JOURNAL OF NATURAL REMEDIES
DOI: 10.18311/jnr/2023/34287

REVIEW ARTICLE

Comprehensive Ethnomedicinal, Pharmacological and Phytochemical Report on *Basella alba* L. (Basellaceae)

Abhijit Bose[1*], Sabyasachi Banerjee[2], Sudip Kumar Mandal[3], Sankhadip Bose[4] and Subhasis Maity[5]

[1]T. C. G. Life Sciences Pvt. Limited (Chembiotek), BN Block, Sector V, Kolkata, West Bengal - 700091, India; bose.abhiphtk@gmail.com

[2]Department of Pharmaceutical Chemistry, Gupta College of Technological Sciences, Asansol - 713301, West Bengal, India

[3]Dr. B. C. Roy College of Pharmacy and A. H. S., Dr. Meghnad Saha Sarani, Bidhan Nagar, Durgapur - 713206, West Bengal, India

[4]School of Pharmacy, The Neotia University, Sarisa – 743368, West Bengal, India

[5]NSHM Knowledge Campus, Kolkata – Group of Institutions, Kolkata - 700053, West Bengal, India

Abstract

From the primitive era to the current generation, natural extracts or products played the most conservative therapeutic and nutritional resources. Starting from the era of folklore or ancient, mother nature has protected us from various diseases by producing various natural products having strong medicinal implications like quinine, taxol, vinblastine, etc. Among the many available sources of natural products, pharma-herb being a new member has drawn considerable attention of the researcher in order to have a new pool of products having pronounced pharmaceutical activity. Now *Basella alba* is one of the brightest candidates belonging to pharma-herb because of its considerably enriched pharmacologically important product stocks like vitamin C, flavonoid compounds, carotenoids, saponins as well as a large number of different minerals and numerous amino acids. This plant is a perennial vine that is often cultivated as a food crop during the cooler months. It is also able to grow very fast and can resist temperatures that are quite high. *Basella alba* has been referred to by a number of different names throughout history, including Indian-, Malabar-, climber-, Ceylon-, and vine-spinach. Poi is the term that the majority of people in India use when referring to it. The various natural products isolated from *B. alba* have significant medicinal utilization because of its antimicrobial, anti-ulcer, wound healing, antiviral, anti- inflammatory depressant, androgenic potential, hepatoprotective, antidiabetic, antioxidant, anti-anxiety, diuretic and anti-urolithiatic activities. This review will cover a detailed journey about *Basella alba* L. ranging from phytochemical to toxicological, morphological, pharmacological as well as medicinal importance.

Keywords: *Basella alba* L., *Basella rubra*, Herb, Natural Products, Pharmacological, Pharmacology

1. Introduction

Mother Nature has produced a lot of small molecules including some primary and secondary metabolites, which are called natural products. These are very versatile in nature starting from small molecules like urea to complex molecules like Taxol[1]. Since few past decades, secondary metabolites; a class of natural products has been found playing as potential leading drug candidates[2]. Not only that, natural products were used as remedies in ancient

*Author for correspondence

Article Received on: 30.06.2023 Revised on: 27.07.2023 Accepted on: 14.09.2023

times as well as in folklore. Today's medicinal practices have included a lot of drugs which had been derived from various plants, for example anti-inflammatory medication methyl salicylic acid, named as aspirin, has been produced from salicin, a natural substance obtained from the willow (*Salix alba* L.) tree's bark. Another example in the similar line is that morphine was derived from the plant *Papaver somniferum*. Similarly, quinine is a Food and Drug Administration (FDA) approved drug against malaria, procured from *Cinchona succirubra* Pav. ex Klotsch bark, Pilocarpine, a drug against acute angle-closure and chronic open-angle glaucoma derived from *Pilocarpus jaborandi* (Rutaceae) revels that plant-based drug investigation is an incredible consideration in order to find new molecules having high medicinal reputes[3,4]. Therapeutic herbs contain a rich well spring of naturally powerful molecules having significant medicinal importance like alkaloids, glycosides, tannins, saponins, sterols, direct phenolic blends, quinones, terpenoids, carotenoids, flavonoids, polyphenols, terpenoids, sugars, proteins, synthetic concoctions, fats and oils, minerals, supplements and so on. In recent years, there is increasing enthusiasm has been noted among the scientists about the natural source of biologically active molecules bearing therapeutic significance and to establish therapeutic herb as an alternative platform for human life saving drugs. Such types of investigation have brought an evolution in the domain of new drug development. There are significant numbers of plants, distributed worldwide, showing multiple activities. At present, regardless of the benefits of chemically synthesized modern medicines, a consistent development of new medications from natural sources is still significantly important because of low cost and less side effects. The photochemical advancement of new medications has opened a new door and attracted more attraction to build up a character of conventional prescription and phototherapy[5,6].

Natural product synthesis is a significant task in organic chemistry since they are isolable in smaller amounts; and possess impressive biological functions and molecular structure. At present, among the many, one of the most attractive herbs is *B. alba* or *B. alba* L. (Identical word: *Basella rubra* Roxb.) (Figure 1) belonging to the family Basellaceae, efficiently recognized by two species as *B. alba* in addition, *Basella rubra* L. It has a large distribution in the region of tropical Asia. The plant shows variation in the continent of Africa from that of tropical America.

Comparison between the five species, "*Basella alba*" and "*Basella rubra*" are widely studied in the country of Bangladesh. *Basella alba* L. states of sound phytochemical establishment, wellsprings of phytosterols, phenolic acids,

(a) (b)

Figure 1. Photographic representation of (a) *Basella alba* and (b) *Basella rubra.*

[*Basella alba* ("*alba*" means "white" in Latin) has white stem; *B. rubra* ("*rubra*" means "red" in *Latin*) has reddish stem]

triterpenes, nutrient thiamine, riboflavin, niacin, minerals like calcium, magnesium and iron, vitamins A, C and B9, amino acids, flavonoids, saponins, organic acids and several antioxidants. *B. alba* has different therapeutic promising activities including androgenic movement, cytotoxic, antiulcer action, Central Nervous System (CNS) depressant activity, anthelmintic, antibacterial action, antifungal and has been used in treating different cases like purgative, rubefacient, skin ailments, eats up, ulcers, heals wounds, free guts, suppresses inflammation and diuretic and it also protects nephron protection[7]. This review will glean a lot of information about the species *B. alba* as well as about the natural products obtained from *Basella alba* L. and their isolation processes and medical importance.

1.1 Taxonomic and Geographical Distribution

The old style of scientific classification of Basella has pulled into attracting consideration because of some clashing reports by taxonomists[8]. *Basella* name was first penned by Linnaeus. He also explained the difference between *Basella rubra* and *alba*. Later in the book Hortus Malabaricum, he wrote *Basella alba* L.= *Basella rubra* L. as a synonym[9]. The genus Basella has 5 species, one of which is pantropical and the other 4 of which are widespread in Madagascar, and Southeast and East Africa. Linnaeus, the classic taxonomist, showed two kinds of Basella species plantarum. It was significantly observed that both species *Basella rubra* and *Basella alba* have critical leaf characteristics and stem colour. According to Roxburgh's (1832) report, *Basella rubra*, *Basella alba*, and *Basella lucida* are synonyms and *B. alba* is the right name, which is beginning at now settled, according to the article of the code[10]. These data have also confirmed that the structural difference between these two taxa is insignificant[11]. Most researchers and authors concluded that the two Basella shading types are not distant species, as revealed by various investigations such as pollen morphology, protein profiles, and cytology expressed that the main types of reddish and greenish stem of it showed that the both stem kinds of *Basella* have a spot with only a single type and evidently *B. alba*[12,13]. As per the taxonomic hierarchy, this monocot plant belongs to the domain of Eukaryota within the kingdom of Plantae. Further details include sub-kingdom, phylum, sub-phylum, infra phylum, class, sub-class, order, sub-order, tribe, genus and species, which are viridaeplantae, trahceophyta, euphyllophytina, radiotopses, magnoliopsida, caryophyllidae, caryophyllales, portulacineae, salvieae, *Basella* and *alba* respectively[14].

There are around 24 species, sub-species, structures, and cultivars in the genus *Basella: Basella alba* (East-Indian Spinach), *Basella alba* var. *rubra, B. cananifolia, B. cordifolia, B. crassifolia, B. diffusa, B. excavate, B. filiformis, B. hookeriana, B. volubilis, B. leandriana, B. ramose, B. nigra, B. oblusifolia, B. japonica, B. lucida, B. marginata, B. obovate, B. paniculaia, Basella rubra, B. trifida, B. tuberosa, B. vesicaria*[15]. *Basella alba* or *Basella rubra* are having several vernacular names in India like in Bengali - *Puishak*; Hindi - *Ialbachlu*; Konkani - *Valchibhaji*; Kannada - *Baselesoppu*; Oriya - *poi saga*; Tamil - *Kodippasali*; Telugu - *Bachhali*; Sanskirt - *Upodika*; Marathi - *Bhajyacha vel, velbondi*; Chinese - *luluokui*; Spanish - *espinacablanca de Malabar*; Portuguese - *Bacela*; Turkish - *pazu*; Filipino - *Alugbati*; Vietnamese - *Mongtoi*. Some other regular names include Ceylon spinach, Indian spinach, Chinese spinach or Vietnamese spinach, Malabar spinach, Surinam spinach, climbing spinach, buffalo spinach, vine spinach, creeping spinach, red vine spinach, Malabar nightshade and broad bologi. International common names include *Epinard de Malaba* (French), *Malabarspinat* (Germany), *Espinacablanca* (Spanish), *Spinaciodella China* (Italy), *Espinacachina* (Latin America), *Ibanag* (Southeast Asia), *Efoamunututu* (West Africa), *Puishak* (India), *Gendola* (Malaysia), *Gandola and Genjerot* (Indonesia), *Alugbati* (Philippines), *Phakpang* (Thailand), *Môngtơi*, *mùngtơi* (Vietnam)[16-20].

Tough matured in Africa-Tropical America regions, its beginnings are in tropical Asia. It has five types of which the 2 *Basella* species (*B. rubra* and *B. alba)* are broadly developed in Bangladesh. It is also spread over Indian land mass (Subcontinent), New Guinea and Southeast Asia[21]. Indian spinach or Malabar spinach is typically considered to originate from local southern Asia (India). Be that as it may, since old occasions it has been developed in China and Southeast Asia. Tropical Asia, Africa and America are the most mainstream nations where it has been developed generally and is even developed in calm zones as a yearly. It is especially famous in the Philippines, Southeast Asia and Malaysia[20,21].

2. Appropriate Environment for Cultivation and Propagation of *B. alba*

Preferred climatic conditions for the cultivation of *B. alba* are as follows: Light: Full daylight, hot, muggy (unpleasantly warm and humid) atmospheres. If the

length of the day exceeds 13 hours, *B. alba* will not bloom[22,23]. Soil: Rich, fertile, damp retentive soils. Reduce watering throughout the winter season. Endures high rainfall. It develops best in sandy loam soils wealthy in organic matter with a pH in the range from 5.5 to 8.0 but could withstand 4.3 - 7.5. It can tolerate poor soils and brief drought conditions[22,23]. Temperature: Plants are frost-sensitive and don't perform well if summer temperatures reliably plunge underneath nighttime. 59°F around plant growth needs a minimum daylight heat of 15°C whether it wants to continue maturing energetically or rapidly. The minimum temperature during the day should be 15°C for the active growth of the plant. Fertilizer: Utilize moderate discharge compost (slow-release fertilizer)[22,23]. For the most part, favouring, the necessary developing state of *Basella alba* is full sunshine in hot, damp atmospheres and in regions lower than 500 meters (1,500 ft) above ocean level. It requires an all-around depleted dampness retentive soil, warm radiant protected position and brimming sun presentation. Seed may likewise be planted legitimately in the nursery at the previous spring ice date. Blossoming is actuated during the short-day long periods of November to February. By and large, produced for its consumable leaves in the tropics, there are some named arrangements. It is an incredible sweltering climate substitute for spinach. At the point when developed as a vegetable, train it on a solid trellis or other help. At the point when developed for fancy purposes, develop it on a fence or light post or other structure. Plants are biased toward ice and don't perform well if summer temperatures dependably plunge below 59°F around nighttime. Plants may in like manner be allowed to only way along the ground[24].

A few authorities perceive three unique species, *B. alba, B. rubra* and *B. cordifolia*, they are totally treated here as being part of one species. It will be four and a half months until the first harvest. Leaves will just store for one day at 20-30 °C. A yield of 40 kg of leaves from a 10-meter square bed is conceivably more than 75 days. Leaves are plucked from the vine[22-24].

3. Morphological Characteristics of *B. alba*

B. alba, normally called Malabar spinach or Indian spinach, is a vegetable which rapidly creates a tropical vine. Indian Spinach is a yearly or suffering climbing herb with red or green vines and leaves. The leaves are thick, meaty, pointed at the tip and organized then again along the vine. Flowers comprise short spikes with pink, red or white shades and spikes are organized in the leaf axils. The fruits are round and delicate and can be white, red, or dark in shading. The seeds are round and dark. It is a stretched, smooth, succulent, twining herbaceous vine, a few meters long. Leaves are beefy, applaud or heart-molded, 5 to 12 cm since quite a while ago, stalked. It decreases to a sharp tip. The base is cordate. Stems are purplish or green. Spikes are singular, axillaries, 5-28 cm in length. Fruit ovoid or circular, stalkless, 5-6 mm long, beefy and purple when experienced. Little purple-white blossoms may show up toward the finish of the mid-year. Fundamentally leaves and stems are utilized for therapeutic reason[25]. In Nigeria, essentially two assortments of Basella are typically distinguished. (i) *Basella alba* or the group type which has white blossoms, (ii) *Basella rubra* or the red Indian spinach which has red (dim purple) stems, petioles and leaves and pale pink blossoms. The two varieties are tolerant to considerable precipitation and are normal in the southern bit of the country. The two combinations have high water content[26]. A survey on characterization and assessment of landraces of *Basella* sp. has been reported by Reddy *et al*[27]. Plants have been collected from different places in Andhra Pradesh and Odisha. The information about different species is reported in Table 1.

4. Ethnomedicinal Uses

The incredible therapeutic properties of *B. alba* are still being used possibly from ancient periods[28]. The plant (especially leaves and stem) is utilized in ayurvedic treatment in India for anticancer, for instance, melanoma, leukaemia and oral cancer[29]. As indicated by noticeable quality, *Basella alba* is the noteworthy regulator in the Northern and North-eastern as a source of sustenance or nourishment (food and drink regarded as a source of strength), among various waterfront systems of Southern Nigeria[30]. In Nigeria, the entire plant of *B. alba* is utilized as an anti-inflammatory, pain relieving, androgenic, antifungal, anticonvulsant and used for sickliness treatment[31-35]. In a gathering of the populace in Bangladesh, there is a high danger of vitamin A deficiency, so among the people of Bangladesh, consistent use of essentially verdant vegetables such as *Basella alba* has a beneficial outcome[36]. In Focal Kenya *B. alba* is said to fix skin problems and looseness of the bowels[37,38].

Table 1. Characterization and assessment of landraces of *Basella* sp.[27]

Site/Character	Sample_1	Sample_2	Sample_3	Sample_4	Sample_5	Sample_6
Botanical name	*B. alba* L.	*B. alba* L.	*B. alba* L.	*B. alba* L.	*B. alba* L.	*B. alba* L.
Vernacular name	Mattubacchali	Mattubacchali	Erra Bacchali	Mattu Bacchali	Bhaji	Bhaji
Village	Bavajipeta	Peddaveedhi	PathaBobbili	Chipurupalli	Lamtaput	Malliput
District	Srikakulam	Srikakulam	Vizianagaram	Vizianagaram	Koraput	Koraput
State	AP	AP	AP	AP	Odisha	Odisha
Latitude (ºN)	18.36	18.77	18.59	18.31	18.63	18.58
Longitude (ºE)	83.87	84.41	83.37	83.57	82.59	82.91
Altitude (m)	28.65	35.05	131.37	66.14	605.33	1009.80
Growth habit	Twining	Twining	Twining	Twining	Procumbent	Procumbent
Stem colour	Greenish	Reddish	Dark reddish	Greenish	Greenish	Light reddish
Stem shape	Annular	Annular	Angular	Annular	Angular	Angular
Leaves color	Light greenish	Dark greenish	Dark greenish	Light greenish	Light greenish	Dark greenish
Leaves shape	Ovate	Ovate	Oval	Ovate	Ovate	Oval
Leaves margin	Entire	Entire	Entire	Entire	Entire	Entire
Leaf margin color	Greenish	Greenish	Greenish	Greenish	Greenish	Greenish
Leaves apex	Acuminate	Acuminate	Acuminate	Acuminate	Acuminate	Acuminate
Petiole color	Greenish	Greenish	Reddish	Greenish	Greenish	Greenish
Flower color	Light pinkish	Pinkish	Pinkish	Pinkish	Light pinkish	Pinkish
Leaf length(cm)	5.26	5.69	4.73	4.16	5.99	6.37
Leaf width(cm)	3.65	3.62	2.95	2.91	4.54	3.89
Leaf weight(g)	0.77	0.76	0.74	0.78	0.93	0.82
Petiole length(cm)	1.04	1.07	1.00	1.03	1.87	1.82
Length of tender shoot(cm)	41.43	38.55	46.79	43.31	42.78	45.00
Internodal length(cm)	2.76	2.21	2.80	2.84	4.82	3.95
Weight of tender shoot(g)	11.31	11.54	10.47	10.48	25.71	18.21
Leaf yield	8.05 g/shoot	7.81 g/shoot	7.45 g/shoot	7.10 g/shoot	9.79 g/shoot	8.55 g/shoot
Stalk yield	3.17 g/shoot	4.31 g/shoot	2.77 g/shoot	2.78 g/shoot	14.04 g/shoot	10.39 g/shoot
Total biomass	532.33 g/plant	547.67 g/plant	473.33 g/plan	569.67 g/plant	814.67 g/plant	495.67 g/plant

In India, it's utilized for the treatment of head fetal membrane, gonorrhoea balanitis and anaplasmosis[39-41]. Among Indian individuals, it has been acknowledged to utilize exhaustively the *B. rubra* (*B. alba* var. *cordifolia*) as a standard remedy for the treatment of pimples, bleeding piles, bubbles, whooping cough, tumour, to fix aggravations, urticarial and shuddering to recuperate ringworm, skin bothering, injuries due to sepsis, iron need,ulcers, as a sensible tooth powder that fixes different ailments of gum and teeth, fix every single scorn impact of liquor abuse, biliousness, infirmity (leprosy) and so forth[42-46] and diuretic, demulcent and purgative exercises and can be utilized as a cooling medication in stomach related disperses[47]. In India, China, and Nigeria it is valuable for evacuation of kidney stones, gonorrhoea and cerebral pain, and also utilized as a remedy for harm[45,48]. Hues (colour or shade) acquired from the leaves and stems are utilized for kicking the bucket textures and in worksof art[27,49]. Both the leaves and stem are utilized in syphilis, intestinal scatters, tumour, skin inflammation,

and leucorrhoea[50]. Whereas its paste is applied to fix skin break outs, ulcers, and skin infections in Kavirajes in Bangladesh[51]. In Malaya promontory, the individuals use leaf squeeze as recommended if there should arise an occurrence of clogging (constipation) particularlyif there should be an occurrence of youngsters and pregnant ladies and in urinary ailments[12,52-54]. In Indian individuals, mucilage fluid from leaves is broadly utilized as a solution for routine migraines and decoction of leaves is purgative for expecting ladies and youngsters[55].

In India, Nepal and Southwest Uganda the leaves of *Basella alba* are utilized as a vegetable and consumed in soups and stew. Juice of the leaf is used for the treatment of catarrh and remotely used as a coat in urticaria, burns, vomiting and in intestinal protests, diminishing local swellings and skin inflammation by using a poultice[56,57]. It has also been investigated that *B. alba* stem and leaves are utilized in the Indian Ayurvedic treatments for anticancer, for example, melanoma, leukaemia and oral malignant growth[58,59]. In India, Cameroon, Nigeria and various parts of Asia, Indian spinach leaves are applied for treating hypertension, constipation and gonorrhoea, also used for the treatment of malaria, employed to fix scabies, burns, liver contaminations, sore throat, blood creator and to extend weight[60-64]. In India, China, Nigeria, and Bangladesh *Basella alba* conventionally professed to build libido, the blossoms are utilized as a remedy for injury, significant for the excretion of kidney stones[45,39]. Red *Basella alba* root paste and rice-washed water when consumed toward the beginning of the day on an empty stomach for a month; unpredictable periods by the rural individuals of Orissa, India got fixed[65]. *Basella alba* is orally used for butt-centric prolapsed or hernia pharmacotherapy. Ground leaves of *Basella alba* when used on the animal vagina each morning, sterility treatment occurs[46]. Root and leaf have been utilized in the after-birth process expulsion, stomach torments and increment milk secretion[66]. Basellamucilage has been utilized essentially in Thai conventional medication as a topical medicine for the treatment of irritation, ringworm injury and labouring. Stem and leaves are utilized as mild purgative, diuretic and antipyretic[67].

5. Traditional Uses of *B. alba*

In the Ayurveda system of medication, the leaves of *B. alba* are traditionally utilized from extremely past time and sleep quality gets improved on the head application about 30 minutes before bathing[35]. Root paste on swellings and sap is applied to skin break-out emissions to diminish inflammation. Leaf-juice blended in with margarine, is calming and cooling on application to burns and scalds. In Ayurvedic medicine, it's utilized for sexual deficiency, skin ailments, haemorrhages, ulcers and as a diuretic in kids and pregnant women. This plant served as a Thai standard vegetable. Basella mucilage has been utilized in Thai conventional medication as a topical application for aggravation, wound, and ringworm[67,68]. Maceration of leaves is consumed orally for pelvic provocative infection, infertility, epididymitis, orchitis, compromised premature birth, and misleading work[69]. The mucilage characteristics of the herb make it an extraordinary thickening agent in soups, stews, and so on. The sap, nearly purple from organic products is utilized as a shading agent in baked goods and desserts. The fruit gives dull violet shading to the nourishing colourant. *B. alba* is a herb utilized in conventional medication in the West Cameroon district in the treatment of sexual asthenia and is ineffective in men[69-72].

6. Reported Phytoconstituents from *B. alba*

As a primitive ethnomedicinal-cum-edible tard herbaceous plant species, several bioactive constituents have been reported such as alkaloids, phenols or flavonoids, steroids, saponin, polysaccharides with proteins, minerals, vitamins, starches, etc[73]. The significant phytochemical composition of leaves incorporates vitamins A, B9, C, E, K, fat, proteins, thiamine, riboflavin, niacin, and minerals, for example, iron, magnesium, and calcium. According to Toshiyuki *et al.*, Kaempferol is the most abundant flavonoid in *B. alba*, with a 1.4 mg/100g concentration[74,75]. *B. alba* contains viscous Basellasaponins, peptides and phenolic compounds. Partial purifications of Basella mucilage end up being made from D-galactose with polysaccharide as a significant compound[76]. As per Maisuthisakul *et al.*, and Olajire *et al.*, *B. alba* contains amino acids apart from Basellasaponins, for example, leucine, arginine, lysine, isoleucine, tryptophan and threonine, peptides, and phenolic mixes in different concentrates[77,78]. As indicated by Glassgen *et al.*, the fruit includes gomphrenin derivatives, which are plain pigments and give the fruit its distinctive hue which is liable for the purple, blue, red

and violet hues in blossoms, fruits, stems and leaves[79]. Crossman *et al.* revealed that the mucilage of *B. alba* comprises a blend of polysaccharides80 and starch-type glucan that may be isolated using starch iodine complex[81]. As documented by Haq (1969) the plant contains basic amino acids such as isoleucine, arginine, lysine, leucine, tryptophan, and threonine, as well as a few vitamins, low level of dissolvable oxalates and minerals; and the leaves additionally comprises of carotenoids, natural acids, and water solvent polysaccharides, bioflavonoid82. Jiwajinda *et al.*, examined the seed attributes that contain linoleic acid (49.1%), unsaturated fats (50.3%), oils (36.9%), and proteins (23.1%)83. The sound segregation techniques of momordins IIb and IIc84 have been perceived by researchers Iwamoto *et al.*, (1985), Saleem *et al.*, (2001) and Sharma *et al.*, (2010) have announced the anti-inflammatory, antioxidant, and anticancer actions because of the existence of lupeol and β- sitosterol in the plant[85,86]. Hebbar *et al.*, (2004) and Glassgen *et al.*, (1993) have announced the existence of β-cyanins, carotenoids and natural acids in *B. rubra* aerial parts[79,87]. The triterpene oligo-glycosides Basellasaponins A-D[76] were segregated by the analyst Inadzuki (1999); and Murakami *et al.*, (1999) have disclosed the existence of β-vulgaroside[88]. As indicated by Paul *et al.* (2010), the identification and isolation of two critical sterols, stigmasterol and β-sitosterol glucoside, in high yield from *B. alba rubra* leaves[46]. Plant mucilages are water-soluble polysaccharides that serve as a water reservoir, germinating aid, food reservoir, and repository for secondary metabolites. Mucilage could be utilized as a thickening, water-retaining agent, suspending operator, gelling operator, and film forming in pharmaceutical guides[85]. Overall, we have described some major phytoconstituents below with more relevant information (Figures 2 and 3).

7. Reported Some Major Bioactive Constituents from *B. alba*

7.1 Reported Alkaloid Class of Constituents from *B. alba*

β-cyanine (1), a nitrogenous anthocyanidins, are well known for their antioxidant as well as their anti-inflammatory effects. Additionally, β-cyanin exhibits prebiotic functions[89]. To extract β- cyanin *B. alba* methanolic fraction was warmed in 2 M HCl for 5 min at 100°C. The colour disappears, which shows the possibilities of β-cyanin. To this sample solution, 2 M NaOH was added in a dropwise manner and the solution colour changes to yellow and the subsequent spectroscopic data confirmed the compound as β-cyanin[75,90].

7.2 Reported Flavonoid or Polyphenolic Class of Constituents from *B. alba*

Acecetin (2) is a highly important *B. alba-derived* flavonoid class of product, which exhibits a pronounced effect in preventing cancer progression. Additionally, acacetin exhibits anti- plasmodial, antimutagenic, anti-inflammatory and anti-oxidant activities[91]. Acacetin directly expresses APP and β-Site amyloid precursor protein cleaving enzyme 1(BACE-1 inhibitor), making it a BACE-1 inhibitor. It arrests BACE-1 and APP production, resulting in a reduction in APP carboxy-terminal fragmentation and APP intracellular domains. Acacetin's protective impact over Aβ productions is governed through transcriptional modulation of APP and BACE-1. Acacetin likewise inhibited APP synthesis, bringing about abatement in the number of amyloid plaques. Acacetin was isolated from the chloroform part through column chromatography. The chloroform is evaporated in a vacuum to get a solid. Now acacetin is isolated from this solid by column chromatography using Hexane and ethyl acetate as eluent[92,93].

Kaempferol (3) is highly important as a chemotherapeutic agent as it inhibits the cell migration of glioma cells. It amplifies the function of doxorubicin by working together and hence it is used together[94]. Kaempferol has been shown to inhibit cellular proliferation via modulating cyclin B marker and Cyclin-Dependent Kinase 1 (CDK1) for the transition from G_2 to M stage. Then again, the capacity of kaempferol to attenuate oxidative stress has been accounted for both *in vitro* and *in vivo*, including direct and indirect mechanisms. Kaempferol scavenges different types of radicals, it inhibits Receptive Oxygen Species (ROS)-generating protein enzymes and increasing the expression of antioxidant enzymes. Data recommend that concerted impacts of kaempferol on multiple immunologically pertinent targets are responsible for its immunomodulatory action. To isolate kaempferol, it was extracted with 60% EtOH which was then subjected to repeated chromatography on Sephadex LH-20, silica gel, MCI gel CHP20P (Polyaromatic adsorbent resin), and Octadecylsilane (ODSC18) columns with gradient mobile

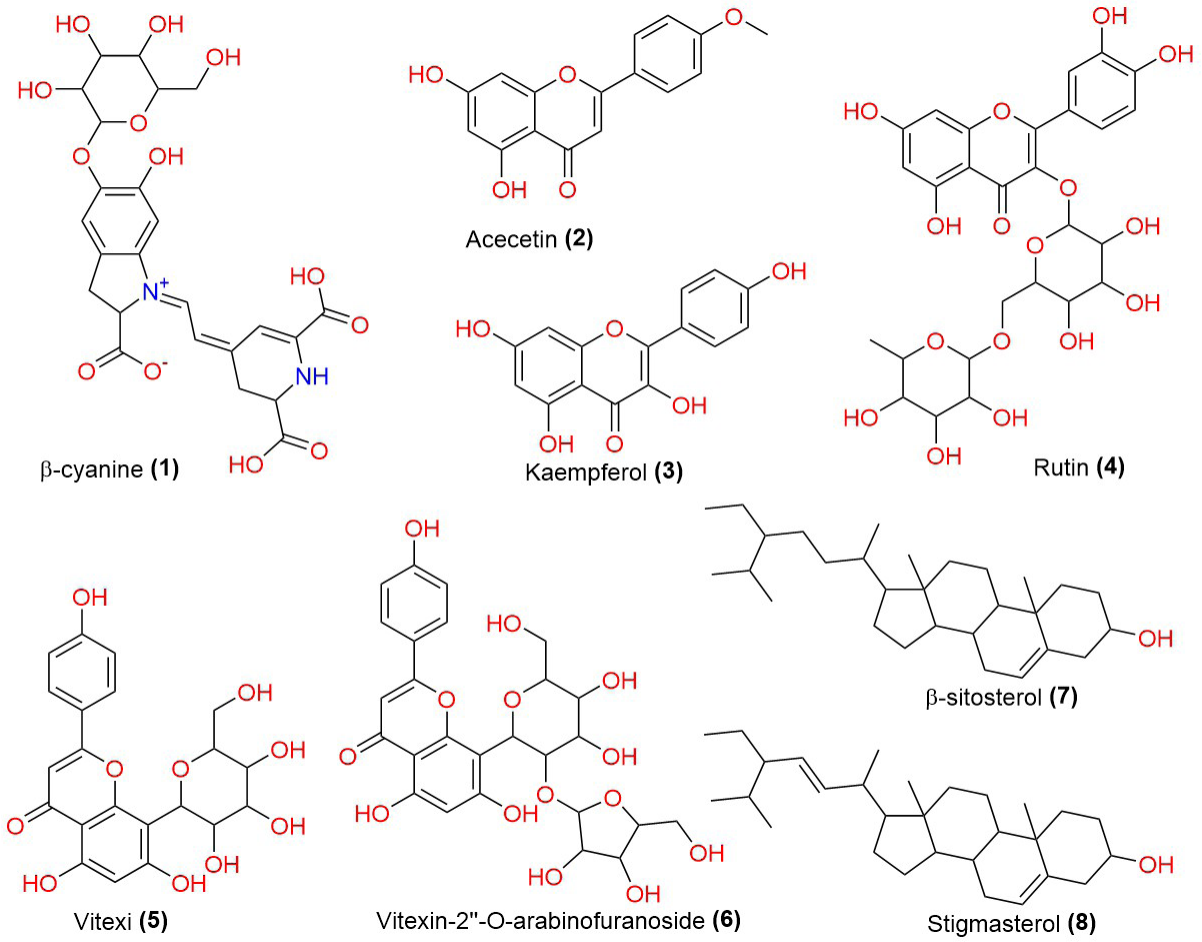

Figure 2. Chemical structure of some major bioactive compounds (1-8) from *B. alba.*

phases hexane–ethyl acetate (50:1–1:1), hexane–acetone (100:1–10:1), $CHCl_3$:MeOH (1:1, 95:5, 10:1) to isolate pure compound[95].

Rutin (4) covers a wide range of pharmacological importance: it has anti- neuroinflammation effects and it exhibits sedative activity, anticonvulsant activity anti-Alzheimer activity, antidepressant activity and antiulcer activities. It is also used against hyperkinetic movement disorder[96]. Rutin's scavenging capability might be because of its xanthine oxidase- inhibiting action. It can inhibit Low-Density Lipid (LDL) oxidation through scavenging radicals. To separate rutin the ethanolic *B. alba* segment was filtered and allowed to evaporate under vacuum to about 10 ml blended with 25 ml distilled water and washed with chloroform (50 ml x 3) and pet-ether (50 ml x 3). During this separation, the watery layer was procured together and stored to remain in a cold place for 72 hours. A yellowish compound precipitated out, which was rinsed with a blend of ethyl acetate: chloroform: ethanol (25:50:25). The precipitation was mixed in hot methanol and filtrated; the filtrate was dried to get yellow powder rutin[8].

7.3 Reported Steroid Class of Constituents from *B. alba*

β-sitosterol (7), named "plant sterol ester" has a similar structure as that of naturally occurring cholesterol and so it bears huge medical implications through lowering of blood cholesterol levels. Thus, it is a highly important molecule in hypercholesterolemia. β-sitosterol also has anticancer, antioxidant, anti-inflammatory, immunomodulatory and anti-infective activities[97]. β-sitosterol treated transgenic animals show progressive improvement in working memory and motor coordination. Because of such results, β-sitosterol falls in the category of compounds that may betreated for memory shortage problems like Alzheimer's disease. To isolate β-sitosterol the chloroform, ethyl acetate and acetone *B. alba* leaves extracts were separated, and refined to yield a dark greenish semi-solid substance that has been run through TLC, utilizing ethyl acetate-

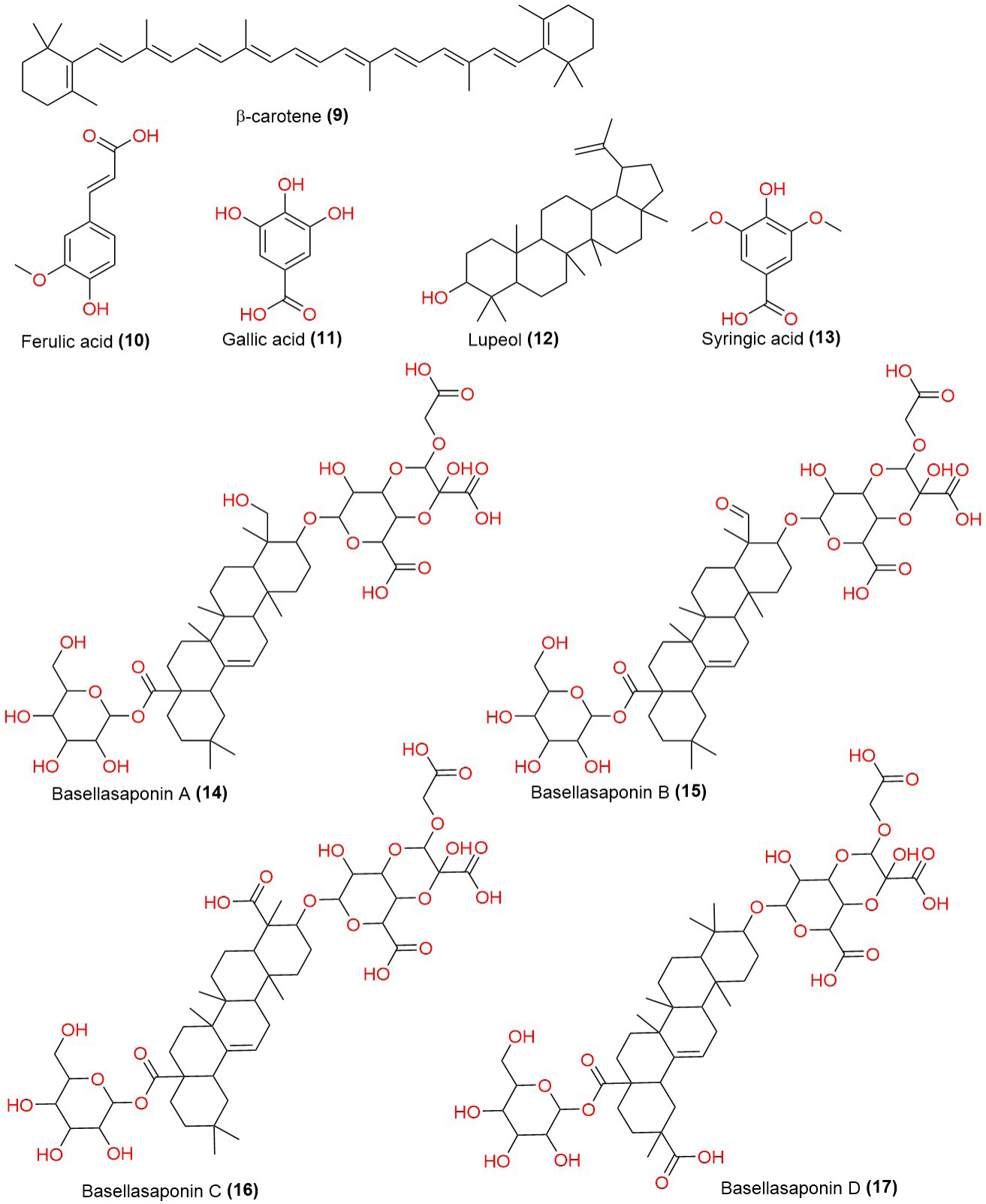

Figure 3. Chemical structure of some bioactive major compounds from *B. alba*.

petroleum ether (2:8), where 5 spots were observed. On elution of this dark green semi- polysubstance ethyl acetate-petroleum ether (5:95), a semi-solid grey component was isolated and gone for further recrystallization from methanol to produce β-sitosterol[46].

Stigmasterol (8) is capable of lowering cholesterol production in human Caco-2 and HL- 60 cell lines by inhibiting sterol Δ-24-reductase, therefore inhibiting hepatic cholesterol. These activities occurred as a result of the suppression of DNA repair synthesis. Stigmasterol has been examined for its pharmacological actions, for example, anti-osteoarthritic, anti-hyper- cholesterolemia, cytotoxicity, hypoglycemic, antimutagenic, anti-inflammatory, antitumor and CNS effects. Stigmasterol is involved in the synthesis of a variety of hormones, including androgens, progesterone, corticoids and estrogens[98]. To procure stigmasterol, the leaf powder (200 g) was defatted with hexane and afterwards extracted thoroughly in a Soxhlet apparatus with acetone. The crude fraction (extract) was filtered and concentrated in a vacuum to have a yellowish-white oily substance which was exposed to TLC utilizing mobile phase toluene-ethyl acetate (9.5:0.5), indicating three spots. It was filtered by silica gel column chromatography utilizing mobile phase pet ether-ethyl acetate (9.7:0.3). From the column, two mixtures were separated - a yellowish white sleek (oily) compound (7) and a yellowish semi-strong (8). Compound 7 was obtained in low amounts; hence no further assessment could be endeavoured. Compound 8 was additionally decontaminated by preparative TLC with mobile phase ether-ethyl acetate (9.5:0.5). From the acetone concentrate of the leaves of *Basella alba* was segregated the compound 8 as indicated by Proton nuclear magnetic resonance (proton NMR, hydrogen-1 NMR, or ^{1}H NMR), Carbon-13 (C13) nuclear magnetic resonance (most known as carbon-13 NMR spectroscopy or ^{13}C NMR spectra and comparing the melting point, the compound 8 was recognized stigmasterol[64].

8. Reported Other Organic Class of Constituents from *B. alba*

β-carotene (9) is a provitamin as it is converted into retinol. β-carotene also has cancer-preventive properties. It is an antioxidant which traps reactive oxygen species[99]. β-carotene is an antioxidant that shows huge adequacy against the Reactive Oxygen Species (ROS). Within the membranes of every cell compartment, β-carotene arrests the lipophilic radicals. It additionally presents an oxidative modification of Low-Density Lipoprotein (LDL). β-carotene is changed over in our body to nutrient A, a basic supplement. Because of its potential antioxidant activity, this helps protect the cells from damage. Antioxidants have been widely studied for chemoprevention of prostate malignant growth with the essential rationale of decreasing oxidative DNA damage. To isolate β-carotene the *B. alba* methanolic part was concentrated in vacuum and after that preparative thin layer chromatography was carried out using mobile phase diethyl ether: petroleum ether: acetic acid (20:80:1). The spot appearing with the same R_f value of references, B-carotene was recuperated from Thin Layer Chromatography (TLC) plate, re-disintegrated in dichloromethane, and concentrated in vacuum to acquire as β-carotene[100].

Ferulic acid (10) having similar structure as that of tyrosine inhibits melanin formation in a competitive manner. It protects skin from UV irradiation. Basically, it is a potential pigmentation inhibitor. It has a huge application in cosmetics[101]. To isolate ferulic acid, acetone leaf maceration extract was taken for evaporation to get a greenish condensed product, which was then filtered over a bed of silica gel using heptane-EtOAc. Then it was fractionized by Vacuum Liquid Chromatography (VLC) (Silica gel RP18) utilizing a gradient m.p. methanol: water (from 60-100 percent) to procure seven sections. The first 3 divisions were isolated by TLC using a reagent cerium sulphate molybdate and condensed employing rotating evaporator. Afterwards, those were isolated via VLC (normal phase, silica gel) utilizing heptane-EtOAC (7:32:8) to procure another 8 fractions, among the eight, the 3rd one (light yellowish crystal) was recrystallized till resulting in pure crystalline. Other portions were eliminated. Then the isolated compound was screened by ^{1}HNMR, ^{13}CNMR, IR, MS and melting point determining (168^{o}C) which confirmed the product as ferulic acid[102].

Lupeol (12) is a triterpene class of compound which exhibits remarkable cholesterol lowering properties. It has immense anti-inflammatory potential because it arrests different molecular pathways. It also has cancer preventive properties[103]. It appears to be a substantial anti- inflammatory and multi-targeted medication, focusing on major cellular pathways like NF-kappa B, and many others. Moreover, LA diminished the quantity of NOS cells, proposing that supportive of fiery cytokines and the NO framework perform an essential function in drug activity. (i) Lupeol was shown to sensitize pancreatic

malignancy cells to TRAIL treatment. This study demonstrated that lupeol therapy (40 mg/kg; 3 times/ week) diminished the development of tumors began from human pancreatic cancer cells (AsPC-1) embedded in a xenograft mouse model, (ii) Possesses wound healing potential in hyperglycemic conditions and might be valuable as a therapy for chronic wounds in diabetic patients. To isolate lupeol the *B. alba* aerial part was extracted by Soxhlet extractor with ethyl acetate (90%). Then the concentrate was condensed under decreased pressure utilizing a rotary evaporator, providing a dried residual (32.16%). The residue was passed through column chromatography with gradient mobile phase ethyl acetate and n-hexane. The fractions were assessed by Thin Layer Chromatography (TLC) with n-hexane and EtOAc (97.5: 2.5 v/v). The compound was indicated as a violet spot (R_f value=0.52) when 1% Vanillic-sulphuric acid reagent was sprayed and warmed for 5 minutes at 110ºC. Co-TLC using actual tests and substance portrayal utilizing UV and IR investigations demonstrated that the segregated component is lupeol[43,104].

Syringic acid (13) with the chemical name, 4-hydroxy-3,5-dimethoxybenzoic acid, is a phenolic component found naturally which is used against various diseases like diabetes, cardiovascular disease, cancer, and cerebral ischemia. It is also used in cases of neuro and liver damage. It also bears antioxidant, antimicrobial, anti-inflammatory as well as anti-endotoxin effects[105]. To separate syringic acid, the crude methanolic segment was obtained by cold macerating *B. alba* powder, which was subsequently concentrated to semi-solid in a rotary evaporator under decreased pressure and at a temperature < 45ºC. This was then extracted with a 3x100 ml solution of chloroform and methanol (2: l). At lower pressure and temperature, the three extracts were mixed and concentrated to dryness. To remove the insoluble component, the residue was dissolved in acetone and filtered. The filtrate was entirely distilled away, leaving a pale-yellow amorphous powder. That powder was then put through silica-packed column chromatography and eluted with chloroform, chloroform-methanol combinations in various ratios, and ultimately pure methanol. TLC was used to combine similar fractions produced with chloroform and methanol mixtures. The fraction produced with a 2:1 ratio resulted in a solid with a melting point of 190- 198 ºC. It was recrystallized from ethanol to a molecular weight of 202-204. With ferric chloride solution, it produced a black/ blue colour. It was highly soluble in acetone, methanol, and chloroform. It showed no decrease in mixed melting point when compared to the authentic sample of syringic acid and displayed superimposable IR spectra when compared to the authentic sample of syringic acid[106].

Basellasaponins are used as the treatment for constipation and have anti-inflammatory properties[107]. The isolation of novel saponins named Basellasaponin A (14), B (15), C (16), and D (17) from *B. alba* aerial parts was affirmed by structural elucidation and spectrum analysis. The methanolic segment from fresh aerial parts was exposed to dianion HP-20 (H_2O—MeOH—$CHCl_3$) and silica gel ($CHCl_3$–MeOH–H_2O) column chromatography and lastly, HPLC [YMC- Pack ODS-A, CH_3CN–1% AcOH, CH_3CN–1% fluid trifluoracetic acid] to yield basellasaponins A, B, C and D. All are procured from aqueous methanol[108-112]. Basellasaponin A (1, 0.0003%) was recovered as colourless fine crystals. The IR range of 1 indicated a carboxyl capacity absorption band at 1736 cm and stronger absorption bands at 3403, 1036, and 1076 cm, indicating an oligo-glycosidic structure[108-112]. Basellasaponin B (2, 0.0002%) likewise segregated as colourless fine crystals of m.p. 226-228 °C, released gypsogenin, D-glucuronic acid, and D- glucose after acid hydrolysing with 5% aqueous H_2SO_4–1,4-dioxane. The molecular formula C47H68O21 of 2 was explained from quasi-molecular ion peaks [m/z 967 (M2H)2 and m/z 991 (M1Na)1] as well as high-resolution mass spectroscopy investigation monitored in the positive- and negative-ion Fast Atom Bombardment-Mass Spectroscopy (FAB-MS)[108-112]. Basellasaponin C (3,0.0004%) and D (4, 0.0001%) were obtained as dull fine precious stones with melting points 230-232 and 215-217 °C. Those were discovered to contain an equivalent sub-atomic equation, C47H68O22, that was separated from the quasi-molecular particle tops [m/z 983(M2H)2, m/z 1007 (M1Na)1] in the positive-and negative-ions FAB-MS and by high-goals MS estimation[108-112].

9. Pharmacological Potency of *B. alba*

9.1 Wound Healing Activity

Mohanta *et al.* have reported that *B. alba* has been found to have wound-healing activities in albinomale rats. After 20 days, significant burning wound healing activities were observed on the posterior side of rodents with combustion wounds and treated with *B. alba* leaves extract with glycerin. Right now, aqueous segments of leaves of *Basella alba* were formulated as watery concentrates of

Basella alba (2% w/v) utilizing polymers carbopol 934 and carbopol 940 as a matrix. The formulation 1.5% w/w carbopol 934 showed good physicochemical attributes, higher pharmacological movement and sound stability when compared with others[44,98].

9.2 Anti-Ulcer Activity

Chashoo *et al.* provided details regarding the anti-ulcer studies regarding aspirin-induced ulcerated rodent models. The significant parameters associated with the investigation included, gastric pH, amount of pepsin, lipid hydro peroxidases, CAT, GSH, SOD, GPx, thiobarbituric acid reactive agents, vitamin E and vitamin C. Treatment of *Basella alba* leaf turned such fluctuating parameters, closer to normal level. Kumar *et al*., have examined the antiulcer efficacy of *B. alba* leaves in rodents. Processed dried powder leaves of *Basella alba* were used as animal feed for such experiments. They used six groups of rats of either sex. Animals of Groups II and III were treated with AEBA (independently 200 mg per kg and 400 mg per kg) while animals of Groups IV and V were orally upgraded with EEBA (200 mg per kg and 400mg per kg, independently). The dose- dependent activity was shown in this experiment. Both the AEBA and EEBA groups improved mucosal resistance and diminished gastric acidity, which demonstrates the *Basella alba*'s gastroprotective activity[113].

9.3 Antiviral Activity

A group of scientists have checked the antiviral action of *Basella* and have concluded that it has remarkable antiviral activities. Rao *et al. have* audited the antiviral movement on this and drawn the same conclusion[114]. Bolognesi (1997), separated single-chain ribosome-inactivating protein from the *B. rubra* seeds and believed that it could have some antiviral efficacy and indeed it was true[115,116]. Meng *et al.* discovered that *B. rubra* inhibited tobacco mosaic infection[117]. Dong *et al.* have discovered that a polysaccharide from *Basella rubra* shows an inhibitory effect over type 2 herpes simplex infections[118].

9.4 Anti-Inflammatory Action

The most encouraging anti-inflammatory activities have been performed by Krishna Mohan *et al.* For their experiment, they used phenylbutazone as a standard anti-inflammatory and their experiment revealed that an aqueous extract of *Basella alba* significantly decreased the inflammation in rodents. They have also mentioned that, in carrageenan-induced inflammatory methods, pet-ether *B. alba* extract didn't show substantial anti-inflammatory activities[116]. Using the human platelet film adjustment technique Kumar *et al.* have reported promising *in-vitro* anti- inflammatory action of *Basella alba*[119].

9.5 CNS Depressant Activity

Rajagopal *et al*., have used petroleum ether, methanol, and aqueous extracts of dried aerial parts of *B. alba* to study the CNS depressant action in mice. Exceptionally sound CNS depressant action was noted by the methanol part rather than the other extract part used for the same experiment. The reason behind the noteworthy CNS depressant value of the methanolic part may be the existence of psychoactive materials such as terpenoids[35].

9.6 Androgenic Potential

The plant *B. alba* possesses androgenic potency, which is one of its key functions. As per Moundipa *et al.,* and Nenita *et al., Basella alba* methanolic extract not only enhances the creation of testosterone but also can invigorate or induce both androgen and estrogen production. Moundipa *et al*., have investigated the significant impacts of *B. alba* aqueous extract over the reproductive system in developed albino male Wistar rodents. In those examinations, surprising changes were observed having a significant increase in the weight of seminal vesicles, *in- vitro* testosterone creation, movement of prostatic acid phosphatase and, lumen containing seminiferous tubules and concentration of spermatozoa upon treatment with both the dried and fresh leaves extract on rodents. The reason behind such types of androgenic potential of *Basella alba* is because of its promising analyzing and virializing impacts. In this experiment, it was found that testosterone production increased in the presence of Basella leaf extract in a concentration- dependent way. Moundipa *et al*., conducted another remarkable *in vitro* study of producing testosterone in adult rat testes slices in the presence of extracts from *B. alba* and *Hibiscus macranthus*[31,120-122].

9.7 Hepatoprotective Potency

Bamidele *et al*., have reported the lead-induced hepatoprotective actions of *Basella alba* L. in male waster rodents. Some rodents were categorized and offered an oral dose of 10, 50 and 250 mg per kg respectively for 3 weeks to evaluate the changes in different hematological and biochemical degrees of significant parameters of the liver

enzymes. They observed that the hematological parameters like RBC count, platelet check, WBC counts, packed cell volume and hemoglobin concentrations have elevated levels while the enzymes such as Alkaline Phosphatase (ALP), Aspartate Aminotransaminase (AST) and Alanine Aminotransaminase (ALT) have decreased level. These results demand a high hepatoprotective potential of *Basella alba*[34,123,124]. Yanadaiah *et al*., also reported the hepatoprotective movement of *B. rubra* aqua-ethanolic extract against paracetamol- and carbon tetrachloride-mediated hepatotoxic effects in rodents. The Wistar rodents treated with paracetamol and carbon tetrachloride showed a rise in AST, ALT, and ALP functionalities along with increased levels of serum bilirubin, all of which are indications of hepatic damage. The raised markers, such as AST, ALT, and ALP, which had high levels due to paracetamol and carbon tetrachloride intoxication, returned to normal ranges after being treated with *B. alba* ethanol extract. The above investigations indicate the promising hepatoprotective nature of *Basella alba*[124].

9.8 Antidiabetic Potency

Nirmala *et al*. investigated the hypoglycemic impact of *B. alba* aqueous leaf extract on 30 diabetic albino rats. The rodents were split into five groups at random, containing 6 rodents in each group marked as Group I to Group IV. The healthy control groups intended to be considered as Group I rodents which were normal. Another type of group served as diabetic control and was marked as Gr-II rodents. The diabetic rodent Groups III and IV were treated individually with *B. alba* leaves fraction (at various dosages as 100 mg/kg). Metformin was administered to Group V rodents (additionally, diabetes induced) at a dosage of 100 mg/kg. Each rodent's Fasting Blood Glucose (FBG) was monitored by a glucometer in a weekly manner. The rodents administered with Malabar spinach with dosages of 100-200 mg/kg showed lower" mean fasting blood glucose" levels compared to the diabetic "control group". Correspondingly, there was significant differentiation in mean fasting blood glucose value between the rodents treated group with the diabetic control and the Metformin-treated group. In this manner, the outcomes show that *B. alba* leaf extracts have significant hypoglycemic effects[125].

9.9 Antioxidant Potency

Reshmi *et al*., reported the total phenol content, and total β-cyanin and investigated the antioxidant action against superoxide anions, DPPH radical, hydroxyl radical, hydrogen peroxide and metal chelating. β-cyanin segregated from *B. alba* fruit showed incredible antioxidant agents[126].

9.10 Antianxiety Potency

Basella alba L. contains a few flavonoids, mostly kaempferol type of flavonoid and this is the key reason for having anxiolytic activity of it[127]. Utilizing the technique "Elevated Plus-Maze Test" in mice model, which evaluated the anxiety level surveyed by Karunakar *et al*.,[128-130]. Utilizing the technique "Hole board test in rodent" framework, Leela *et al*. and Soman *et al*., have explained the anti-anxiety activities of *Basella alba* L.[131-132]. Similarly, by using the method "Light-dark model" transition test in mice Zanoli *et al*. demonstrated the Anti-anxiety activity[132-135]. By the "Open field test" technique, the anxiety level was assessed by File *et al.,* and Sonovane *et al*[136,137].

9.11 Diuretic and Anti-Urolithiatic Potency

Freitas *et al*., reported the diuretic and against urolithiasis actions of ethanolic leaf extracts of *B. alba* in albino rats. They used ethanolic leaf extracts in experimental rodents orally at dosages of 250 mg/ kg and 500 mg/ kg whereas Furosemide (5 mg/kg) was used as control. The diuretic impact of the extract was assessed by estimating the urine volume and deciding on sodium, potassium, chloride, and bicarbonate substances. The extract of *Basella alba* was found to be safe and did not show any gross behavioural changes in the rodents. Ethanolic leaf extract of *Basella alba* leaves showed good diuretic activity by increasing the total urine output and elevated discharge of sodium, potassium, chloride and bicarbonate levels. Additionally, anti- urolithiasis action was also observed as the elevated levels of oxalate, calcium and phosphate in urine and calcium, uric acid and creatinine in serum lowered upon treatment with ethanolic leaf extract of *B. alba*[138].

9.12 Antimicrobial Potency

Pumchaosuan *et al*., have demonstrated antimicrobial impacts of *Basella alba* against *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli* and *Candida albicans*. The result showed that the leaf of crude methanolic extract for Minimum Inhibitory Concentration (MIC) and stem extract was 50 mg/ml for *E. coli* and *S. aureus* while for *E. coli* and *P. aeruginosa,* the Minimum Bactericidal

Concentration (MBC) was 50 mg/ml and was 100mg/ml for *S. aureus* respectively. Hence the examination results prescribed that the methanolic extracts of *Basella alba* crude may be worthy for treating the contaminations brought about by *S. aureus*, *P. aeruginosa* and *E. coli*[139].

9.13 Cytotoxic Activities

To have a proper implication in a real scenario, evaluation of cytotoxic activity is very much essential. Selvakumaran *et al.*, evaluated the cytotoxic activities of methanolic extract *Basella alba* at different dilutions against "Jurkat" and lung sickness cell lines[140]. The *Basella alba* extract indicated significant dose-dependent cytotoxicity on Jurkat cell lines. They used Paclitaxel as a positive control in a concentration of 5 µM. Consequently, it was highly interesting to note that the extract of *Basella alba* displayed cytotoxic action against malignant cell lines.

9.14 Nephroprotective Effects

In Wistar albino rats, ethanolic extracts of *B. alba* L. have a potential nephroprotective impact ongentamicin (GM)-mediated nephrotoxicity. This was studied for 8 days by directing GM only (100mg per kg, i.p.). A group of rodents were pre-treated with *B. alba*, with an oral dose of 250 mg/kg and 500 mg/kg reliably, for 2 weeks and another group was co-treated for 8 days with GM. After 24 hr of the last dosage urine, blood, and tissue specimens were procured from the animals. Through the administration of gentamicin, marked renal failure was induced resulting in a critical rise in pee and serum creatinine, uric acid, protein, Gamma-Glutamyl Transferase (GGT) and urea levels. The experimental data demonstrated that GM-media tendineae durine and serum levels of urea, protein, uric acid, GGT, creatinine, sodium, potassium, and calcium drop down to normal ranges after treatment with *B. alba* extract[141].

10. Significance of General Wellbeing

The purpose of shedding light on the capabilities and significance of *B. alba* L. is to develop newpharmaceuticals. Both plants, *B. alba* and *B. alba* var. *cordifolia* (*B. rubra* L.) are ethno- therapeutically significant and are utilized to treat many ailments; as a result, should be extensively domesticated and grown on a larger scale. *Basella* is a significant verdant vegetable just as a sound restorative plant which is generally well known in the customary ayurvedic framework in India. It is one of such plants which have an enormous reputation in indigenous conventional arrangement of medication in India by virtue of which it has drawn the attention and concern of researchers forvalidation of its therapeutic properties. The beauty of interest of *Basella alba* L. is being exploited in recent days by numerous individuals of scientists worldwide of its unique constituents like Basellasaponins, kaempferol, βlain, gomphrenin subordinates, B-carotene, some significant acid substituents (syringic acid, ferulic acid, linoleic acid, and so forth) and potential sources of amino acids[142,143]. *Basella alba* L. are especially valuable in treating a great number of vital life- threatening ailments, for example, malignant growth, malaria, HIV, hypertension, Pneumonia, jaundice, and dengue. This pant is also very useful to treat bilious vomiting, sexual asthenia, headache, gonorrhoea, burns, cerebral pain, ulcers, diarrhoea, liver disorders, stomach- related scatters, bleeding piles, skin diseases, urticaria, pimples, aggravation, iron deficiency, leprosy, whooping cough, insomnia and aphthae[144]. All the biological functions displayed by plants have incredible potency and relevance in the zone of therapeutic investigation. The recent research concluded methanol extract of *Basella alba* directly stimulates estradiol, testosterone, and aromatase mRNA levels in isolated male rodent Leydig cells.

11. Conclusion

B. alba, one of the newest pharma-herb, stores a lot of pharmacologically important organic molecules like acacetin, rutin, quercetin, kaempferol, some crucial terpenoids such as B-carotene, *Basella* saponins, lupeol and some valuable phenolic acids such as vanillic acid, ferulic acid, and syringic acid and as a result it bears a significant pharmacological importance because of its anti- ulcer, antiviral, antimicrobial, anti-inflammatory, androgenic potential depressant, wound healing, hepatoprotective, antidiabetic, antioxidant, anti-anxiety, diuretic and anti-urolithiasis activities etc. The cultivation, as well as extraction processes of *Basella alba*, is very cost-effective. *Basellaalba* also has exceptionally few side effects. So, *Basella alba* having such worthy pharmacological parameters can foster a new doorstep in medical sciences.

12. Acknowledgements

The authors are very much thankful to N. S. H. M. Knowledge Campus, Kolkata – Group of Institutions,

Kolkata and T. C. G. Life Sciences Pvt. Limited (Chembiotek), Plot No-7, Salt Lake Electronics Complex, BN Block, Sector V, Kolkata, West Bengal - 700091, India for providing the necessary things to complete this work.

13. References

1. De Furia MD. Paclitaxel (Taxol®): A new natural product with major anticancer activity. Phytomed. 1997; 4(3):273-82. https://doi.org/10.1016/S0944-7113(97)80081-5 PMid: 23195489
2. Mishra BB, Tiwari VK. Natural products: An evolving role in future drug discovery. Eur J Med Chem. 2011; 46(10):4769-807. https://doi.org/10.1016/j.ejmech.2011.07.057 PMid: 21889825
3. Rey-Ladino J, Ross AG, Cripps AW, McManus DP, Quinn R. Natural products, and the search for novel vaccine adjuvants. Vaccine. 2011; 29(38):6464-71. https://doi.org/10.1016/j.vaccine.2011.07.041 PMid:21787827
4. Cragg GM, Newman DJ. Biodiversity: A continuing source of novel drug leads. Pure Appl Chem. 2005; 77(1):7-24. https://doi.org/10.1351/pac200577010007
5. Haefner B. Drugs from the deep: marine natural products as drug candidates. Drug Discovery Today. 2003; 8(12):536-44. https://doi.org/10.1016/S1359-6446(03)02713-2 PMid: 12821301
6. Butler MS. The role of natural product chemistry in drug discovery. J Nat Prod. 2004; 67(12):2141-53.https://doi.org/10.1021/np040106y PMid:15620274
7. Der Marderosian A, Beutler JA. The review of natural products, 2nd ed.; Facts and Comparisons; Seattle, WA, USA, 2002, 13–43.
8. Ekor M. The growing use of herbal medicines: issues relating to adverse reactions and challenges in monitoring safety. Front. Pharmacol. 2014; 4:177. https://doi.org/10.3389/fphar.2013.00177 PMid: 24454289 PMCid:PMC3887317
9. Atanasov AG, Waltenberger B, Pferschy-Wenzig EM, Linder T, Wawrosch C, Uhrin P, Temml V, Wang L, Schwaiger S, Heiss EH, Rollinger JM. Discovery and resupply of pharmacologically active plant-derived natural products: A review. Biotechnol. Adv. 2015; 33(8):1582-614. https://doi.org/10.1016/j.biotechadv.2015.08.001 PMid:26281720 PMCid: PMC4748402
10. Adhikari R, Kumar HN, Shruthi SD. A review on the medicinal importance of *Basella alba* L. Int. J. Pharm. Pharm. Res. 2012; 4(2):110-14.
11. Ray T, Roy SC. Phylogenetic relationships between members of Amaranthaceae and Chenopodiaceae of lower Gangetic plains using RAPD and ISSR markers. Bangl. J. Bot. 2007; 36(1):21-8. https://doi.org/10.3329/bjb.v36i1.1544
12. Cook A. Linnaeus and Chinese plants: A test of the linguistic imperialism thesis. Notes Rec Roy Soc. 2010; 64(2):121-38. https://doi.org/10.1098/rsnr.2009.0051
13. Vanaliya S, Rao PS, Rao SK, Sameja K. Pharmacognostical study of *Basella alba* stem. Int. J. Pharma Sci. 2012; 3(3):1093-4.
14. Gabriela B, Camelia I. Some histo-anatomical aspects concerning the leaf structure of *Basella alba* and *Basella rubra*. J. Plant Dev. 2004; 12(1).
15. Roy SK, Gangopadhyay G, Mukherjee KK. Is the stem twining form of *Basella alba* L., a naturally occurring variant? Curr Sci. 2010; 98(10):1370-5.
16. Mhatre K, Singh R, Cerejo S, Shinde R. Tersity of mangroves in Raigad district, Maharashtra. Int J Environ Sci. 2013; 2(4):205-9.
17. Lorenzo-González M, Ruano-Ravina A, Torres-Durán M, Kelsey KT, Provencio M, Parente-Lamelas I, Leiro-Fernández V, Vidal-García I, Castro-Añón O, Martínez C, Golpe-Gómez A. Lung cancer and residential radon in never-smokers: A pooling study in the Northwest of Spain. Environ Res. 2019; 172:713-8. https://doi.org/10.1016/j.envres.2019.03.011 PMid: 30903971
18. Shilla O, Dinssa FF, Omondi EO, Winkelmann T, Abukutsa-Onyango MO. *Cleome gynandra* L. Origin, taxonomy, and morphology: A review. Afr J Agric Res. 2019; 14(32):1568-83. https://doi.org/10.5897/AJAR2019.14064
19. Azad AK, Wan Azizi WS, Babar ZM, Labu ZK, Zabin S. An overview on phytochemical, anti-inflammatory and anti-bacterial activity of *Basella alba* leaves extract. Middle East J Sci Res. 2013; 14(5):650-5.
20. Chakraborty SB, Molnár, T, Hancz C. Effects of methyltestosterone, tamoxifen, genistein and *Basella alba* extract on masculinization of guppy (*Poecilia reticulata*). J Appl Pharm Sci. 2012; 2(12):48.
21. Ndinya CA. The genetic diversity of popular African leafy vegetables in western Kenya. In Genetic Diversity in Horticultural Plants; Springer: Cham, 2019; 127-59. https://doi.org/10.1007/978-3-319-96454-6_5
22. Arslangündoğdu Z, Hızal E. *Anoplophora glabripennis* (Coleoptera: Cerambycidae) mistakenly reported in Turkey. Fla. Entomol. 2019; 102(1):287-9. https://doi.org/10.1653/024.102.0157
23. Vandebroek I, Voeks R. The gradual loss of African indigenous vegetables in tropical America: A review. Econ Bot. 2018; 72(4):543-71. https://doi.org/10.1007/s12231-019- 09446-3
24. Mohapatra SP, Sahoo HP. An ethno-medico-botanical study of Bolangir, Orissa, India: native plant remedies against gynaecological diseases. J Ethnobot Leaflets. 2008; 22(1):115.
25. Deshpande SS, Shah GB, Deshpande I, Parmar NS. Antiulcer activity of aqueous extract of *Basella rubra* in albino rats. J Nat Med. 2003; 3(2):212-4.
26. Abhilash PC, Tripathi V, Edrisi SA, Dubey RK, Bakshi M, Dubey PK, Singh HB, Ebbs SD. Sustainability of crop production from polluted lands. Energy Environ Sci. 2016; 1(1):54-65. https://doi.org/10.1007/s40974-016-0007-x
27. Kosson R, Felczyński K, Szwejda-Grzybowska J, Grzegorzewska M, Tuccio L, Agati G, Kaniszewski S.

Nutritive value of marketable heads and outer leaves of white head cabbage cultivated at different nitrogen rates. Acta Agr Scand B-S P. 2017; 67(6):524-33. https://doi.org/10.1080/09064710.2017.1308006
28. Titanji VP, Zofou D, Ngemenya MN. The antimalarial potential of medicinal plants used for the treatment of malaria in Cameroonian folk medicine. Afr J Tradit Complement Altern Med. 2008; 5(3):302-21.
29. Udofia US, Obizoba IC. Effect of traditional processing techniques on leafy vegetable and starchy staple and their uses in traditional soups and dishes as consumed in Akwa Ibom State. J Biochem Invest. 2005; 3:1-5.
30. Reddy MT, Begum H, Sunil N, Rao PS, Sivaraj N, Kumar S. Preliminary characterization, and evaluation of landraces of Indian spinach (*Basella alba* L.) for agro-economic and quality traits. Plant Breed Biotechnol. 2014; 2(1):48-63. https://doi.org/10.9787/PBB.2014.2.1.048
31. Olowokudejo JD, Kadiri AB, Travih VA. An ethnobotanical survey of herbal markets and medicinal plants in the Lagos State of Nigeria. Ethnobot Leaflets. 2008; 12(7):851-65.
32. Garza DL, Arcilla RG, Enriquez ML, Luisa D, Tan MC, Noel MG. The genotoxic potential of *Alugbati* leaf extracts on MCF-7 Cells. Jordan J Biol Sci. 2019; 12(2):161-5.
33. Pareek V, Singh M, Bhat ZA, Singh P, Kumar D, Sheela S. Studies on mucilage of *Basella alba* Linn. J Pharm Res. 2010; 8(3):1892-4.
34. Moundipa PF, Beboyl NS, Zelefack F, Ngouela S, Tsamo E, Schill WB, Monsees TK. Effects of *Basella alba* and *Hibiscus macranthus* extracts on testosterone production of adult rat and bull Leydig cells. Asian J Androl. 2005; 7(4):411-7. https://doi.org/10.1111/j.1745-7262.2005.00056.x PMid:16281090
35. Kar A, Borthakur SK. Dye-yielding plants of Assam for dyeing handloom textile products. Indian J Tradit Knowl. 2008; 7(5):166-71.
36. Premakumari KB, Siddiqua A, Banu S, Josephine J, Jenita L, Raj B. Comparative antimicrobial studies of methanolic extract of *Muntingia calabura*, *Basella alba* and *Basella rubra* Leaves. Int J Pharmacogn Phytochem. 2010; 2(3):246-8.
37. Bamidele O, Akinnuga AM, Olorunfemi JO, Odetola OA, Oparaji CK, Ezeigbo N. Effects of aqueous extract of *Basella alba* leaves on haematological and biochemical parameters in albino rats. Afr J Biotechnol. 2010; 9(41):6952-5.
38. Anandarajagopal K, Sudhahar D, Ajaykumar TV, Muthukumaran G. Evaluation of CNS depressant activity of aerial parts of *Basella alba* Linn. IJPI'S J. Pharmacol Toxicol. 2011; 1(5):24-6.
39. Haskell MJ, Jamil KM, Hassan F, Peerson JM, Hossain MI, Fuchs GJ, Brown KH. Daily consumption of Indian spinach (*Basella alba*) or sweet potatoes has a positive effect on total-body vitamin A stores in Bangladeshi men. Am J Clin Nutr. 2004; 80(3):705-14. https://doi.org/10.1093/ajcn/80.3.705 PMid:15321812
40. Njoroge GN, Bussmann RW, Gemmill B, Newton LE, Ngumi VW. The utilisation of weed species as sources of traditional medicines in central Kenya. Lyonia. 2004; 7(2):71-87.
41. Onyango MA, Onyango JC. Conservation and seed production of African leafy vegetables at Maseno University botanic garden, Kenya. Afr Crop Sci J. 2005; 1201-4.
42. Dixit U, Goyal VC. Traditional knowledge from and for the elderly. Indian J Tradit Knowl. 2011; 10(6):429-38.
43. Babalola JO, Babarinde NAA, Oninla VO, Popoola OA. Kinetics, equilibrium and thermodynamics studies of the biosorption of lead (II) and chromium (III) by *Basella alba* L. Pac J Sci Technol. 2008; 9(2):610-20.
44. Sen K, Goel A, Rawal S, Mahajan N, Baboo S, Alok S. Antimicrobial activity of *Basella rubra* leaves. Int J Pharma Sci. 2010; 1(2):88-91.
45. Deshmukh SA, Gaikwad DK. A review of the taxonomy, ethnobotany, phytochemistry and pharmacology of *Basella alba* (Basellaceae). J Appl Pharm. 2014; 4(01):153-65. https://doi.org/10.7324/JAPS.2014.40125
46. Rajasab AH, Isaq M. Documentation of folk knowledge on edible wild plants of North Karnataka. Indian J Tradit Knowl. 2004; 3(4):419-29.
47. Mohanta GP, Abraham A, Saraswathi R, Haneefa MK, Nayar C. Formulation, and evaluation of herbal gel of *Basella alba* for wound healing activity. Int J Pharm Sci Rev Res. 2012; 4(1):1642.
48. Vaidya SK, Kumar S, Prasad AK, Iyer SV. Systematic pharmacognostic, phytochemical and pharmacological review on an ethno medicinal plant, *Basella alba* L. J Pharmacog Phytochem. 2013; 5(4):53-8.
49. Paul SB, Singha S. Isolation and identification of physiologically important Sterols and sterol glucoside from *Basella rubra* Linn. Assam University J Sci Technol. 2010; 5(1):120-2.
50. Ruth L, Manani Solomon, D. Ethnobotanical survey and propagation of some endangered medicinal plants from south Nandi district of Kenya. J Anim Plant Sci. 2010; 8(3):1016-43.
51. 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. Eur J Exp Biol. 2012; 2:337-42.
52. Oladele OO, Aborisade AT. Influence of different drying methods and Storage on the quality of Indian Spinach (*Basella rubra* L.) Am J Food Technol. 2009; 4(2):66-70. https://doi.org/10.3923/ajft.2009.66.70
53. Rahmatullah M, Jahan FI, Seraj S, Khatun Z, Islam F, Sattar MM, Khan T, Ishika T, Rahman M, Jahan R. Correlation between non-conventional plants consumed during food scarcity and their folk medicinal usages, a case study in two villages of Kurigram district, Bangladesh. Am Eurasian J Sustain. 2011; 5(2):240-6.
54. Potsangbam L, Ningombam, S, Laitonjam WS. Natural dye-yielding plants and indigenous knowledge of dyeing in Manipur, Northeast India. Indian J Biochem Biophys. 2008; 14(9):141-7.

55. Gabriela B, Camelia I. Some histo-anatomical aspects concerning the leaf structure of *Basella alba* and *Basella rubra*. J. Plant Growth Regul. 2004; 12(7):95-9.
56. Kumar CK, Kumar RV, Sridharan R. Traditional use of medicinal plants in Puducherry for treatment of urinary tract disorders. Indian J Public Health Res Dev. 2019; 10(1):160-4. https://doi.org/10.5958/0976-5506.2019.00035.4
57. Mishra S, Shrivastava RK, Sheikh M, Soni VK. Ethnomedicinal uses of certain plants by korku tribals of Khandawa District in MP (India). National Conference on Forest Biodiversity Resources, Exploitation Conservation and Management, 2006; 21-2.
58. Lin SM, Lin BH, Hsieh WM, Ko HJ, Liu CD, Chen LG, Chiou RY. Structural identification, and bioactivities of red-violet pigments present in *Basella alba* fruits. J Agric Food Chem. 2010; 58(19):10364-72. https://doi.org/10.1021/jf1017719 PMid:20839771
59. Chaitanya BK. Anti-inflammatory activity of *Basella alba* Linn. in albino rats. J Appl Pharm. 2012; 12(5):87-9. https://doi.org/10.7324/JAPS.2012.2413
60. de Boer HJ, Kool A, Broberg A, Mziray WR, Hedberg I, Levenfors JJ. Anti-fungal and anti-bacterial activity of some herbal remedies from Tanzania. J Ethnopharmacol. 2005; 96(3):461-9. https://doi.org/10.1016/j.jep.2004.09.035 PMid:15619565
61. Balachandran P, Govindarajan R. Cancer - an Ayurvedic perspective. Pharmacol Res. 2005; 51(1):19-30. https://doi.org/10.1016/j.phrs.2004.04.010 PMid:15519531
62. Chatchawal C, Nualkaew N, Preeprame S, Porasuphatana S, Priprame A. Physical, and biological properties of mucilage from *Basella alba* L. stem and its gel formulation. Turk J Pharm Sci. 2010; 6(3):104-12.
63. Saikia AP, Ryakala VK, Sharma P, Goswami P, Bora U. Ethnobotany of medicinal plants used by Assamese people for various skin ailments and cosmetics. J. Ethnopharmacol. 2006; 106(2):149-57. https://doi.org/10.1016/j.jep.2005.11.033 PMid:16473486
64. Varalakshmi B. Genetic variability in Indian spinach (*Basella alba* L.). Int J Hortic Sci. 2010; 6(3):21-4.
65. Singh PK, Kumar V, Tiwari RK, Sharma A, Rao CV, Singh RH. Medico-ethnobotany of 'chatara' block of district Sonebhadra, Uttar Pradesh, India. Adv Exp Med Biol. 2010; 4(1):65-80.
66. Ostlund RE. Phytosterols in human nutrition. Annu Rev Nutr. 2002; 22(1):533-49. https://doi.org/10.1146/annurev.nutr.22.020702.075220 PMid:12055357
67. Yasmin H, Kaiser MA, Sarker MM, Rahman MS, Rashid MA. Preliminary anti-bacterial activity of some indigenous plants of Bangladesh. Dhaka Univ J Pharm Sci. 2009; 8(1):61- 5. https://doi.org/10.3329/dujps.v8i1.5337
68. Nishimato T, Hirose R. Red colouring method using *Basella rubra* fruit juice. Chem Abstr. 1991; 115(90):790.
69. Kumar BR, Anupam A, Manchikanti P, Rameshbabu AP, Dasgupta S, Dhara S. Identification and characterization of bioactive phenolic constituents, anti-proliferative, and anti-angiogenic activity of stem extracts of *Basella alba* and *rubra*. J Food Sci Technol. 2018; 55(5):1675-84. https://doi.org/10.1007/s13197-018-3079-0 PMid:29666520 PMCid:PMC5897285
70. Chou CT. The anti-inflammatory effect of an extract of *Tripterygium wilfordii* hook F on adjuvant-induced paw oedema in rats and inflammatory mediator's release. Phytoth Res. 1997; 11(2):152-4. https://doi.org/10.1002/(SICI)1099-1573(199703)11:2%3C152::AID-PTR45%3E3.0.CO;2-L
71. Akhter S, Halim A, Sohel SI, Sarker SK, Chowdhury MS, Sonet SS. A review on the use of non-timber forest products in beauty care in Bangladesh. J For Res. 2008; 19(1):72-8. https://doi.org/10.1007/s11676-008-0014-7
72. Focho DA, Nkeng EA, Lucha CF, Ndam WT, Afegenui A. Ethnobotanical survey of plants used to treat diseases of the reproductive system and preliminary phytochemical screening of some species of Malvaceae in Ndop Central Sub-division, Cameroon. J Med Plants Res. 2009; 3(4):301-14.
73. Malviya R, Srivastava P, Kulkarni GT. Applications of mucilages in drug delivery-a review. Adv Biol Res (Faisalabad). 2011; 5(1):1-7.
74. Vanaliya S, Rao PS, Rao SK, Sameja K. Pharmacognostical study of *Basella alba* stem. Int J Pharm. 2012; 3(3):1093-4.
75. Vélez-Gavilán J. *Basella alba* (malabar spinach). Invasive Species Compendium. Wallingford, UK, CABI. 2018. https://doi.org/10.1079/ISC.8273.20203483150
76. Sen P, Sahu PK, Haldar R, Sahu K, Prasad P, Roy A. Apigenin naturally occurring flavonoids, occurrence and bioactivity. UK J. Pharm. Biosci. 2016; 4(6):56-68. https://doi.org/10.20510/ukjpb/4/i6/134666
77. Yang RY, Lin S, Kuo G. Content and distribution of flavonoids among 91 edible plant species. Asia Pac J Clin Nutr. 2008; 17 (S1) (Suppl. 1):275-9.
78. Izonfuo WA, Fekarurhobo GK, Obomanu FG, Daworiye LT. Acid-base indicator properties of dyes from local plants I, dyes from *Basella alba* (Indian spinach) and *Hibiscus sabdariffa* (Zobo). J Appl Sci Environ. 2006; 10(1):5-8. https://doi.org/10.4314/jasem.v10i1.17295
79. Murakami T, Hirano K, Yoshikawa M. Medicinal foodstuffs. XXIII. Structures of new oleanane-type triterpene oligoglycosides, basellasaponins A, B, C, and D, from the fresh aerial parts of *Basella rubra* L. Chem Pharm Bull (Tokyo). 2011; 49(6):776-9. https://doi.org/10.1248/cpb.49.776 PMid:11411538
80. Maisuthisakul P, Pasuk S, Ritthiruangdej P. Relationship between antioxidant properties and chemical composition of some Thai plants. J Food Compos Anal. 2008; 21(3):229-40. https://doi.org/10.1016/j.jfca.2007.11.005
81. Olajire AA. Total antioxidant activity, phenolic, flavonoid and ascorbic acid contents of Nigerian vegetables. Afr J Food Sci. 2011; 2(2):22-9.

82. Glässgen WE, Metzger JW, Heuer S, Strack D. Betacyanins from fruits of *Basella rubra*. Phytochem. 1993; 33(6):1525-7. https://doi.org/10.1016/0031-9422(93)85126-C
83. Crossman SM, Palada MC. Evaluation of tropical leaf vegetables in the Virgin Islands. Perspectives on New Crops and New Uses. 1999; p. 388-93.
84. Tongco JVV, Añis AD, Tamayo JP. Nutritional analysis, phytochemical screening, and total phenolic content of *Basella alba* leaves from the Philippines. Int J Pharmacog Phytochem. 2015; 7(4):1031-3.
85. Haq QN, Awal A, Chowdhury MK, Khan NA. Studies on water-soluble polysaccharides from the leaves of *Basella rubra* Linn. Sci Res Pakistan. 1969; 6:63-6.
86. Jiwajinda S, Santisopasri V, Murakami A, Kim OK, Kim HW, Ohigashi H. Suppressive effects of edible Thai plants on superoxide and nitric oxide generation. Asian Pac J Cancer Prev. 2002; 3(3):215-23.
87. Iwamoto M, Okabe H, Yamauchi T, Tanaka M, Rokutani Y, Hara S, Mihashi K, Higuchi R. Studies on the constituents of *Momordica cochinchinensis* Spreng. I. isolation and characterization of the seed saponins, *Momordica sapponins* I and II. Chem. Pharm Bull (Tokyo). 1985; 33(2):464-78. https://doi.org/10.1248/cpb.33.464
88. Sharma M, Tandon N. Quality standards of Indian medicinal plants; Indian C Med Res, New Delhi. Vol. VIII, 2010; 2:72-280.
89. Ullah H, Khan H. Epigenetic drug development for autoimmune and inflammatory diseases. In Histone Modifications in Therapy. Academic Press, 2020; pp. 395-413. https://doi.org/10.1016/B978-0-12-816422-8.00017-9 PMid:32829558
90. Preedy VR. Ageing: oxidative stress and dietary antioxidants. Academic Press. 2014. https://doi.org/10.1016/B978-0-08-102922-0.00007-9
91. Saleem M, Alam A, Arifin S, Shah MS, Ahmed B, Sultana S. Lupeol, a triterpene, inhibits early responses of tumor promotion induced by benzoyl peroxide in murine skin. Pharmacol. Res. 2001; 43(2):127-34. https://doi.org/10.1006/phrs.2000.0710 PMid:11243713
92. Hebbar SS, Harsha VH, Shripathi V, Hegde GR. Ethnomedicine of Dharwad district in Karnataka, India--plants used in oral health care. J Ethnopharmacol. 2004; 94(2-3):261-6. https://doi.org/10.1016/j.jep.2004.04.021 PMid:15325728
93. Murakami T, Matsuda H, Inadzuki M, Hirano K, Yoshikawa M. Medicinal foodstuffs. XVI. Sugar beet. (3), Absolute stereo structures of betavulgarosides II and IV, hypoglycemic saponins having a unique substituent, from the roots of *Beta vulgaris* L. Chem Pharm Bull. 1999; 47(12):1717-24. https://doi.org/10.1248/cpb.47.1717
94. Chakraborty SB. Evaluation of plant extracts on sex reversal and growth of Nile tilapia. Studies. 2013-2016; 4(1):358-63.
95. Haneefa MK, 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(1):1642.
96. Okabe H, Iwamoto M, Yamauchi T. Studies on the constituents of *Momordica cochinchinensis* Spreng. II. Isolation and characterization of the root saponins, momordins I, II and III. Chem Pharm Bull (Tokyo). 1985; 33(1):1-7. https://doi.org/10.1248/cpb.33.1
97. Salimi A, Pourahmad J. Role of natural compounds in prevention and treatment of chronic lymphocytic leukaemia. Polyphenols, prevention and treatment of human disease. 2018; 195-203. https://doi.org/10.1016/B978-0-12-813008-7.00016-3
98. Kaur N, Chaudhary J, Jain A, Kishore L. Stigmasterol, a comprehensive review. Int J Pharm Sci Res. 2011; 2(9):2259-65.
99. Hussain EA, Sadiq Z, Zia-Ul-Haq M. Sources of Betalains. In Betalains, Biomolecular Aspects; Springer, Cham. 2018; 15-23. https://doi.org/10.1007/978-3-319-95624-4_2
100. Kumar S, Prasad AK, Iyer SV, Vaidya SK. Systematic pharmacognostical, phytochemical and pharmacological review on an ethno medicinal plant, *Basella alba* L. J Pharmacog Phytother. 2013; 5(4):53-8.
101. Sharma V, Joseph C, Ghosh S, Agarwal A, Mishra MK, Sen E. Kaempferol induces apoptosis in glioblastoma cells through oxidative stress. Mol Cancer Ther. 2007; 6(9):2544-53. https://doi.org/10.1158/1535-7163.MCT-06-0788PMid:17876051
102. Saleem M. Lupeol, a novel anti-inflammatory and anti-cancer dietary triterpene. Cancer Lett. 2009; 285(2):109-15. https://doi.org/10.1016/j.canlet.2009.04.033 PMid:19464787 PMCid:PMC2764818
103. Ganeshpurkar A, Saluja AK. The pharmacological potential of rutin. Saudi Pharm J, 2017; 25(2):149-64. https://doi.org/10.1016/j.jsps.2016.04.025 PMid:28344465 PMCid:PMC5355559
104. Toshiyuki M, Kazuhiro H, Masayuki Y. Structures of new oleanane-type triterpene oligoglycosides, basella saponins A, B, C, and D, from the fresh aerial parts of *Basella rubra* L. Chem Pharm Bull (Tokyo). 2001; 49(6):776-9. https://doi.org/10.1248/cpb.49.776 PMid:11411538
105. Calabrese V, Mancuso C, De Marco C, Stella AM, Butterfield DA. Nitric oxide and cellular stress response in brain ageing and neurodegenerative disorders. Oxidative stress and neurodegenerative disorders. 2007; 115-34. https://doi.org/10.1016/B978- 044452809-4/50145-9
106. Srinivasulu C, Ramgopal M, Ramanjaneyulu G, Anuradha CM, Kumar CS. Syringic Acid (SA)–a review of its occurrence, biosynthesis, pharmacological and industrial importance. Biomed Pharmacother. 2018; 108:547-57. https://doi.org/10.1016/j.biopha.2018.09.069 PMid:30243088
107. Uhegbu FO, Elekwa I, Iweala EE, Kanu, I. Cyanide, nitrate and nitrite content of some leafy vegetables and fruits commonly consumed in the south-east of Nigeria. Pak. J. Nutr.2011; 10(12):1190-4. https://doi.org/10.3923/pjn.2011.1190.1194
108. Habtemariam S. Medicinal foods as potential therapies for Type-2 diabetes and associated diseases: the chemical

and pharmacological basis of their action. Academic Press. 2019. https://doi.org/10.1016/B978-0-08-102922-0.00007-9
109. Maran JP, Priya B. Natural pigments extraction from *Basella rubra* L. fruits by ultrasound- assisted extraction combined with Box-Behnken response surface design. Separation Sci Tech. 2015; 50(10):1532-40. https://doi.org/10.1080/01496395.2014.980003
110. Murakami T, Hirano K, Yoshikawa M. Medicinal Foodstuffs. XXIII. Structures of new oleanane-type triterpene oligoglycosides, basellasaponins A, B, C, and D, from the fresh aerial parts of *Basella rubra* L. Chem Pharm Bull. 2001; 49(6):776-9. https://doi.org/10.1248/cpb.49.776 PMid:11411538
111. Abubacker MN, Ganapathy G, Sebastin LM, Mondal KS. Histochemical and shoot induction studies of *Basella rubra* L. (Basellaceae). Biosci Biotechnol Res Asia. 2019; 16(1):187-94.
112. Shantha TR, Patchaimal P, Reddy MP, Kumar RK, Tewari D, Bharti V, Venkateshwarlu G, Mangal AK, Padhi MM, Dhiman KS. Pharmacognostical standardization of Upodika- *Basella alba* L., An Important Ayurvedic Antidiabetic Plant. Anc Sci Life. 2016; 36(1):35-41. https://doi.org/10.4103/0257-7941.195411 PMid:28182032 PMCid:PMC5255969
113. Kumar V, Bhat ZA, Kumar D, Khan NA, Chashoo IA, Ara I. Khan, Ara, I. Gastroprotective effect of leaf extracts of *Basella alba* var. *alba* against experimental gastric ulcers in rats. Rev Bras Farmacogn. 2012; 22(3):657-62. https://doi.org/10.1590/S0102-695X 2012005000032
114. Rao CV, Jaiswal SK. Evaluation of standardized fractions of *Basella alba* leaves as gastroprotective activity on ulcerated rats. Orient Pharm Exp Med. 2016; 16(4):339-47. https://doi.org/10.1007/s13596-016-0244-8
115. Barbieri L, Battelli MG, Stirpe F. Ribosome-inactivating proteins from plants. Biochim Biophys Acta. 1993; 1154(3-4):237-82. https://doi.org/10.1016/0304- 4157(93)90002-6
116. Bolognesi A, Polito L, Olivieri F, Valbonesi P, Barbieri L, Battelli MG, Carusi MV, Benvenuto E, Blanco FD, Di Maro A, Parente A. New ribosome-inactivating proteins with polynucleotide, adenosine glycosidase and antiviral activities from *Basella rubra* L. and *Bougainvillea spectabilis* Willd. Planta. 1997; 203(4):422-9. https://doi.org/10.1007/s004250050209 PMid:9421927
117. Liu H, Han JF, Zhang YF, Meng F, Wang F, Guo C. The inhibitory effects of extracts from *B. rubra* L. on Tobacco Mosaic Virus. Acta Agr Scand A-AN. 2006; 21:184-7.
118. Dong CX, Hayashi K, Mizukoshi Y, Lee JB, Hayashi T. Structures of acidic polysaccharides from *Basella rubra* L. and their antiviral effects. Carbohydr Polym 2011;84(3):1084-92. https://doi.org/10.1016/j.carbpol.2010.12.073
119. Ramu G, Mohan GK, Jayaveera KN. Preliminary investigation of patchaippasali mucilage (*Basella alba*) as tablet binder. Int J Green Pharm. 2011; 5(1):25-7. https://doi.org/10.4103/0973-8258.82091
120. Huang FL, Chiou RYY, Chen WC, Ko HJ, Lai LJ, Lin SM. Dehydrated *Basella alba* fruit juice as a novel natural colourant, pigment stability, *in vivo* food safety evaluation and anti-inflammatory mechanism characterization. Plant Foods Hum Nutr. 2016; 71(3):322-9. https://doi.org/10.1007/s11130-016-0563-4 PMid:27405766
121. Rodda R, Kota A, Sindhuri T, Kumar SA, Gnananath K. Investigation on anti- inflammatory property of *Basella alba* Linn leaf extract. Int J Pharm Pharmaceutic Sci. 2012; 4:452-4.
122. Kumar D, Kumar V, Bhat ZA, 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(2):176-9.
123. Nantia EA, Travert C, Manfo FP, Carreau S, Monsees TK, Fewou Moundipa P. Effects of the methanol extract of *Basella alba* L (Basellaceae) on steroid production in Leydig cells. Int J Mol Sci. 2011; 12(1):376-84. https://doi.org/10.3390/ijms12010376 PMid:21339992 PMCid:PMC3039958
124. Moundipa PF, Ngouela S, Kamtchouing P, Tsamo E, Tchouanguep FM, Carreau S. Effects of extracts from *Hibiscus macranthus* and *Basella alba* mixture on testosterone production *in vitro* in adult rat testes slices. Asian J Androl. 2006; 8(1):111-4. https://doi.org/10.1111/j.1745-7262.2006.00057.x PMid:16372129
125. Nantia EA, Manfo PF, Beboy NE, Travert C, Carreau S, Monsees TK, Moundipa PF. Effect of methanol extract of *Basella alba* L. (Basellaceae) on the fecundity and testosterone level in male rats exposed to flutamide *in utero*. Andrologia. 2012; 44(1):38- 45. https://doi.org/10.1111/j.1439-0272.2010.01104.x PMid:21592171
126. Sushila R, Deepti A, Permender R, Madhavi T, Dharmender R, Rathee D. Cytotoxic and antibacterial activity of *Basella alba* whole plant: A relatively unexplored plant. Pharmacologyonline. 2010; 3:651-8.
127. 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. Int J Pharm. 2011; 3:502-6. https://doi.org/10.4314/ijhr.v3i3.70303
128. Nirmala A, Saroja S, Devi GG. Antidiabetic activity of *Basella rubra* and its relationship with the antioxidant property. Biotechnol Res Int. 2011; 28(9):1-9. https://doi.org/10.9734/BBJ/2011/223
129. Reshmi SK, Aravindhan KM, Devi PS. The effect of light, temperature, pH on stability of betacyanin pigments in *Basella alba* fruit. Asian J Pharm Clin Res. 2012; 5(4):107-10.
130. Saravanakumar M, Aravindhan KM. The effect of light, temperature, pH on stability of anthocyanin pigments in *Musa acuminata* bract. Curr Plant Biol. 2011; 1(5).
131. Karunakar N, Pillai KK, Hussain SZ, Rao M, Balani DK, Imran M. Further studies on the antihepatotoxic activity of Jigrine. Indian J Pharmacol. 1997; 29(4):222.
132. Pellow S, File SE. Anxiolytic and anxiogenic drug effects on exploratory activity in an elevated plus-maze,

a novel test of anxiety in the rat. Pharmacol Biochem Behav. 1986; 24(3):525-9. https://doi.org/10.1016/0091-3057(86)90552-6 PMid:2871560

133. Kulkarni SK. New drug Discovery process. In Handbook of experimental pharmacology, 3rd ed; Vallabh Prakashan, Delhi. 2011; pp.19-84.
134. Leela A, Vivekanandan M. Tapping the unexploited plant resources for the synthesis of silver nanoparticles. Afr J Biotechnol. 2008; 7(17):3162- 5.
135. Soman I, Mengi SA, Kasture S. Effect of leaves of *Butea frondosa* on stress, anxiety, and cognition in rats. Pharmacol Biochem Behav. 2004; 79(1):11-6. https://doi.org/10.1016/j.pbb.2004.05.022 PMid:15388278
136. Zanoli P, Avallone R, Baraldi M. Behavioral characterisation of the flavonoids apigenin and chrysin. Fitoterapia. 2000; 71(Suppl. 1):S117-23. https://doi.org/10.1016/S0367-326X(00)00186-6 PMid:10930722
137. Herrera-Ruiz M, García-Beltrán Y, Mora S, Díaz-Véliz G, Viana GS, Tortoriello J, Ramírez G. Antidepressant, and anxiolytic effects of hydroalcoholic extract from *Salvia elegans*. J Ethnopharmacol. 2006; 107(1):53-8. https://doi.org/10.1016/j.jep.2006.02.003 PMid:16530995
138. Crawley J, Goodwin FK. Preliminary report of a simple animal behavior model for the anxiolytic effects of benzodiazepines. Pharmacol Biochem Behav. 1980; 13(2):167- 70.https://doi.org/10.1016/0091-3057(80)90067-2 PMid:6106204
139. File SE. Usefulness of animal models with newer anxiolytics. Clin Neuropharmacol. 1992; 15(Suppl. 1 Pt A):525A-6A. https://doi.org/10.1097/00002826-199201001-00273 PMid:1354059
140. Sonavane GS, Sarveiya VP, Kasture VS, Kasture SB. The anxiogenic activity of *Myristica fragrans* seeds. Pharmacol Biochem Behav. 2002; 71(1-2):239-44. https://doi.org/10.1016/S0091-3057(01)00660-8 PMid:11812528
141. Pumchaosuan T, Wongroung S. *In vitro* propagation of Ceylon spinach *Basella rubra* L. As J Food Ag-Ind. 2009; p. 31-6.
142. Selvakumaran M, Pisarcik DA, Bao R, Yeung AT, Hamilton TC. Enhanced cisplatin cytotoxicity by disturbing the nucleotide excision repair pathway in ovarian cancer cell lines. Cancer Res. 2003; 63(6):1311-6.
143. 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. Journal of food science and technology. 2015; 52:4994-5002. https://doi.org/10.1007/s13197- 014-1527-z PMid:26243919 PMCid:PMC4519477
144. Alqasoumi S. Protective effect of *Basella alba* L. on nephrotoxicity induced by gentamycin in rats. Clin Exp Med. 2011; 5(4):225-33. https://doi.org/10.1556/CEMED.5.2011.4.6