CHAPTER - 1

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1.1 Natural Products Spectrum

Plants, microorganisms, vertebrates and invertebrates are fine biochemical factories for the biosynthesis of both primary and secondary metabolites. Their ingenuity in creating diverse structures with generous sprinkling of functionalities and delicacies is thrilling. This is the outcome of evolution through millions of years during which they have been withstanding many tough tests of survival (Valiathan, 1998).

During last three decades exploration of marine bioresources revealed even more enchanting skeletons with marked contrast from terrestrial natural products, e.g. ultrabitter centapicrin (1) (ca. 4,000,000) from centaury plant, supersweet glycyrrhizinic acid (2) (ca. 100) from licorice root, triflavonoid (3), cytotoxic dimeric alkaloid dramacidin (4) from carribian sponge, steroidal alkaloid cephalostatin I (5), a powerful cell growth inhibitor from marine Cephalodiscus gilchristi, and the extremely toxic palytoxin (LD₅₀ 0.025 µg/kg for rabbit) with 64 chiral centres, the most complex non-polymeric compound (Fischer et al., 1991; Thomson, 1993; Carte, 1996; Cseke et al., 1999; Issa et al., 2003; Blunt et al., 2003).

Natural products in the form of traditional medicines (TM), pharmaceuticals, agrochemicals, neutraceuticals, botanicals, value added
products, lead compound etc. continue to be harnessed for the benefit of mankind (Colegate and Molyneux, 1993).

1.1.1 Traditional Medicine

The importance of traditional systems of medicine, viz., Indian, Chinese, Greek, Arabic etc. are recognized in the world over (Satyavati, 1982). Traditional medicines derive their scientific heritage from rich experiences of ancient civilization and therefore it is not surprising that traditional medicines claim comes for several ‘difficult to cure’ diseases like arthritis, asthma, epilepsy, hepatitis, diabetes and even cancer or AIDS (Doreswamy et al., 1995, Pal et al., 2002).

Indian system of medicines (ISM) such as Ayurveda, Siddha, Unani and Amchi are codified and organised in written treatises. Turmeric, the ayurvedic medicine for inflammatory disorders including arthritis, being used in western world as essential oil-depleted three major curcuminoids (41%) based product (Janet et al., 2006).

In traditional Chinese medicine, the first mention of use of Quinh Hao (Artemisia annua), known as ‘Sweet Annie’ or ‘Sweet Wormwood’ in Europe, is in the prescriptions for 52 kinds of diseases dated 168 BC. The sesquiterpene lactone, artemisinin (6), or qinghaosu, having potential activity against the primaquine-resistant strains of Plasmodium falciparum was isolated (Klayman, 1994; Yan et al., 1999; Thakur et al., 1990).
Ginseng (from roots of Panax ginseng) has been used as a drug in oriental countries for more than 5000 years. Traditional Chinese medicine recommends it for increasing mental efficiency, recovering physical balance and stimulating metabolic functions in man. Many of its constituents are saponins of demmarane triterpenoids such as *protopanaxadiol* (7) (Tanaka, 1984).

Among the medicinal plants, herbs are single largest group. Herbal medicine is still the mainstay of about 75-80% of the world population mainly in developing countries for primary health care (Bisset, 1994; Kamboj, 2000). According to World Health Organisation (WHO) the use of herbal remedies throughout the world exceeds that of the conventional ‘mainstay’ drugs by 2 to 3 times (Evans, 1994).

Folklores describe preventive as well as curative folk medicines, protective folk foods, poisons, beverages, hellucinates, plant protectants etc. (Pal *et. al.*, 1998; Bandyopadhyay *et. al.*, 2002).

All classical pharmacopoeia put together describe about 1700 plant species while folklores describe about 8000 plant species (Pushpangadan, 2004).
Search for bioactive components in these traditional, indigenous and ethnic resources and their clinical trials have become imminent for broadening the health cares facilities (WHO, 1990; Walter, 2003).

Currently multinational companies compete with each other or collaborate for research and development of traditional resources. Phytochemistry has become a multi-billion dollar industry (Williams, 2000).

1.1.2. Pharmaceuticals

For sometime, the exploitation of bioresources for pharmaceuticals was at a low key due to very low abundance of bioactive molecules together with the very time consuming process of their extraction and screening. Now, the high throughput purification and dereplication (HTS approach) of extracts has once again put the natural products base on the highway.

About 45% of the best-selling drugs worldwide are natural products or their derivatives (Schummer et. al, 2004).

Ethnobotanical information discusses about 800 plants having antidiabetic potential. Active principles in this category are alkaloids, glycosides, galactomannan gum, polysaccharides, peptido-glycans, guanidins, steroids, glucoproteins, terpenoids, amino acids etc. The ICMR patented anti-diabetic drug ‘Vijayaar’ obtained from the heartwood of Petrocarpus marsupium contain epicatechin, marsupin, petropsin and other hypoglycemic phenolics (Devi, 2005). The discovery of widely used hypoglycemic drug metformin (8) was from the traditional source Galega officinalis (Alarcon-Aquilaria et. al., 1998).
Antivenom properties are reported in many plants (Ghosh and Biswas, 1997; Chopra et. al., 1995; Alam et. al., 1996). Recent studies show that β-sitosterol, stigmasterol and 2-hydroxy-4-methoxy benzoic acid are some of the natural products isolated from Pluchea indica Less, Hemidesmus indicus R. Br., Strychnos nux vomica Linn etc. which effectively neutralised venom-induced pathophysiological changes (Chatterjee et. al., 2004; Gomes et. al., 2007).

Epidemiological studies have shown that population having high soy intake have lower incidence of breast, prostate and other carcinomas. Genistein (9), present in high quantity in soyabean products decrease incidence, increase latency and inhibits proliferation of some cancer (Barnes and Sartorelli, 1995).

The vinca alkaloids vinblastine (10) and vincristine derived from periwinkle (Catharanthus roseus) have been used for many years in treating lymphomas and acute childhood leukemia respectively (Salmon, 1989).

The taxoids, paclitaxel (11) commonly known as Taxol isolated from the bark of pacific yew (Taxus brevifolia) as well as needles and stems of other Taxus sp. and docetaxel (12) derived from baccatin found in the needles of English yew (Taxus baccata L) are novel anticancer agents produced from plants (Pazdur and Kudelka, 1993).

The bark of Chinese evergreen, Cephalotaxus harringtonia, contains the most active anti-leukemic drug homoharringtonine (HHT, 13) (Zhou et. al., 1995).

Rein anthraquinone (14) is antineoplastic anticancer drug found in rhubarb (Rheum sp.) and other purgative (Iosi et. al., 1993).
Opportunities for research abound in application of phytochemicals to cancer and AIDS epidemic of our current times should be addressed carefully.
1.1.3. Nutraceuticals

In plant-based food, the presence of potentially protective as well as antinutritional factors or toxicants led to the concept of ‘Nutraceutical’ dietary supplements.

Antioxidants such as ascorbic acid (15), tocopherols (16), carotenes, flavonoids, chlorogenic acid (17), curcumin (18) etc. belonging to diverse structural types in low concentrations significantly inhibits or delays oxidation or block carcinogenesis (Walton and Brown, 1999) and affect holistically in diabetes (Tiwari et. al., 2002).

Empirical use of flavonoids as antiinflammatory, antithrombotic, antiaggregatory factors has acquired scientific confirmation (Harborne, 1975; Robak et. al., 1996; Pietta, 2000; Rychlinska et. al., 2003; Mazaruk et. al., 2003; Kreft et. al., 1999; Kim et. al., 2005; Sharma et. al., 2004; Kalinova et. al., 2006).

High value of antioxidant potential was found in intensely coloured vegetables (red cabbage, red onion etc.) while in watery vegetables (potato, cucumber etc.) the values were very low (Pavel et. al., 2006).

Astraxanthin, a red carotenoid pigment, is powerful antioxidant occurring in wide variety of living organism. The richest source being a green micro-algae Haematococcus pluvialis, is neuroprotective and antihypertensive (Ghazi et. al., 2006).

Glucosinolates (19) in Brassica sp. and cysteine sulphoxides in Allium sp. on hydrolysis produce isothiocyanates and diallyl disulphide (20) which prevents carcinogenesis (Wang et. al., 1997).
Phytoestrogens, like genistein (9), an isoflavone found in soyabean seed, to some extent mimic the activity of oestrogens. Epidemiological studies revealed that they offer protection against hormone-dependent cancer in man particularly the breast and prostate cancer (Herman et al., 1995).

Interest in carotenoids as natural food colourants increased after the decline of azo-dye based food pigments. About 600 carotenoids occur naturally and the largest structural variety is encountered in marine carotenoids. Gyroxanthin (21) having acetylenic and allenic groups, has been isolated (Liaaen-Jensen, 1991).

Raffinose oligosaccharides having high nutrition value and low intrinsic toxicity have low acceptability in food due to their flatulence inducing property (Lumen, 1992). Saponins in legumes and allium vegetables influence bioavailability of other food components (Gee et al., 1996).

Natural product search in food also culminated in detection of toxins such as the glycoalkaloid α-solaline (22) in sprouting tubers and furanocoumarin psolaren (23) in Apiaceae and Rutaceae sp. which are generally not removed during cooking (Maga, 1994; Parr et al., 1996).

1.1.4. Agrochemicals

The importance of natural products as biopesticides is rapidly gaining ground. Pesticides of diverse structures from about 2000 species belonging to about 60 families are well characterised (Sukh Dev and Koul, 1997).

Pyrethrins (24) from flowers of Chrysanthemum cineraraefolium, rotenone (25) from root of Derris elliptica (Benth), nicotine from the leaves of Nicotiana tobacum, sesquiterpene with β-dihydroagarofuran skeleton from
(21)

(22) $R = \text{Rha-Gla-Glu}$

(23)

(24)

(25)
root bark of *Celastrus angulatus*, **recaglamide** derivatives from *Aglaia oligophylla*, a plant found in rainforests of Indo-Malaysian region, are powerful natural insecticides.

**Azadirachtin** (26) rich neem (*Azadirachta indica*) formulation with adjuvant has high insecticidal, antifeedant and juv enomimetic properties (Gupta *et al.* and Raghuraman, 2004). Insect antifeedant property of indigenous plant products have been identified (Verma *et al.*, 1987).

![Chemical structures](image)

Pure acetogenins like **squamocin**, **squamocin-D**; alkaloids (+) **O-methyl armepavine** and (-) **Xylopine** from seeds and leaves respectively of *Annona squamosa* showed insecticidal and antifeedant property on tobacco caterpillar (Soni *et al.*, 2004).

**Artemisinin** and **arteether** from *Artemisia annua* are natural products with herbicidal properties (Thakur *et al.*, 1990).

Bioactivity guided fractionation of an extract of the fruit of *Terminalia bellerica* yielded two fungicidal compounds **termilignan** and **thannilignan**.

Microorganisms are most prolific sources of potential fungicides through microbial fermentation. *Streptomyces* sp. produces many metabolites for management of rice diseases. **Natamycin** (27), a fermentation product of
A mixture of *Streptomyces natalensis* and *Streptomyces chattanoogensis* is used in horticulture to control *Fusarium oxysporum*. *Aflastatin* is fungistatic to *Aspergillus* fungi, pathogen of most grain crops and some fruits particularly in Africa and Asia (Omura *et al.*, 1990; Crosby, 1998).

**Strychnine** (28) obtained from leaves, bark, wood and root of *Strychnos nux vomica* is rodenticide. A natural product nematicide named *equol*, a metabolite of isoflavone diadzein, was isolated from *Glycine max* (Sukh Dev and Koul, 1997).

### 1.1.5. Botanicals

In cosmetology, though many a plant products were replaced by synthetic compounds, there is again a revival of preference for the natural products because their safety and efficacy could not find suitable match. These take care of skin, check ageing, protect early fall and delay in graying of hair, wrinkling, cracking or discolouration of skin (Sharma *et al.*, 1982).

There are at least 500 genera of plants having *saponins* or *sapogenins*. Ritha or soap nut (*Sapindus saponaria* L), shikakai (*Acacia concinna* Wall) used in washing costly woolen or silk cloth as well as hair; mustard (*Brassica* sp.) seed powder or oil-cake contain protein and antibacterial sulphur component and hence used in hair wash. Brahmi-ama (Phyllanthus embellica L) fruit is rich in Vitamin C and the oil has fragrance, antifungal and antibacterial properties.

In henna (*Lawsonia albaa* L) leaves *lawsone* (2-hydroxy-1,4-naphthoquinone) (29) has been identified as the antibiotic and antifungal component. Similar substances are *juglone* (30), *vitamin K₃* (31) and plumbagin (32).
Anthraquinones, anthrones, anthranols* and their glucosides present in lotions made from aloe (*Aloe vera* L.) protect skin from radiation burn (X-ray dermatitis) (Sharma *et. al.*, 1982).

Anthraquinones and quinones in Himalayan rhubarb (*Rhehum emodi*) as prospective cosmetic colour have been characterised (Raj *et. al.*, 2005).

1.1.6. Value Added Products

Value addition to agricultural products is a new trend (Nakahora *et. al.*, 2002). Fine tuned products from natural sources by introduction of functionalities improve their suitability for diverse applications. Production of Biodiesel from oil is currently underway (Noureddini, 2005). **Galactomannans** (seed gums) have property of imbibing large quantity of water resulting in dispersions of high viscosity. New functional groups on hydroxyl group of galactomannan backbone by substitution and grafting reaction break the barrier of their monotonous properties (Sharma *et. al.*, 2003a,b).

**Chemotaxonomy** or **chemosystematics** considers constituents as **markers** for evolution and classification of plants (Nakanishi *et. al.*, 1974).

With the commercialisation of herbal medicines on a large scale, their rational use demands assessment of markers for which one or more constituents used as standards for quantification & through generation of standard finger printing patterns. This has become possible by HPTLC, HPLC, LC-MS, SEPBOX and other advanced analytical techniques (RRL, 1998; Prabhakar *et. al.*, 2004).

Euphorbia latexes, commonly known as “Snuhi” and widely used in Ayurveda and Siddha systems of medicine as purgative and other therapeutic
purposes, have been screened and the marker compound found to be the cycloartane tetracyclic triterpene, **nerifoliene (33)** (Sivarajan et. al., 1994; Mallavadhani et. al., 2004).

1.1.7. Lead Compounds

The natural world is rich in potential lead compounds. In folk medicine, there occurs wealth of information regarding noble structures with highly sought-after properties. Modern techniques can be used to quickly identify and isolate such compounds and it is cost-effective to make more use of chemotaxonomic surveys before starting a programme for synthesis of new useful compounds (Walton and Brown, 1999; Cordell et. al., 1998; Atta-Ur-Rahman et. al., 2004).

Plants, trees, snakes, lizards, frogs, fungi, corals and fish all yielded potent lead compounds which have either resulted in clinically useful drugs or have the potential to do so. Lead compounds like artemisinin are useful in their own right but, they have also been used as lead compounds in design of other useful compounds like **combretastatin (34)**. Antihypertensive **captopril (35)** was developed from **teprotide (36)** found in snake venom. **Asperlicin (37)** isolated from microorganism, *Aspergillus alliaceus* is a lead compound for developing novel anti-anxiety agents (Patrick, 2002).

In the area of cancer, study showed that over the period 1981-2002, semi-synthetic new chemical entities was 62%, while in the hypertensive field, 48 out of 74 formally synthetic drugs can be traced to natural product structures / mimics (NM) (Kamal et. al., 2002; Newman et. al., 2003).

The biological activities of monoterpenoids against insects, nematodes, phytopathogenic fungi and other pest species are considered to be related to the

(36)
nature and position of specific groups or substituents. Carvacrol has been recognised to be safe by Food and Drug Administration and documented for its good pest controlling potency. Derivatives of carvacrol, particularly esters have shown to possess better antibacterial potency. In view of severe problems with conventional chemical pesticides, natural products and their derivatives appear to be one of the effective pest management tactics in future (Duke, 1991; Coates et al., 1999; Nikumbh et al., 2003).

The armamentarium of commercial insecticides has greatly benefited from this strategy. Modification of pyrethrin structure has led to synthesis of altethnin and deltamethrin (38). Isobutylamides and avermectins are other examples (Sukh Dev and Koul, 1997).

Basing on the lead fungicide strobilurin A (39) (a β-methoxyacrylate) from Strobilurus tenacellus (basidiomycete) azoxystrobin (40), highly effective against pathogens from all four major fungal classes, has been developed (Hewitt, 1998), which sold at $400 MM in 2000 (Godwin et al., 2000).
1.1.8. Indian Scenario

India is one of the 12 global megabiodiversity centers harbouring about 5,00,000 out of some 10 to 30 million species of living organisms, 17,500 flowering plants, 461 tribal communities. The country accounts for 8% of global biodiversity existing in only 2.4% of the land area in the world. India has contributed at least 167 plants to global agriculture and is the home to two of the world’s 25 hotspots – Western Ghats and the Eastern Himalayas (Natesh, 2004). In India, there are more than 450 dye yielding plants, some of which are also endowed with medicinal properties (Siva, 2007).

The magical power of plants in combating dreaded diseases reached the height of myth in ancient India through the hands of Saints and ‘fakirs’. In medieval period during cultural exchange medical practitioners from Arab, Persia, Greece and China took away many medicinal plants and plant products from India although some such plants also came to India from these countries (Dey, 1999).

Earliest records of efficacies of plants in therapeutics are found in Rgveda (Rick Veda, 3500 BC). These found clinical application from the time of Atharva Veda (1500 BC) when plants were classified on the basis of medical applications (about 50 groups). Indian Medical System and medical treatises are Charak Samhitā and Sushruta Samhitā. The former gives description of about 700 medicinal plants including some of non-Indian origin. Out of about 2000 medicines described in Indian system of medicine (ISM), 200 are of animal origin, another about 200 are of mineral origin and the rest about 1500 are of plant origin. About 15,000 plants of medicinal value are anticipated to be available in India, owing to its climatic conditions and geographical location (Jain, 1995).
Practices in ISM suffered with the advent of allopathic medicine and efforts to scrutinize the bioresources were only sporadic. The first international attention was drawn by the observation that reserpine (41), an alkaloid of Sarpagandha (Rauwolfia serpentina) is antihypertensive. Here the initial clinical observation was made by Rustom Vakil but the drug became a reality thanks to the CIBA of Switzerland. A biomolecule reported by Asima Chatterji (in 1960’s) was developed in France. ‘Guglip’, effective in Type IIB and Type IV hyperlipidemias, was developed in nineties from gugul (Commiphora Wightii) gum (Valiathan, 1998; Chatterjee, 1995).

\[
\text{(41)}
\]

Search into the medicinal and economic values of the Indian bioresources which belatedly started in the post-independence period is now advancing at unprecedented rate (Anonymous, 1995; Hussain, 1992).

1.1.9. North-East Indian Perspectives

North-East India which lies within the Indo-Burmese mega-biodiversity ‘hot-spot’ comprising about 4000 endemic plants offers lot of scope for bioprospecting. This region accounts for 8% of India total area; 26% of this area is forest covered and it accounts for 50% of total flora of Indian sub-continent. This comprises 200 families of flowering plants out of 315 in the country. The matchless wealth of medicinal plants is due to its varied topography, altitude and
climate. Assam alone contributes about 3000 species of medicinal plants (Hooker, 1885; Kanjilal, 1939; Jain et. al., 2001; Baruah, 2001; Jain, 2002; Nath et. al., 2003).

In tune with natural biodiversity in the North-East, there are diverse tribes and ethnic groups who have accumulated rich knowledge in ethno-medical practices. In Arunachal Pradesh alone there are 26 major tribes and three major ethnic groups. Folklores of tea tribes and ethnic groups in river valleys who came from various parts of the country are quite rich in traditional knowledge of medicine, health-care and agricultural practices. There is a decreasing trend in application of this knowledge as well as tremendous stress on the bioresources due to deforestation (Nath et. al., 1988; Patwari, 1992; Mekkalath, 2000; CSIR, 2001; AUS, 2006).

1.2. **Cleome gynandra** L.

The Indian medicinal herb *Cleome gynandra* L. grows throughout the warmer parts of the globe. It is also an ethnomedicinal plant. In most parts of Africa it is also an edible wild leafy vegetable but, unlike most staples, it is underutilised or neglected. It grows as a weed in most tropical countries, but is a semi-cultivated popular tropical leafy vegetable in many parts of Sub-Saharan Africa, especially in most countries in eastern and southern Africa (Tanaka, 1976; Chweya and Manzava, 1997).

Synonyms of *Cleome gynandra* L. are:

- *Gynandropsis gynandra* (L) Briq
- *Gynandropsis gynandra* (Linn) Merr.
- *Cleome pentaphylla* L.
- *Gynandropsis pentaphylla* (L) DC
Some of the local names of *Cleome gynandra* L. are listed in Table 1.1.

**Table 1.1**

Common and Local names of *Cleome gynandra* L.

<table>
<thead>
<tr>
<th>Country</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>African spider flower</td>
</tr>
<tr>
<td>UK</td>
<td>African spider flower</td>
</tr>
<tr>
<td></td>
<td>Cat’s whiskers, bastard mustard</td>
</tr>
<tr>
<td>Netherlands</td>
<td>Kattesnor</td>
</tr>
<tr>
<td>Germany</td>
<td>Senfkapper</td>
</tr>
<tr>
<td>France</td>
<td><em>Cleome, Gynandro, Mouzambe a fleurs blanches</em></td>
</tr>
<tr>
<td>Australia</td>
<td>African spider flower</td>
</tr>
<tr>
<td>China</td>
<td>pe hua tsai</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Babowan</td>
</tr>
<tr>
<td>India</td>
<td>Kurhur, karaila, hurhur etc.</td>
</tr>
<tr>
<td>Malaysia</td>
<td>Maman etc.</td>
</tr>
<tr>
<td>Philippines</td>
<td>Cinco-cinco etc.</td>
</tr>
<tr>
<td>Thailand</td>
<td>Phak sian, Phak som stan</td>
</tr>
<tr>
<td>Egypt</td>
<td>Abu quam</td>
</tr>
<tr>
<td>Kenya</td>
<td>Chinsaga &amp; many other names</td>
</tr>
<tr>
<td>Mauritius</td>
<td>Spider flower, bastard mustard</td>
</tr>
<tr>
<td>South Africa</td>
<td>Tamaleika etc.</td>
</tr>
<tr>
<td>Tanzania</td>
<td>Ejjjoboyo etc.</td>
</tr>
<tr>
<td>Uganda</td>
<td>Gasaya</td>
</tr>
<tr>
<td>Zambia</td>
<td>Spider flower</td>
</tr>
</tbody>
</table>


In Indian literature *Cleome gynandra* is identified by the following vernacular names of *Cleome gynandra* L. are given in Table 1.2:
Table 1.2
Vernacular names of *Cleome gynandra* L.

<table>
<thead>
<tr>
<th>Sanskrit</th>
<th>Hindi</th>
<th>Bengali</th>
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</thead>
<tbody>
<tr>
<td>Surjavarta, arkapushpika</td>
<td>Hulhul, churota, gandhuli, hurhur</td>
<td>Sada hurhuria, ansarisha, arkahuli hulul, hurhur, hurhuria.</td>
</tr>
<tr>
<td>Hindi</td>
<td>Sada hurhuria, ansarisha, arkahuli hulul, hurhur, hurhuria.</td>
<td></td>
</tr>
<tr>
<td>Telegu</td>
<td>Vaminta, vainta, velakura</td>
<td>Kanphodi, motitiilavan, mabli tilavana, pandharitilavan</td>
</tr>
<tr>
<td>Tamil</td>
<td>Kanphodi, motitiilavan, mabli tilavana, pandharitilavan</td>
<td>Kattkadugu, velai, taiwela</td>
</tr>
<tr>
<td>Kannada</td>
<td>Narum byale soppu</td>
<td>Kattkadugu, velai, taiwela</td>
</tr>
<tr>
<td>Malayalam</td>
<td>Seta-kata-arak</td>
<td>Narum byale soppu</td>
</tr>
<tr>
<td>Santali</td>
<td>Seta-kata-arak</td>
<td>Narum byale soppu</td>
</tr>
<tr>
<td>Bihar</td>
<td>Seta-kata-arak, chamani, marang chamani</td>
<td>Karavela, taivela, nei-vaylla</td>
</tr>
<tr>
<td>Punjab</td>
<td>Kathal, parhar</td>
<td>Karavela, taivela, nei-vaylla</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>Bagra</td>
<td>Karavela, taivela, nei-vaylla</td>
</tr>
<tr>
<td>U.P.</td>
<td>Kathal parhar</td>
<td>Karavela, taivela, nei-vaylla</td>
</tr>
<tr>
<td>Assamese &amp; Bodo</td>
<td>Bhutmula</td>
<td>Karavela, taivela, nei-vaylla</td>
</tr>
</tbody>
</table>

(Anonymous, 1956; Chopra *et. al.*, 1984; Baruah *et. al.*, 1984; Bhuyan, 1989).

1.2.1. Botanical Description

*Cleome gynandra* L belongs to the botanical family Cleomaceae (formerly capparaceae). It is an erect, rather showy, strongly smelling, annual herb, which is branched and rather stout. It exhibits variable pigmentation, from green to pink or violet to purple. Depending on environmental conditions, it can grow up to 1.5m in height and usually 0.5 to 1.0m tall (Fig. 1.1).
Fig 1.1: Parts of *Cleome gynandra* L..
1 – Flowering and fruiting branch (x0.5); 2— Flower (x1.5); 3—Sepal (x 5);
4—Petal (x 3); 5—Gynoecium (x5); 6 — Fruit (x 0.9); 7 — Seed(x10)
It has a long tap **root**, with few secondary roots with root hair.

**Leaves** are alternate, digitately palmate, petiolate and long-stalked. Each leaf has 5-7 leaflets which are pinnately dissected and sessile. They vary from obovate to elliptic in shape and usually 2-10 cm long, 2-4 cm wide. They are sparsely hairy & finely toothed margined or rounded ends.

**Inflorescence** is quite showy, usually upto 30cm in length. It has terminated and axillary determinate racemes, bearing flowers with long pedicels which arise singly in the axils of small sessile and trifoliate-to-simple bracts. The bracts are much smaller than leaflets.

**Flowers** measure 1-2.5 cm in diameter and have 4 sepals, 4 narrow clawed petals and 6 stamens with long purple filaments, arising from a much elongated receptacle. The sepals are ovate to lanceolate, measuring upto 8mm in length and are glandular. The petals are white, pale, pink or lilac.

**Floral formula** is: \( K_4C_4A_6G \)

**Fruit** is dehiscent silique which is spindle shaped capsule upto 12cm long and 3-5mm wide. Dry seed dehisce easily to release seeds.

**Seeds** are 1-1.5mm dia suborbicular with many concentric ribs. They are rough greyish-to-black in colour (Kirtikar and Basu, 1935; Anonymous, 1956; Chopra et. al., 1956; Chatterjee, 1995; Basu, 1992; Dey, 1999).
Taxonomic position of *Cleome gynandra* L. is as follows (Singh, 1999).

<table>
<thead>
<tr>
<th>Taxonomic Level</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kingdom</td>
<td>Plantae</td>
</tr>
<tr>
<td>Division</td>
<td>Angiosperms</td>
</tr>
<tr>
<td>Class</td>
<td>Dicotyledones</td>
</tr>
<tr>
<td>Order</td>
<td>Capparidales (Capparales)</td>
</tr>
<tr>
<td>Family</td>
<td>Cleomaceae</td>
</tr>
<tr>
<td>Genus</td>
<td>Cleome</td>
</tr>
<tr>
<td>Species</td>
<td>Gynandra</td>
</tr>
</tbody>
</table>

1.2.2. Distribution

The species is thought to have originated in tropical Africa and have spread to other tropical and sub-tropical countries in Northern and Southern hemispheres (Kokwaro, 1976).

The natural habitat of *Cleome gynandra* L. is wasteland and arable land with annual species as well as grasslands. It grows well up to 2000m above msl in semi-arid, sub-humid and humid climates and is adapted to many soil types but grows luxuriantly around rubbish dumps and soils supplied with organic manure.

The species is native to the following regions:-

Egypt, Mauritania, Cameroon, Ghana, Guinea, Mali, Nigeria, Angola, Zaire, Ethiopia, Kenya, Sudan, Tanzania, Uganda, Madagaskar, Mauritius, Oman, Afghanistan, India, Borneo, Java, Malaysia, Philippines, Sri Lanka, Sumatra, Thailand, Fiji (Holm et al., 1976).
The species has been introduced to:

Caribbean islands, Bermuda, Cuba, Southern USA, midwestern & southwestern USA, Mexico, Venezuela, Peru, Brazil, Argentina, Chile, Italy, France, Central & Northern Europe, USSR, China, Japan, Korea, Australia, New Zealand and Pacific islands (Kuhn, 1988).

1.2.3. Cultivation

*Cleome gynandra* L. is not yet formally cultivated as a commercial crop except in Zambia where a national seed company is marketing its seed and vigorously promoting the crop. Elsewhere it is still regarded as wild, weedy and volunteer crop and is semi-domesticated in home gardens or on fertile land near homesteads in most African countries, where seeds are found to germinate within 4-5 days. Seedlings are thinned about 3 weeks later and the thinnings are used as a vegetable. Topping and removing inflorescenced as soon as they appear are practices that increase leaf production. After several successive leaf harvestings the plants are left to flower and produce capsules. The capsules ripen, dry up and shatter, releasing the seed for the next season. Growers also harvest the ripe fruits at the end of the rainy season to save seed for next crop.

1.2.4. Uses

Throughout Africa, the tender leaves or young shoots and often the flowers as well, are eaten boiled as a pot herb, tasty relish, stew or side dish. The leaves are rather bitter, and for this reason are cooked with other leafy vegetables such as cowpea (*Vigna* sp.), amaranth (*Amaranthus* sp.) and black nightshade (*Solanum nigrum* L.). To reduce the bitterness, milk is added to the boiled leaves, and the mixture preferably left overnight in a cooking pot. In other areas leaves are boiled briefly, the water discarded and they are then combined with
other ingredients in a stew. In Zambia pounded groundnuts are often added to
dishes to enhance flavour. Due to high fibre content the leaves are dried, balled
and stored for 6 months and reconstituted by soaking in water before cooking. In
several African countries, the vegetable is an important food in rural areas. In
India, it is eaten as a pot herb and a flavouring in sauces and in Thailand it is
consumed fermented in a product called ‘pak-sian dang’ (Imbamba, 1973; FAO,
1990).

**Indigenous knowledge** possessed by rural women in Kenya indicates
that *C. gynandra* has several nutritional uses (Opole *et. al.*, 1995). Leaves may
be crushed to make a concoction that is drunk to cure diseases such as scurvy. In
many cultures, boiled leaves are regarded as a medicinal meal. In other
communities, leaves are boiled and marinated in sour milk for 2-3 days and
eaten which is believed to improve eyesight, provide energy and reduce dizzy
spells in pregnant women.

It is believed that regular consumption of leaves by pregnant women
eases childbirth and help to regain normal health more quickly.

It is not a popular infant meal (upto 10 month age) but given to children
from toddler age upwards.

The plant is listed among cattle feeds in Indonesia. Bovines, camels,
equines and game animals graze the leaves as forage. It has been reported to be
poisonous to rams and poultry in Queensland. Seeds are reported to be sold as
bird food in Java (Anonymous, 1956).

**In indigenous medicine** in many countries *Cleome gynandra* finds use:

i) Sap from leaves used as **analgesic**, particularly in headache.
ii) Sap from pounded young leaves is squeezed into ears, nostrils and eyes to treat epileptic fits and earache.

iii) A decoction or infusion of boiled leaves and or roots is administered to facilitate childbirth; treat stomach-ache and constipation, conjunctivitis, severe threadworm infection, chest pain.

iv) The leaves have anti-inflamatory properties and used to treat arthritis.

v) Bruised leaves are rubefacient and vesicant and used to treat neuralgia, otalgia, rheumatism and localised pains. For this they are rubbed on the affected parts of the body or applied as poultice. (however, they are carefully removed before they caused blisters)

vi) Bruised leaves are applied to boils to prevent formation of pus

vii) Infusion from leaves is used to treat anaemia

viii) Sap from the leaves used to cure recurrent malaria.

ix) Leaves are rubbed onto the skin to relieve pneumonia.

x) An infusion of the leaves used as eyewash.

xi) Seeds are anthelmintic and rubefacient and are ingested for the expulsion of round worms or a concoction is applied externally on the stomach as a counter-irritant.

xii) Seeds are applied as a poultice to maggot infested sores.

xiii) Seeds are mixed with oil and applied to the scalp to treat head lice.
xiv) An infusion of seed is administered to reduce coughing.

xv) Seeds are used by veterinarians to treat stomach-ache in equines.

xvi) Seeds are piscicidal.

xvii) Leaves and the plant have anti-tick properties.

xviii) A decoction of roots is reported to possess mild febrifugal properties.

xix) Roots are anthelmintic.

(Anonymous, 1956; Chopra et. al., 1984; Elfers et. al., 1964; Bhattacharjee, 1997; Dey, 1999).

Ethnomedicinal survey of medicinal plants used by Boro tribals of Assam describes use of Cleome gynandra L. in headache, cough and control of round worm (Baruah, 1984). Similar use is reported among the tribes of Arunachal Pradesh (Bhuyan, 1989). Ethnomedicinal survey of Dharwad dist. of Karnataka revealed that Cleome gynandra along with 34 other plants are being used to treat different types of oral ailments like toothache, plaque, caries, pyorrhea and aphthae (Hebber et. al., 2004).

1.2.5. Biological and Chemical Investigations

The following biological studies were conducted using various parts of Cleome gynandra L:
Extracts of whole plant or plant parts showed various plant protectant properties:

Petroleum ether extract at 2% concentration was reported to cause 100% mortality to insect pests of the cruciferous painted bug, *Bagrada cruciferanum* (Verma *et al.*, 1981).

Petroleum ether extract of mature seeds at 1% concentration caused about 58% mortality of brinjal aphid (*Aphis gossypii* Glover) (Pandey *et al.*, 1983b).

At 1% concentration of petroleum ether extract of mature seeds caused about 59% of mortality of larvae of gram caterpillar (*Heliothis armigera*, Hubn.) (Pandey *et al.*, 1983a).

Petroleum ether extract of seeds of *Gynandropsis gynandra* at 0.5% concentration was found to be most toxic to fourth instar larvae of insect pest *Epilachna vigintioctopunctata* Fabr. (Chandel *et al.*, 1987).

*Gynandropsis gynandra* (L) Brig leaves exhibited repellent and acaricidal properties to *Rhipicephalus appendiculatus* and *Amblyomma veriegatum* ticks. In field investigations ticks were not found up to 2-5m from the plant (Malonza *et al.*, 1992).

Volatile oil of the plant permanently repels diamond back moth (*Plutella xylostella* L) larvae from treated cabbage leaves (Pipithsangchan, 1993).

Anticancer activity observed in alcoholic extract of the plant (Dhar *et al.*, 1968).

Alcoholic extract of *Gynandropsis gynandra* at a dose of 1g/kg OS exerted maximum anti-inflammatory activity in carrageenin induced
inflammation in experimental rats. It also reduced cotton pellet granuloma and inhibited phospholipase A2 activity in rats. A probable biochemical mode of action elucidated (Surendra Kumar et. al., 1987).

Alcoholic extract of *Gynandropsis gynandra* roots exhibited significant **antipyretic, analgesic** and **hypoglycaemic** activities in a dose-dependent manner justifying its use in folk medicine (Rao et. al., 1997).

Alcoholic extract of *Gynandropsis gynandra* roots exhibited **antibacterial** activity in a dose dependent manner to *S. aureus, E. coli, B. sublitis, B. pumilis, P. aeruginosa* (Rao et. al., 1998).

**Antibacterial activity** of aqueous residues of *Cleome gynandropsis* (along with 15 other species) showed that it is more effective against *A. viscolactis, A. hydrophilla, K. aerogenas, Bacillus cerues and Streptococcus pyrogens* (Samy et. al., 1999).

Methanol extract of the leaves and stems of *Gynandropsis gynandra* showed **in vitro anthelmintic** activity against *Fasciola gigantica, Taenia solium* and *Pheritima pasthuma*. Stem methanol extract was most active (Ajaiyeoba et. al., 2001).

Ethanolic extract of *Cleome gynandra* leaves at 150mg/kg body wt. for 30 days to experimental arthritis rats suppressed the lysosomal enzyme and protein bound carbohydrate. Triterpenes, tannins, anthraquinones, flavonoids, saponins, steroids etc. proposed to be responsible (Narendhirakannan et. al., 2006).
Phytochemical studies on *Cleome gynandra* L. has been as follows:

**Cleomin** of unidentified structure having formula $C_{17}H_{14}O_7$, m.p. 245-246°C (decomposition) is an unsaturated lactone obtained from the seeds (Misra et. al., 1937).

**Seed oil** of the Indian desert variety of *Gynandropsis pentaphylla* was extracted by light petrol and after removal of the unsaponifiable fraction analysed for the fatty acid by low temperature crystallisation (Sen Gupta and Chakraborty, 1957).

From the alcoholic extractive of defatted seed of *Gynandropsis pentaphylla*, hexacosanol(42), $\beta$-D-glucoside of $\beta$-sitosterol, free $\beta$-sitosterol(8) and kaempferol was isolated by repeated crystallisation (Gupta, 1968).

![Hexacosanol](image)

(42)

Taxonomically significant glucosinolate glucocapparine (43) isolated from the methanolic extract of the plant (Saleh, 1976).

![Glucocapparine](image)

(43)

**Methyl glucosinolate** was isolated from *Gynandropsis gynandra* (L) Briq species from Thailand by defatting with ether, autolysis in distilled water, extraction and GC/MS (Hasapis et. al., 1981).
A cembranoid diterpene isolated from Cleome viscosa, a close relative of C. gynandra (Jente et. al., 1990).

Glucosinolates (19) was further reported from Gynandropsis gynandra along with other plants (Sangzak, 2002).

From the leaves of Gynandropsis pentaphylla growing in Egypt, centauridin, kaempferol (44), kaempferol-3-0-diglucoside, quercitrin (45), myricitrin, α & β-amyrin (46), taraxasterol, β-sitosterol (47) and fatty acids were isolated (Ali et. al., 1987).

From the methanolic extract of the defatted seeds, 5,7-dihydroxy chromone, 5-hydroxy -3,7,4′-trimethoxy flavone and luteolin was isolated by column chromatography (Jain et. al., 1985; Rastogi et. al., 1993).

Rutin (48) was isolated from the fresh flowers of Cleome gynandra Linn. (Ragunathan et. al., 1997).

A novel dammarane triterpenoid, cleogynol (49), (20S, 24S) -epoxy-19, 25-dihydroxydammarane-3-one hemiketal was isolated from the petroleum ether (60-80°C) extract by column chromatography with increasingly polar solvents and using spectral and chemical methods (Das et. al., 1999).

The essential oil of Gynandropsis gynandra was analysed by GC-MS and twenty eight compound were identified of which carvacrol (50) was the major component (29.2%) followed by trans-phytol (24.0%), linalool (13.3%), trans-2-methyl cyclopentanol (7.2%), β-caryophyllene (51) (4.4%) and methyl isocyanate (2.1%). Many of these constituents showed strong repellency effect against R. appendiculatus already reported earlier for the essential oil (Lwande et. al., 1999).
Seeds of *Cleome gynandra* from Zambia have been analysed for crude protein and fatty acid content. The crude protein content varies from 17.9% to 31.4%. The lipid content varies from 25.1% to 29.6%. The protein contains 15 aminoacids where glutamic acid is highest followed by arginine, aspartic acid, lysine, tyrosine and histidine. In seed oil linoleic acid is highest (59%). Linoleic acid and oleic acid together account for 81% of total fatty acids. The lipids have high degree of unsaturation as shown by iodine number 123 and sapanification value 192 (Mnzava, 1990).

Nutritional value of leaves of *Cleome gynandra* was determined. It shows 127-484 mg Ascorbic acid, 213-434 mg Calcium, 86mg Magnesium, 410mg Potassium, 1-11mg Iron, 6.7-18.9mg β-carotene per 100g of the leaves. Nutritional quality varied with many factors including method of cooking (Gomez, 1981; Sreeramulu et. al., 1982, 1983; Akhtar, 1990; Mathooko et. al., 1994; Mathenge, 1995; Abe et. al., 1997).

1.2.6 Need Statement

Perusal of above cited literature shows that certain chemical and biological aspects of *Cleome gynandra* L. have been studied and there is much need of systematic investigation in respect of many fold utilities of this indigenous medicinal wild annual herb.

In most of the Indian studies on this medicinal plant, samples were from Southern India. Although the plant is abundant & being used in North-East India, no such study was conducted using sample from this region. Hence the present study was conducted in respect of chemical and biological properties of *Cleome gynandra* L. growing in Barak valley of Assam.
1.3. REFERENCES


Akhtar M.N., 1990: Phytochemical Screening of the Medicinal Plants of Faislabad (Pakistan), Univ. of Faislabad, Pakistan, 75.


Anonymous, 1995 : Current Research on Medicinal and Aromatic plants, vol. 4-17, Central Institute of Medicinal and Aromatic Plants (CSIR), Lucknow.


Bandyopadhyay, M., Bhattacharjee, S. and Chakraborty, K., 2002: Importance of Folk Medicine in Developing Countries, In: Proceedings of Workshop on Folkloristics in the Modern Context, Kolkata.


Baruah, P., 2001: Asomar apuroogia Goss-Gosani (Some Valuable & Rare Plants of Assam), Assam Academic Centre, Jorhat, Assam, 2.


Bisset, N.G. (Ed.) 1994: Herbal Drugs, CRC Press, Boca Raton,


Chopra, R.N. and Chopra, I.C., 1995: A review work on Indian Medicinal plants (including indigenous drugs and poisonous plants) Special Report Series No. 30, ICMR.


Cseke, L. J. et al., 1999: Natural Products from Plants, CRC Press, Boca Raton, 37, 84.

CSIR, 2001: National Seminar on Traditional Knowledge Base on Herbal Medicines and Plant Resources of N.E. India (Abstracts).


FAO, 1990: Utilization of Tropical Foods, Food and Nutrition, 47/7, Rome, Italy.


Jain, S.K. and Srivastava, S., 2001: Prospects of Herbal Drugs for Ethno Veterinary Practices (EVP) in North East India, National Seminar an Traditional Knowledge based on herbal medicines and plant resources of North East India – Protection, utilization and conservation (Abstract), National Institute of Science Communication (CSIR), New Delhi, 16.


Malonza, M.M., Dipeolu, O.O., Amoo, A.O. and Hassan, S.M., 1992 : Laboratory and field observations on anti-lick properties of the plant *Gynandropsis gynandra* (L) Briq., *Veterinary Parasitol.*, 42 (1-2), 123.


Mekkalath, T., 2000: Mizorama Thing Leh Hnim Damdawia Hman Theihte (Medicinal Plants of Mizoram), Homeopathic Medical Centre, Kolasib, Mizoram.


Narendhirakannan, R.T., et. al, 2006: Antiinflammatory and lysosomal stability action of *Cleome gynandra* L. studied in adjuvant induced arthritis rats, *Food and Toxicology*, 20 Dec., on line.

Natesh, S., 2004: Prospecting for useful products from biological sources, IUPAC Conference on Biodiversity and Natural Products, Chemistry and Medical Application, New Delhi, Jan 26-31. IL55.


Pushpangadan, P., 2004: Traditional Medicine and Medicinal Plants – Challenges and Opportunities for India in 21st Century, IUPAC Conference, **IL-2**


RRL (CSIR), 1998: Indian Herbal Pharmacopoeia, CSIR & Indian Drug Manufactures Association, Mumbai.


Schummer, D., Seibert, G., Stump-Neuhaus, H. and Toti, L., 2004: High Throughput purification and dereplication of Natural Extracts for industrial drug lead finding process, IUPAC Conference, New Delhi, **OP 21**.


Wang, W., et. al., 1997: Cancer Lett, 114, 121.

Williams, C., 2000: Medicine Land, Well being, 81.

