur, 2008.
		Red dye from the fruit of has been used for official seals and as rouge.	India	Chatchawal *et al.*, 2010.
7.	Seed	Boiled seeds are added to dahl.	Bangladesh	Echo plant information sheet (2006, ECHO, Inc). www.echonet.org
		Immature seeds are used to cure intestinal disorders, earache, carminative, itch, scabies, colic, sore throat, liver diseases and as a blood producer.	Bangladesh	Chatchawal *et al.*, 2010. Paul, *et al.*, 2011.
8.	Root	Paste of root has rubefacient activity. Cooked roots are also used as an astringent.	China, India.	Duke and Ayensu, 1985. Manadhar, 2002. Sen *et al.*, 2010.
		Cooked roots have been reported to be used in the treatment of diarrhea.	Many regions where plant species is cultivated	Larkcom, 1991. Phillips and Rix, 1995.
		Decoction relieves bilious vomiting.	Caribbean islands	Palada and Crossman, 1998.
		A paste of root is used as a rubefacient and also applied to swellings.	India	Manadhar, 2002.
		Used as an anti inflammatory agent after menstrual periods.	Kheri district of Uttar Pradesh, India,	Maurya and Gupta, 2006.
		Decoction is given in intestinal disorders.	UP, India	Singh *et al.*, 2010.
		Decoction is used internally for removal of after birth stomach pains, increase milk production.	South Nandi district of Kenya.	Pascaline *et al.*, 2010.
		Paste of *Basella rubra (B. alba var. cordifolia)* root along with rice washed water is used to cure irregular periods.	Rural people in Orissa, India	Mohapatra and Sahoo, 2008.

Table. 2: Compounds isolated from *Basella alba* L.

Sr. No	Compound structural class/ name/ code	Molecular formula	Palnt Part	Reference (s)
1	Acacetin	$C_{16}H_{12}O_5$	Leaves	Kumar *et al.*, 2013.
2	Anthraquinone	$C_{14}H_8O_2$	Leaf and stem	Oyewole and Kalejaiye, 2012.
3	Arginine	$C_6H_{14}N_4O_2$	Whole plant	Khare *et al.*, 2007.
4	Basella saponins A	C47H70O21	Fresh aerial parts	Toshiyuki, *et al.*, 2001.
5	Basella saponins B	C47H68O21	Fresh aerial parts	Toshiyuki, *et al.*, 2001.
6	Basella saponins C	C47H68O22	Fresh aerial parts	Toshiyuki, *et al.*, 2001.
7	Basella saponins D	C47H68O22	Fresh aerial parts	Toshiyuki, *et al.*, 2001.
8	Beta sitosterol	$C_{29}H_{50}O$	Leaves	Paul and Singha 2010.
9	Beta-carotene	$C_{40}H_{56}$	Leaves	Werner and Raus, 2006.
10	Betacyanin	$C_{30}H_{34}N_2O_{19}$	Fruit	Nishimato and Hirose, 1991.
11	Betavulgaroside I	$C_{47}H_{72}O_{20}$	Whole plant	Murakami *et al.*, 1999.
12	Bioflavonoid(Rutin)	$C_{27}H_{30}O_{16}$	Leaf	Khare, 2007.
13	Ferullic acid	$C_{10}H_{10}O_4$	Leaf	Kumar *et al.*, 2013.
14	Gomphrenin I	$C_{24}H_{26}N_2O_{13}$	Fruit	Glassgen *et al.*, 1993. Lin *et al.*, 2010.
15	Gomphrenin II	$C_{24}H_{26}N_2O_{13}$	Fruit	Glassgen *et al.*, 1993.
16	Gomphrenin III	$C_{33}H_{32}N_2O_{15}$	Fruit	Glassgen *et al.*, 1993.
17	Isoleucine	$C_6H_{13}NO_2$	Whole plant	Khare, 2007.
18	Kaempherol	$C_{15}H_{10}O_6$	leaves	Kumar *et al.*, 2013.
19	Leucine	$C_6H_{13}NO_2$	Whole plant	Khare *et al.*, 2007.
20	Linoleic acid	$C_{18}H_{32}O_2$	Seed	Killur *et al.*, 1983.
21	Lupeol	$C_{30}H_{50}O$	Aerial parts	Gupta *et al.*, 2008 and Saleem *et al.*, 2001.
22	Lysine	$C_6H_{14}N_2O_2$	Whole plant	Khare *et al.*, 2007.
23	Momordin II B	$C_{27}H_{28}ClN_5O_2S$	Leaf	Iwamoto *et al.*, 1985.
24	Momordin II C	$C_{27}H_{28}ClN_5O_2S$	Leaf	Iwamoto *et al.*, 1985.
25	Niacin	$C_6H_5NO_2$	Whole plant	Grubben and Denton, 2004.
26	Stigmasterol glucoside	$C_{35}H_{58}O_6$	Leaves	Paul and Singha, 2010.
27	Syringic acid	$C_9H_{10}O_5$	Leaf	Kumar *et al.*, 2013.
28	Thiamine	$C_{12}H_{17}ClN_4OS$	Whole plant	Grubben and Denton, 2004.
29	Threonine	$C_4H_9NO_3$	Whole plant	Khare, 2007.
30	Tryptophan	$C_{11}H_{12}N_2O_2$	Whole plant	Khare, 2007.
31	Uronic acid	$C_{58}H_{106}N_2O_{24}$	Leaf mucilage	Pareek *et al.*, 2010.
32	Vanilla	$C_8H_8O_3$	Leaf	Kumar *et al.*, 2013.
33	Vitamin C	$C_6H_8O_6$	Aerial plant parts	Anusuya *et al.*, 2012.
34	Vitamin E	$C_{29}H_{50}O_2$	Leaf	Venkatalakshmi and Senthamaraiselvi, 2012.
35	Vitamin K	$C_{31}H_{46}O_2$	Leaf	Khare 2007.

CONCLUSION

The sincere aim of this review is to enlighten the focus on scopes and the importance of *Basella alba* in the medicinal field. The taxonomy of the plant is still puzzling and different taxonomists have different opinions. For the sake of our convenience we have adapted the nomenclature system laid by Almeida. Further studies based on molecular studies will definitely solve the problems related to the taxonomical conflicts. Both the plants i. e. *Basella alba* and *Basella alba var. cordifolia* (*Basella rubra* L.) is ethnomedicinally very important and are used to cure various diseases and therefore, should have to be widely domesticated and cultivated on a large scale.

Plant with green stem and green petiole i. e. (*Basella alba*) has great biological activities. One of the promising and very important activities of the plant is its androgenic potential. The plant has anabolizing and virilizing effects, methanol extracts of which increases the production of testosterone and has the capacity to stimulate both estrogen level and androgen production. Further fractionation of MEBa is required which will facilitate isolation of pure active compounds exhibiting steroidogenic effect and male fertility enhancement (Moundipa *et al.*, 1999, 2005, 2006; Nantia *et al.*, 2011, 2012). Chakraborty *et al.*, (2012) analyzed the use and importance of non steroidal compounds like *Basella alba* in sex reversal of guppy fishes mentioning the need for further studies in the determination of the optimum treatment regime for induction of cent percent sex reversal in particular species or in some fruit vegetables will be very useful in the net productivity. The anti inflammatory constituents present in the aqueous extract of plant body plays a vital role in reducing the carageeneen and formaldehyde induced inflammation (Kachchhava *et al.*, 2006). The use of such herbal preparation will be very beneficial and cost effective in comparison with the certain chemical based anti inflammatory agents. Methanol extracts of aerial plants contain psychoactive constituents like terpenoids which has a central nervous depressant activity which is definitely useful to treat certain stress problems like sound refreshing sleep in today's busy life schedule. CNS depressant studies by Anandarajagopal *et al.*, (2011) concluded that, the *Basella alba* has importance in further development of some potential CNS depressant drugs. Bamidele *et al.*, (2010) proved that the plant leaves may not have deleterious effect on the body system and are traditionally used in the treatment of anaemia with hepatoprotective property. *Basella alba* also exhibits presence of antiulcerogenic constituents, which leads to the enhancement in gastric cytoprotection or inhibition of acid secretion (Kumar *et al.*, 2012; Venkatalakshmi and Senthamaraiselvi, 2012).

The plant with red stem and red petiole i. e. *Basella alba var cordifolia* also possess very significant biological activities indicating its importance in ethnobotany. Ethanol extracts of the plant expressed hepatoprotective activity (Yanadaiah *et al.*, 2011). Active constituents present in the *Basella alba var cordifolia* play vital role in controlling the glucose level and increasing the antioxidant potential (Nirmala *et al.*, 2009). Histopathological examinations confirmed the hypoglycemic property of *Basella alba var cordifolia*. Although the chemical compounds responsible for the hypoglycemic effects are still speculative. Amylase activity shown by the leaves play a crucial role in diagnosis of acute pancreatitis (Ostlund R., 2002; Sonkar *et al.*, 2012). In order to standardize the plant preparation for maximum culinary and therapeutic benefit, further studies are required towards isolation of the specific components in the plant (Adekilekun *et al.*, 2012). Detailed account of the studies is required to isolate the active compound present in the ethanolic extract which will be a significant milestone in the antimicrobial arena (Sen *et al.*, 2010). All these biological activities exhibited by the plants are with great potential and significance in the field of medicinal research, detailed accounts of which should have to be performed at the molecular level.

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