Review on biological activities in medicinal plants of acanthaceae family

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ABSTRACT
Acanthaceae is popularly known as acanthus family which belong to mint order – lamiales. They are distributed from tropics to a temperate region such as India, Malaysia, Brunei, Indonesia, Brazil, Central America and Africa. Most members of this family are therapeutically important since they are in the up to date usage by ethnic communities. Andrographis paniculata, Clinacanthus nutans, Graptophyllum pictum, Hemigraphis alternata, Justicia gendarussa and Strobilanthes Crispus are some of the medicinal plants of Acanthaceae family. These plants are recognized for their biopharmaceutical potential usage in traditional medicine. These plants have a plethora of phytochemical compounds such as flavonoids, phenolic compounds, glycosides, terpenoids, benzenoids, quinine, triterpenoids and naphthoquinone present in various parts of the plant that plays a vital role in drug industries. The pharmacological properties of these plants such as anti-bacterial, anti-diabetic, anti-cancer, anti-oxidant, anti-inflammatory, anti-arthritis, hepatoprotective, anti-viral and anti-hypertensive are in general practice as an alternative and complementary medicine in both ethnobotanical and pharmacological fields. This article encompasses not only the comprehensive survey based on the electronic resources, scientific journals but also the books that summarize the botanical, phytochemical properties of these plants and also accentuate their significant role in both ethnobotanical and pharmacological fields. It is felt that this article would provide more insight into the health benefits of some plants of the Acanthaceae family.

INTRODUCTION
Acanthaceae belong to mint order – Lamiales, it is a dicotyledonous flowering plant, containing about 220 genera and 4000 species They are distributed across the temperate, tropical region. Most members of this family are therapeutically important since they are in the up to date usage by ethnic communities. Species such as A. paniculata, C. nutans, G. pictum, H. alternata, J. gendarussa and S. Crispus has enormous phytochemical properties and they are widely used as an alternative and complementary medicine in both ethnobotanical and pharmacological fields to treat various types of disease. This sur-
vey article encompasses a comprehensive literature survey based on the sources of electronic resources, scientific journals and books that summarize the botanical, phytochemical properties of these species and also highlights their significant role in both ethnobotanical and pharmacological fields. The purpose of this review is to ensure that the researchers, who are interested can get a glance about the medicinal potency of these plants.

Botanical Description Of Species

Acanthaceae’s species (A. paniculata, C. nutans, G. pictum, H. alternata, J. gendarussa and S. Crispus) are distributed across the temperate, tropical region such as India, Malaysia, China, Indonesia, Brazil, Central America and Africa. Most of them are habitat to grow in moist tropical forest and they are of shrubs, herbs, epiphytes or twining vines (perennial or annual) and few of them are tree types. As they belong to the sundry family, stems shape vary from quadrangular to circular, cystoliths, leaves are oppositely arranged, exstipulate and flowers are bisexual, usually arranged to terminal or axillary spikes, and racemes or panicles. Sepals and petals can be subactinomorphic to zygomorphi, 4 - 5 each form a tubular structure by often fusing. The ovary is superior, 2-locule, and placentation axile. Fruits are explosive dehiscent capsule, and usually loculicidal and racemes or panicles. Sepals and petals can be subactinomorphic to zygomorphi, 4 - 5 each form a tubular structure by often fusing. The ovary is superior, 2-locule, and placentation axile. Fruits are explosive dehiscent capsule, and usually loculicidal with compressed seeds. Tables 1 and 2 summarize the morphology, distribution and habitat, and vernacular name of the Acanthaceae species such as A. paniculata, C. nutans, G. pictum, H. alternata, J. gendarussa and S. Crispus.

Phytochemical Properties

The member of the Acanthaceae’s family (A. paniculata, C. nutans, G. pictum, H. alternata, J. gendarussa and S. crispus) has abundance of medicinal properties that cures many of the ailments such as diabetes, dysentery, edema, emesis, fever, headache, eye problem, piles and also used to treat varicella-zoster virus (VZV) lesions and herpes simplex virus (HSV) (Kamarudina et al., 2017).

Treating of various ailment is possible, due to the presence of significant phytochemical constituents such as steroids, alkaloids, catechins, flavonoids, saponins, phytoestrogen, quinone, phenolic compound, glycosides, carbohydrates, proteins and amino acid, anthraquinones, coumarins, carotenoids, ascorbic acid, terpenoids in these species. These constituents are generally extracted by several techniques for instance preliminary phytochemical analysis using various solvents (ethanol, methanol, chloroform, ethyl acetate etc.) and GC-MS techniques. 14-deoxy-11,12-dehydroandrographolide, 14-deoxyandrographolide, andrographin, lupeol, propanoic acid, neoandrographolide, botulin from A. paniculata; vitexin, schaftoside, isoorientin, isovitexin, 6, 8-apigenin-C-α-L-pyranarabinoside, orientin from C. nutans; anthraquinones, steroids, tannins, sugars and coumarins from G. pictum; n-nonacosane and hexahydrofarnesyl acetone from H. alternata; lupeol, O methyl ethers, β-sitosterol, and friedelin from J. gendarussa; verbascoside from S. crispus are extracted from various parts of these plants using the techniques such as high performance thin-layer chromatography (HPTLC) or by thin-layer chromatography TLC (CHCL3 /CH3OH (9:1)) fraction of whole plant. Tables 3 and 4 encapsulate some of the phytochemical constituents of the A. paniculata, C. nutans, G. pictum, H. alternata, J. gendarussa and S. crispus and Figure 1 depicts the phytochemical constituent’s structures of these species.

Ethnobotanical Properties

The indigenous traditional medicinal plants and plant-derived medicinal drugs are the powerful source of alternative medicine and are chiefly used to treat various ailments. These traditional medicines are prepared from the various plant parts of acanthaceae species such as A. paniculata, C. nutans, G. pictum, H. alternata, J. gendarussa and S. crispus. Some of the tribe’s, folklore’s, locals and herbalists from countries like India, Malaysia, Indonesia, Brunei, Singapore, Bangladesh, Africa, China, Sri Lanka practice to use these plant’s extracts either in the form of decoction, infusion, herbal tea, or in the form of herbal shower or topical administrations to treat numerous kinds of diseases. Tables 5 and 6 sketches the ethnic uses of these medicinal plants as a remedy for several ailments.

Pharmacological Properties

Members of this family have more traditional medicinal values that have been utilized by the ethnic groups, but for commercial utilization, scientific authenticity and favored evidence are more essential. Thus, some of the available reports about the pharmacological budding of these plant extracts have been discussed in the following subsections. Tables 7, 8 and 9 and Tables 10, 11 and 12 demonstrate the overview of the pharmacological properties of these family members. Members of this family have numerous medicinal values such as anti-oxidant, anti-microbial, anti-cancer, anti-diabetics, anti-viral, anti-inflammatory, wound healing properties, hypoglycemic effects, immunomodulatory effect, hepato-protective effect, contraceptive effect, cardiovascular effect, neuroprotective, α-glucosidase inhibition...
| Genus      | Morphology                                                                                                                                                                                                 | Distribution and Habitat                                                                 | Vernacular Name                                                                                                                                 |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| A. paniculata | Type-Annual herbs  
Height- 70cm.  
Stem-quadrangular and swollen node with Branches.  
Foliage- Leaves are simple, oppositely arranged, glabrous, green to pale green with ovate-lanceolate, pinnate venation.  
Flowers- small white with purple or pink tint.  
Fruits- oblong, hairy capsule.  
Seeds- plethora of pale brown.  
Propagation- sexual (seed) or asexual (stem cutting). | Native to India and Sri Lanka.  
Widely cultivate in Southeastern Asia. Found mainly in plains, hillsides, coastlines and cultivated in areas such as farms, wastelands and roadsides. | Daun pahit (Brunei),  
Hempedu bumi (Malaysia)  
King of Bitter (English)  
Quasabhuva (Arabic),  
Kiriyath (India),  
Kirayat (Hindi),  
Chuan Xin lian (Chinese),  
Sambiloto (Indonesia),  
Nilavembu (Tamil),  
Kalmegha (Sanskrit) |
| C. nutans   | Type- Terrestrial erect shrub or herb.  
Height- 3m.  
Stem- small, soft, thin and slightly curved stem that resembles the curve of an elephant’s trunk.  
Foliage- Leaves are paired opposite arrangement, narrowly elliptic-oblong in shape and pale green in color.  
Flowers- Red panicle shaped with tubed petal.  
Fruits- hairy capsule.  
Seeds- 4 seeded.  
Propagation: asexual (stem cutting). | Native to tropical Asia.  
Plants of this family can be grown in dense or open forest, bushes, damp field. Ariful. | Lindau, Balalai gajah (Brunei and Malaysia)  
Snake Grass,  
Elephants trunk (English),  
Phayayo (Thai),  
Dandang gendis (Jawa). |
| G. pictum   | Type- Perennial small tree or shrub.  
Height- 3m  
Stem- sparsely branched  
Foliage- Leaves are white or black patches on the surface, simple, glabrous oppositely arranged with ovate-lanceolate leaf blade.  
Flowers- Tubular reddish or pinkish-purple Inflorescence at terminal cyme.  
Propagation- asexual (stem cutting). | Native of the Indo-Pacific region, found in gentle slope and near village. Grow in moist fertile land. | Daun talai (Belait),  
Ongkalai putih (Dusun),  
Caricature Plant (English),  
Kaala-adusua (India),  
Kabikabi/  
andeuleum (Indonesia),  
Dauprada (Malaysia),  
Kalpueng (Philippines) Bai Ngeon (Thai) |
### Table 2: Botanical descriptions of species

| Genus       | Morphology                                                                 | Distribution and Habitat                                                                 | Vernacular Name                                      |
|-------------|----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|------------------------------------------------------|
| H. alternata| Type- Perennial creeping herb                                              | Native to tropical Asia. Shade-tolerant species, capable of growing and invading into the forest. | Metallic plant, red ivy plant, cemetery plant (English), Seliwah merah (Brunei), Murikooti (Kerala), lile buntal / remek getih (Indonesia). |
|             | Height- 40 cm                                                              |                                                                         |                                                      |
|             | Stem- glabrous, purple, bend out at the node.                              |                                                                         |                                                      |
|             | Foliage- Leaves are simple, oppositely arranged, glossy trichome, silver green turn to purple when older. Ovate-oblong rounded leaf blade at the apex. |                                                                         |                                                      |
|             | Flowers- Inflorescence terminal cyme, tubular, small, white with purple tint. |                                                                         |                                                      |
|             | Fruits- dehiscent capsule. Propagation- asexual (Stem or leaf cutting).    |                                                                         |                                                      |
| J. gendarussa| Type- Deciduous shrub. Height- 1.5m                                       | Native to China E. Asia - India to Beds of streams in moister areas of the Himalayas. Burma | Water willow (English), Variegated Gandarussa (Indonesia) Sarim bangun hitam (Brunei) Kasanah/ vaidyasinha (Sanskrit) |
|             | Stem- Erect, sub cylinder, glabrous and dark purple.                      |                                                                         |                                                      |
|             | Foliage- Leaves are simple, opposite decussate and glabrous with linear lanceolate leaf blade acute at apex. |                                                                         |                                                      |
|             | Flowers- Inflorescence axillary spike, white- creamy with purple tinge.   |                                                                         |                                                      |
|             | Fruits- capsules club-shaped, glabrous. Seeds- 4 seeded. Propagation- sexual (seed) and asexual. |                                                                         |                                                      |
| S. crispus  | Type- Perennial shrub. Height- 1m.                                        | Native to Madagascar, found in Southeast Asia, found wild in scrublands and river banks or cultivated. | Yellow Strobilanthes Pecah beling (Brunei) pokok pecah kaca or pokok pecah beling (Malaysia) Daun picah beling / Keji belingb (Jakarta-Indonesia), enyoh kelo, keci beling (Javanese). |
|             | Stem- Woody at base Quadrangular.                                           |                                                                         |                                                      |
|             | Foliage: Leaves are simple, oppositely arranged, glossy and trichome with elliptic or oblong-lanceolate leaf blade. |                                                                         |                                                      |
|             | Flowers- Tubular yellow, Inflorescence at terminal apex.                  |                                                                         |                                                      |
|             | Fruits- spindle shaped, Capsule Propagation- asexual (stem cutting).       |                                                                         |                                                      |
| Genus       | Methods and parts of the plants                                                                 | Phytochemical constituent                                                                 | References                     |
|------------|-------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|--------------------------------|
| A. paniculata | Preliminary phytochemical analysis of A. paniculata leaves in various solvents. TLC (CHCL3 / CH3OH (9:1)) fraction of whole plant; SGCC (CHCL3 / CH3OH (19:1)). HPTLC | Steroids, alkaloids, phenols, catechine, flavonoids, saponins and tannins. 1,1,3-triethoxy-propane, n-hexadecanoic acid, Phytol, Squalene, 1,2-benzenedicarboxylic acid; Retinoic acid methyl ester, β-sitosterol, Methyl ferulate, methyl caffeate, apigenin and 7-O-methylwogonin. 14-deoxy-11,12-didehydro andragrapholide, paniculide-A, B, and C, 14-deoxy o xoandrographolide, andragrapholide, panicoline, andragraphn, neoandrographolide. | (Hossain et al., 2014) |
| C. nutans  | Preliminary phytochemical analysis. 100% or 70% methanol extract of leaf. Leaf and stem are mixed with absolute methanol, absolute ethyl acetate extracts. Analyzed by GC-MS methods. 30% ethanol of aerial extract of the plant analyzed - HPLC. | Alkaloid, saponin, flavonoids, steroids (triterpenoids lupeol, β-sitosterol and stigmasterol) diterpenes, phytoester, tannin, quinone, phenolic compound, glycosides, carbohydrates, proteins and aminoacid. Squalene, botulin, β-tocopherol, lupeol γ-sitosterol, vitamin E, campsterol, stigmasterol, α-amyrin, β-amyrin, propanoic acid. Vitexin, isovitexin, isoorientin, orientin, schaftoside, 6, 8- apigenin-C-α-L-pyranarabinoside. | (Khoo et al., 2018) |
| G. pictum  | The preliminary phytochemical screening of G. pictum, leaves in different fractions. TLC using silica gel 60 GF254 aluminum sheets. GC-FID and GC-MS analysis. | Flavonoids, saponins, phenolics, anthraquinones, steroids, tannins, sugars and coumarins. The major constituents were hexahydrofarnesyl acetone (2.6 %), α-nonacosane (6.5 %) and phytol (75.7 %). | (Jiangseubchatveera et al., 2017) |
| Genus        | Methods and parts of the plants | Phytochemical constituent | References                          |
|--------------|---------------------------------|---------------------------|-------------------------------------|
| H. alternata | The preliminary phytochemical  | Steroids, phenol, carbo-  | (Rangheetha et al., 2016)           |
|              | screening of H. alternata      |   hydrates, proteins,     |                                     |
|              | leaves in various solvents.    | saponins, coumarins,     |                                     |
|              |                                 | flavonoids, alkaloids,    |                                     |
|              |                                 | amino acids and tannins.  |                                     |
| J. gendarussa| The preliminary phytochemical  | Alkoloids, gums, starch, | (Nirmalraj et al., 2015)            |
|              | screening of J. gendarussa     | glycosides, saponins,    |                                     |
|              | (Brum.f.) leaves in various    | steroids, flavonoids,    |                                     |
|              | solvents. Leaves were dried    | anthraquinones, lignin,  |                                     |
|              | at room temperature and finely | proteins, coumarin,       |                                     |
|              | powdered. The powder was       | tannins, carotenoids,    |                                     |
|              | extracted with different       | ascorbic acid, phenolic   |                                     |
|              | solvent (1:5) by soxhlet       | compounds and terpenoids. |                                     |
|              | extraction method.             | Vitexin, api-             |                                     |
|              |                                 | genin flavonoid glyco-    |                                     |
|              |                                 | side (Gendarusin A and    |                                     |
|              |                                 | B) and ustidrusamide      |                                     |
|              |                                 | alkaloids A, B, C and D;  |                                     |
|              |                                 | O-di-substituted aromatic |                                     |
|              |                                 | amines, friedelin, lupeol,|                                     |
|              |                                 | 0 methyl ethers,          |                                     |
|              |                                 | 2-aminobenzyl alcohol,    |                                     |
|              |                                 | and β-sitosterol.         |                                     |
| S. crispus   | Proximate analyses is employed | High mineral content,     | (Nurraihana and Norfarizan-Hanoon, |
|              | water-soluble vitamins are     | especially iron, sodium, | 2013)                               |
|              | determined by Ultraviolet-     | phosphorus, potassium and |                                     |
|              | Visible Spectrophotometer (UV- | calcium. Nutrients such as |                                     |
|              | VIS) spectrophotometer and fluorimeter (Vitamin C and Vitamin B1 and B2) and other compound studied respectively and mineral content of the leaves is determined by TLC, paper chromatography and Ultraviolet Spectrophotometer (UV). Flavonoid compound by HPLC. TLC, paper chromatography and UV spectrophotometric techniques. Methanolic extract of S. crispus; 3-(4, 5-dimethylthiazol-2yl) -2, 5- diphenyl tetrazolium bromide (MTT) assay. |                                     |
|              |                                  | catechin, alkaloids and   |                                     |
|              |                                  | tannin are present.       |                                     |
|              |                                  | Catechin, naringenin,    |                                     |
|              |                                  | kaempferol, luteolin,    |                                     |
|              |                                  | apigenin, rutin and       |                                     |
|              |                                  | myricetin are the eight    |                                     |
|              |                                  | flavonoids. Seven phenolic compounds such as caffeic, vanilic, syringic, p-coumeric, gentisic, p-hydroxy benzoic and ferulic. |                                     |
|              |                                  | Stigmasterol and β-      |                                     |
|              |                                  | sitosterol               |                                     |
### Table 5: Ethnobotanical properties of species

| Genus      | Folks and Tribes                                                                 | Parts Utilized                  | Treatments for Ailments                                                                 | References                        |
|------------|---------------------------------------------------------------------------------|---------------------------------|----------------------------------------------------------------------------------------|-----------------------------------|
| A. paniculata | Tripura tribe of Bangladeshi, Malaysia folklores, Indian Ayurvedic healers and tribes of Mayurbhanj district of North Orissa. | Whole plant or leaves or shoots; | Edema, emesis, diabetes, headache, dysentery, fever, acute diarrhea, anorexia, blood purifier, common cold, cough, constipation, helminthiasis, hypertension, liver diseases, vitiligo, treats eye problem and piles. | (Hossain et al., 2014) |
| C. nutans    | Malaysia healer, Thailand herbalist and Indonesia tribes                        | Alcoholic extract of fresh leaves or whole plant | Consumed as herbal tea to treat as diuretics, skin rashes, dysentery, fever and diabetes, treats VZV lesions and HSV. | (Kamarudina et al., 2017) |
| G. pictum    | Asian and African folklore medicine                                              | Leaf extract                    | Treats hemorrhoids, ulcers, abscesses and also used it enhances the fertility, poultice on swelling, cuts and wounds, rheumatism, hepatomegaly, laxative and ear disease, anti-fungal, anti-inflammatory and anti-plaque. | (Singh et al., 2015) |
| H. alternata | Lako Akediri Village, West Halmahera district, North Moluccas – Indonesia and tribal folk villages at Thrissur forest circle, Kerala, India | Leaf or whole plant             | Used to prepare Oke sou herbal drink to maintain health of women reproductive function. Stomach ache, anti-diabetic, anemia, skin ailment, wound healer (psoriasis) bone fracture. | (Raghunathan, 2017) |
| Genus        | Folks and Tribes                          | Parts Utilized                | Treatments for Ailments                                                                 | References                           |
|-------------|-------------------------------------------|-------------------------------|----------------------------------------------------------------------------------------|--------------------------------------|
| J. gendarussa | Mirzapur village of Dinajpur district, Bangladesh. Herbalist in China, Sri Lanka, India and Malaysia | Leaf or whole plant or twig   | Relieve back pain. Pills are made from the crushed leaves and orally taken. Decoction is used to treat fever, arthritis, respiratory disorder, digestive trouble, headache, haemorrhoids, muscle pain, cure bone fracture and also used as Herbal bath at the time of child birth. | (Rahmatullah et al., 2010)            |
| S. crispus   | Kampung Bawong People, Perak of West Malaysia. | Whole plant or leaves         | Plant contains calcium carbonate makes water mildly alkaline after boiling this makes the way for frequent urination. Leaves are chewed and swallowed to enhance immunization and also extracted as tea decoction and drank for cancer treatment. | (Samuel et al., 2010)               |

activity, ALP marker of osteoblast differentiation, anti-arthritic, anthelmintic activities, hypolipidemic activity effects etc.

**A. paniculata**

A. paniculata is a key medicinal plant that is used widely in most region of the countries, as a complementary and alternative medicine in Ayurvedic, Unani and TCHM. Whole plant, roots, shoot. Leaves extract of this species are used by folklore, tribal's and local herbalist as a remedy to cure both communicable and non-communicable diseases in most of the continent. According to (Hossain et al., 2014) studies in Randall-Selitto tested rat and Acetic-induced writhing tested mice the SGCC (CHCL₃/MEOH (19:1)) extract of whole plant part at the dosage of 300mg/kg shows significant analgesic activity. This In-Vivo model shows that this plant has an anti-inflammatory effect. A. paniculata has an anti-hyperglycemic effect that shows a reducing blood glucose level, improved β-cell functions and also islet in diabetic rat, when treated with SGCC extract of whole plant in the dosage of 50 mg/kg (Nugroho et al., 2014). The comparative studies, tested against carbon tetra chloride (CCL₄) induced hepatic microsomal lipid peroxides with the leaf extract and andrographolide of this species. This In-vitro model shows that extract of the leaf shows a high protective against carbon tetra
Table 7: Pharmacological properties of species

| Genus    | Experiment Methods                        | Extraction, plant part and Dose | Result                                                                                       | References                                                                                      |
|----------|-------------------------------------------|---------------------------------|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| A. paniculata | Pharmacological activity- Anti-Inflammatory. Technique- In-vivo. Test Subject- Randall-Selitto test in rat. Acetic-induce writhing test in mice. Pharmacological activity- Anti-hyperglycemic Effect. Technique- In vivo. Test Subject- Diabetic rats. Pharmacological activity- Hepatoprotective Effect. Technique- In-Vitro. Test Subject- CCL4 – induced microsomal lipid peroxides. Pharmacological activity- Anti-Viral effect Technique- In-Vitro. Pharmacological activity- Cardiovascular Effect. | Extraction- SGCC (CHCL3/MEOH (19:1)) Part- Whole plant Dosage- 300 mg/Kg. Extraction- SGCC Part- whole plant Dosage- 50mg/kg. Extraction- Alcohol Part- leaf Extraction- Hot aqueous and also methanol extract Part- aerial or whole plant. Extraction- Aqueous Part- leaf. Dosage- Plant mixed with food eaten by mice daily. | Shows significant analgesic activity. Reduced blood glucose level, improved β - cell functions and also islet in diabetic rat. Protect the high concentration of CCL4- induced microsomal lipid peroxides. Decreases the HIV antigen-positive H9 cell percentage. Inhibits against the activity of dengue virus (DENV-1). Shows definite antihypertensive activity in both the subjects and also improved the blood pressure in animals. There was no pregnancy in the female mice noticed after matting with untreated male, show that plant has contraceptive effect in female mice. | (Hossain et al., 2014; Parveen et al., 2019; Nugroho et al., 2014) |
| Genus          | Experiment Methods                          | Extraction, plant part and Dose | Result | References |
|---------------|----------------------------------------------|---------------------------------|--------|------------|
| *C. nutans*   | Pharmacological activity-Neuromodulating activity Technique- In vitro; Assay- OGD reoxygenation Test Subject- 30min subjected OGD injured primary cortical neuron mouse. | Extraction- 80% of ethanol. Part- leaf Dosage – 10μg/mL. | The level of expression of cPLA2 mRNA is reduced and also the suppression of HDAC and hypoxic neuronal death in an OGD assay is found in the mouse. | (Khoo et al., 2018; Kamarudina et al., 2017; Tsai et al., 2016) |
|               | Pharmacological activity-Anti-Inflammatory Technique- In vitro Assay- FMLP/CB induced elastase release. Test Subject- Human neutrophils Pharmacological activity-Immunomodulating effect Technique- In vitro Assay- IL-4 Production – ELISA; Incubation period-72h Test Subject- HPBMC; 0.5-5000μg/mL. | Extraction- 80% ethanol Part- Aerial Dosage- 10μg/mL. | Result shows that the 80% of ethanol extract has higher capacity to inhibit release of elastase about 68.33% in human neutrophils. | |
|               | Pharmacological activity-α-glucosidase inhibition activity. Technique- In vitro Assay- α-glucosidase inhibition activity. Pharmacological activity-Anti-diabetic Technique- In vivo Assay- Alloxan induced model-daily treatment for 9 days. Test Subject- Swiss webster mice (male). | Extraction- Ethanol Soxhlet Part- Leaf. Extraction- Methanol; Oven dry; Sonication Part- Leaf, Stem Dosage- 5000μg/ml (in stock). | 2.5 and 5 mg/mL-raise in IL-4 production and Natural killer cells activity is suppressed by 1 and 5 mg/ml of extract. 17.67 (stem) and 13.57 (leaf) percentage of inhibition. | |
|               | Pharmacological activity-Anti-cancer Technique- In vivo Assay- *Allium cepa* chromosome assay – post and suppressive treatment Test Subject- MMS induced. | Extraction- water; methanol; oven dry Part- Leaf Dosage: 100, 200, 400, 800mg/kg. | 150 mg/kg significantly lower blood glucose serum level from 442 ± 149mg/dl (day 0) to195 ± 66mg/dl (day 9). 440mg/kg of aqueos extract has repairing and anti-mutagenic effect against MMS. | |
| Genus  | Experiment Methods | Extraction, plant part and Dose | Result | References |
|--------|--------------------|--------------------------------|--------|------------|
| G. pictum | Pharmacological activity- Anti-oxidant Technique- In vitro Assay- DPPH and ABTS. | Extraction- Ethyl acetate Part- leaves. | Highest antioxidant. | (Jiangseubchatveera et al., 2017, 2015; Widyowati, 2011) |
|        | Pharmacological activity- Anti-cancer Technique- In vitro Assay- REMA | Extraction- hexane, ethyl acetate and aqueous fraction Part- leaves. | Exhibits the cytotoxic activities of fractions against MCF-7 cell lines with IC50 values of 38.66, 26.01 and 20.41µg/ml. and Non cytotoxic activities against Vero cells is seen. |
|        | Test Subject- 3 cancerous human cell lines, KB (epidermoid carcinoma), NCI-H187 (small cell lung carcinoma) and MCF-7 (breast adenocarcinoma). | | |
|        | Pharmacological activity- Anti-bacterial Technique- In vitro Assay- disc diffusion assay | Extraction- Hydrodistillation Part- Leaves oil | The oil exhibited antibacterial activity with Minimum inhibitory concentration (MIC) values of 11.75 and 35.25 µg/disc, respectively. |
|        | Test Subject- S. aureus and E. coli. | | |
|        | Pharmacological activity- ALP marker of osteoblast differentiation Technique- Assay- ALP | Extraction- 70% Ethanol-water extract and sequential fractions with n-butanol, ethyl acetate and water solvent. Part- leaves | ALP assay result shows that n – butanol and water fractions of G. pictum has significant stimulating activity of ALP (112% and 122% respectively) against MC3T3-E1. |
|        | Test Subject- MC3T3-E1 osteoblast cell | Dosage: 10 to 50µg/ml. | | |
|        | Analyzes- Analysis of Variance (ANOVA). | | | |

chloride (CCL₄) - induced hepatic microsomal lipid peroxides but not by the andrographolide phyto compound. This indicates hepatoprotective properties of the plant (Hossain et al., 2014). Research of (Parveen et al., 2019) reported that hot aqueous and methanol aerial extract of the plant show the remarkable decreases in the Human Immunodeficiency Viruses (HIV) antigen-positive H9 cell percentage this proof that plant have an anti-viral effect. Aqueous leaf extract of this species, indicate a definite antihypertensive activity in both normotensive Wister-Kyoto rats and spontaneous hypertensive rats and it shows a notable improvement in the blood pressure of the animals. This In-Vivo studies of (Hossain et al., 2014) report that plant has a cardiovascular effect. According to (Parveen et al., 2019), In –Vivo studies on female rat, which are fed with the plant mixed food, noticed that there is no effect.
| Genus       | Experiment Methods                                                                 | Extraction, plant part and Dose                           | Result                                                                                                                                                                                                 | References                                                                 |
|------------|------------------------------------------------------------------------------------|-----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| H. alternata | Pharmacological activity- Anti-bacterial activity Technique- In vitro Test Subject- Acinetobacter species and Streptococcus aureus Pharmacological activity- Anti-diabetic activity Technique- In vivo Test Subject- Rats Pharmacological activity- Wound healing activity Technique- In vivo Test Subject- mice Studies- Excision and incision Pharmacological activity- Anti-oxidant activity Assay- Ferrous iron activity and Nitric oxides radical scavenging Pharmacological activity- Anti-inflammatory, anti-nociceptive, anti diarrheal Technique- In vivo Test Subject- Swiss albino mice Test- Cotton pellet-induced granuloma anti-inflammatory; Formalin-induced paw licking; Acetic acid-induced writhing; castor oil induced anti-diarrheal. | Extraction- Benzene Part- leaves Extraction- n-Hexane and ethanol Part- Whole plant Extraction- Methanol Part: Leaves Extraction- Ethanol, petroleum ether, aqueous and standard ascorbic acid Part- Leaves Extraction- Ethyl acetate and methanol Part- Leaves | Antibacterial activity against Acinetobacter species and Streptococcus aureus Presence of steroids and coumarins lowers the blood glucose levels of the rats. Crude paste cure the wound by providing epithelization and contraction in mice. Scaffold made from chitosan are highly haemostatic and are more effective for treating infectious wound. Ethanol extract exhibit free radical scavenging. Leaves exhibit good scavenging activity. In nitric oxide 65.8% and in ferrous ion 56.9% higher Concentration of scavenges is seen. Highest percentage of inhibition is exhibited by ethanol 400mg/kg dose for anti-inflammatory; All the extracts shows a significant reduction of abdominal writhing and paw licking of mice in anti-nociceptive test; For anti-diarrheal methanol inhibit the percentage of diarrhea. | (Panthallookaran et al., 2017; Agneeswari and Jansi, 2019; Rahman et al., 2019) |
### Table 11: Pharmacological properties of species

| Genus       | Experiment Methods                                      | Extraction, plant part and Dose | Result                                                                 | References                      |
|-------------|--------------------------------------------------------|---------------------------------|------------------------------------------------------------------------|---------------------------------|
| J. gendarussa | Pharmacological activity- Anti-cancer and Anti-oxidant. | Extraction-Methanolic extract.  | Flavonoids (kaempferol and naringenin) has significant anti-cancer activity and Anti-oxidant activity. | (Nirmalraj et al., 2015; Putri et al., 2020) |
|             | Technique- In vitro.                                    | Part- Leaf.                     | Significant inhibition was seen on Bacillus subtilis and Escherichia coli bacteria. |                                 |
|             | Assay- MTT                                             | Extraction-Methanol fractions   | Shows a significant anti-inflammatory activity.                         |                                 |
|             | Test Subject- HT-29, BxPC-3 and HeLa.                  | Part- Leaves.                   | Ethanolic leaf extract treated rat shows a significant inhibition of paw edema say about 43% (FCA) and 47% (Collagen) respectively than the aspirin. |                                 |
|             | Pharmacological activity- Anti-bacterial.              | Extraction-Ethanol              | Part- leaf                                                             |                                 |
|             | Technique- In vitro.                                    | Dosage- To 1ml of HRBC suspension add 1000, 500 and 250 g / mL of extract. |                                 |
|             | Assay- disc diffusion.                                  | Extraction-Ethanol              | Part- Leaves                                                           |                                 |
|             | Test Subject- Staphylococcus aureus (MTCC 96), Proteus vulgaris (MTCC 426), Shigella flexneri (MTCC 1457), Micrococcus luteus (MTCC 1538), Klebsiella pneumonia (MTCC 109), Escherichia coli (MTCC 443), Staphylococcus mutans (MTCC 497) and Bacillus subtilis (MTCC 441). |                                 |
|             | Pharmacological activity- Anti-inflammatory activity.   | Evaluation- Dimethyl sulfoxide (DMSO). | shows that this plant has immunosuppressive effect                     |                                 |
|             | Technique- In Vitro.                                    | Pharmacological activity- Anti-arthritic activity |                                 |
|             | Assay- HRBC membrane stabilization method; Spectrometer at 560nm | Technique- In-Vivo             |                                                                     |                                 |
|             | Incubation period: 37°C for 30min. Test Subject- Blood sample of healthy Volunteers. | Pharmacological activity- Anthelminic activities |                                                                     |                                 |
|             | Test Subject- Staphylococcus aureus (MTCC 96), Proteus vulgaris (MTCC 426), Shigella flexneri (MTCC 1457), Micrococcus luteus (MTCC 1538), Klebsiella pneumonia (MTCC 109), Escherichia coli (MTCC 443), Staphylococcus mutans (MTCC 497) and Bacillus subtilis (MTCC 441). | Technique: In -Vitro           |                                                                     |                                 |
|             | Pharmacological activity- Anthelminic activities       | Assay- Bio assay                |                                                                     |                                 |
|             | Technique: In-Vitro                                    | Test Subject- Albendazole (control) and Pheretima posthuma worms. |                                                                     |                                 |
|             | Pharmacological activity- Immunosuppressive effect      | Pharmacological activity- Immunosuppressive effect |                                                                     |                                 |
|             | Technique- In-Vitro                                    | Assay- Lymphocyte proliferation assay by adding H thymidine. |                                                                     |                                 |
|             | Incubation- 16h                                        | Test Subject- Peripheral blood mononuclear cells (PBMC) healthy volunteers. |                                                                     |                                 |
|             | Test Subject- Peripheral blood mononuclear cells (PBMC) healthy volunteers. | |

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Table 12: Pharmacological properties of species

| Genus     | Experiment Methods                              | Extraction, plant part and Dose                      | Result                                                                 | References                                      |
|-----------|-------------------------------------------------|-----------------------------------------------------|------------------------------------------------------------------------|------------------------------------------------|
| S. crispus| Pharmacological activity- Anti-Diabetic         | Extraction- Aqueous of fermented and unfermented tea| Both show positive result in hyperglycemic rats. Shows effective antibacterial activity. There is no changes in Serum parameters (AST, Urea, Creatinine, ALP, and ALT) with no lethal effects are seen in rats and also Liver and Kidney functions are normal. HepG-2 cell by exposing to S. crispus, shows a dose - dependent induction of apoptosis. Wound part healed quickly. |
|           | Technique- In Vivo                              | Part- Leaves Extraction: Methanolic and water solvent and butanol fraction. Part: leaves Extraction Ethanol extract Part-Leaves Dosage- 150, 300 and 600mg/kg (Single oral dose daily for 14 days) |                                                                      | (Nurrai- hana and Norfarizan-Hanoon, 2013; Lim et al., 2012; Al-Henhena et al., 2011) |
|           | Test Subject- Streptozotocin – induced hyperglycemic rats. Pharmacological activity- Anti-microbial activities. Technique- In vitro Test Subject- Staphylococcus aureus, Streptococcus faecalis, Vibrio cholera and Pseudomonas aeruginosa. Pharmacological activity- Toxicology properties Technique- In Vivo Assay- Oral test Test Subject- Liver and Kidney function of Sprague Dawley female rats Pharmacological activity- Anti – Cancer activity Technique- In Vitro Assay- TUNEL, Apoptosis Detection System, Fluoresein, CLSM. Test Subject- HepG-2 Cells (Liver Cancer Cell). Pharmacological activity- Wound healing properties Technique- In Vivo Test Subject- Male Sprague Dawley rats wounded in the posterior area of the neck. |                                                                      |                                                                      |

C. nutans

C. nutans, is a popular traditional vegetable and medicinal herb in Southeast Asia countries. Leaf is most frequently used by the folks in the form of decoction either oral ingestion with water or topical administration with alcohol on the affected part (Khoo et al., 2018). National Drug Committee of Thailand know this plant as National List of Essential Medicine and service as a safety and cost effective native primary medicine, of Thailand. (Tsai et al., 2016), examined the 30min subjected OGD injured primary cortical neuron mouse. The mouse was treated with less than 10μg/ml dose of 80% ethanol leaf extract, after treatment the in-vitro studies, shows that the level of expression of cytosolic phospholipase2 (cPLA2) mRNA is reduced and also the suppression of HDAC and hypoxic neuronal death in an OGD assay is found in the mouse this exhibit the neuromodulating activity in plant. An anti-inflammatory effect of the plant was studied by (Khoo et al., 2018), by evaluating human neutrophil after treating with the extract of 80% ethanol aerial part, through a Formyl-L-methionyl-L-leucyl-
The result shows that the 80% of ethanol extract has higher capacity to inhibit release of elastase about 68.33% in human neutrophils. Investigation by (Kamarudina et al., 2017), profound that immunomodulating effect of plant by treating an ethanol extract on Human peripheral blood mononuclear cells (HPBMC). The IL-4 Production – enzyme-linked immunosorbent assay (ELISA) Assay result reveal that the extract has raise in the production of IL-4 and also it suppress the natural killer cell activity. In-vitro study of (Khoo et al., 2018) examine α-glucoside inhibition activity in plant through α-glucosidase inhibition assay. When dosage of extract is about 5000 μg/ml it exhibits 17.67 (stem) and 13.57 (leaf) percentage of inhibition respectively. The hot aqueous extract of leaf is orally administrated with the dosage of 50, 100 and 150mg/kg and also with oral glibenclamide to Alloxan induced model Swiss Webster mice (male) daily for about 9 days. The In-vivo studies of (Kamarudina et al., 2017), exhibit the evi-
ences that 150mg/kg of extracted leaf shows the significant decrease in serum blood glucose level from beginning of the day (day0) is about 442 ± 149mg/dl to end of the day (day 9) is about 195 ± 66 mg/dl respectively. Studies of (Khoo et al., 2018) investigate the antimutagenic properties of C. nutans against MMS. In their In -vivo studies through Allium cepa chromosome assay reveal that the 400mg/kg of aqueous extract of leaf has high capacity of repairing and anti-mutagenic properties against MMS, this shows that the plant has an anticancer effect.

**G. pictum**

G. pictum is an ornamental plant, has medicinal value among the ethnic groups of Asian folk to cure many ailments such as diuretic, and antipyretic and as an antihelmentic. The pharmacological activities of the plant extracts have been reported by many researchers as follows.

In vitro, 1, 1-Diphenyl-2-picrylhydrazyl (DPPH) and 2, 2' azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) Assay of antioxidant using different solvent fractions (hexane, ethyl acetate, butanoic and aqueous) of G. pictum plant species were studied by (Jiangseubchatveera et al., 2017). They reported that the ethyl acetate extract of leaves has highest antioxidant activities in these 2 methods when compare to rest of the solvent. For cytotoxic activity of the plant, they took 3 cancerous human cell lines, KB (epidermoid carcinoma), MCF-7 (breast adenocarcinoma) and NCI-H187 (small cell lung carcinoma) and treated with different solvent fractions, with the use of Resazurin microtitre assay (REMA) they determined that 3 fractions (hexane, ethyl acetate and aqueous ) has the highest capacity of cytotoxic against MCF-7 growth cell lines (with the IC50 values of 38.66, 26.01 and 20.41µg/ml respectively) and there is no cytotoxic action of fractions against Vero cells is seen. In vitro, disc diffusion assay, examined by (Jiangseubchatveera et al., 2015) to determine antibacterial properties of the plant, reveals that the oil extract of leaves has a strong antibacterial activity against Escherichia coli and Staphylococcus aureus with MIC values (11.75 and 35.25µg/disc) respectively. ALP marker of osteoblast differentiation is evaluated by (Widyowati, 2011), by using 70% Ethanol- water extract with sequential fractions (n-butanol, ethyl acetate and water solvent) against MC3T3-E1 osteoblast cell. The ALP assay result shows that n– butanol and water fractions of G. pictum has significant stimulating activity of ALP (112% and 122% respectively) against MC3T3-E1.

**H. alternata**

H. alternata is exotic plant, adapted to grow in Bangladesh and India. The notable phytochemical compounds and their secondary metabolites possess various medicinal properties. The benzene extract of leaves has an antibacterial effect against Acinetobacter species and Streptococcus aureus. The ethanol and n-hexane extraction of whole plant found to have hypoglycemic and anti-diabetics properties in glucose fed rats (Panthallookaran et al., 2017). (Agneeswari and Jansi, 2019) reported that the plant has antioxidant properties by analyzing with two different assay namely nitric oxide radical scavenging and ferrous ion chelatin in dose dependent manner. (Rahman et al., 2019) investigated and evaluated that administration of ethyl acetate leaves extract of H. alternata, over swiss albino mice by cotton pellet-induced granuloma formation test shows significant anti-inflammatory effect than methanol extract. They also used castor oil induced antidiarrheal test, which show that methanol extraction has significant inhibition of diarrhea activities in mouse compare to ethyl acetate.

**J. gendarussa**

J. gendarussa is a renowned plant, grown throughout various regions of India. The plant leaves are used in the form of infusion, decoction and also as a paste for treating various ailments in the ancient periods by the ethnic groups. Most of the phytochemical compounds and also secondary metabolites derived from the plants have plethora of pharmacological values that have been reported by many of the researchers. This significant reports of J. gendarussa species by the researcher have been discussed as follows.

The in-vitro studies on methanol extraction of the leaf from J. gendarussa plant, using MTT assay against HT-29, BxPC-3 and HeLa human cancer cells was postulated by (Putri et al., 2020). Their studies reported that flavonoids (kaempferol and naringenin) present in the leaf of J. gendarussa plant, has a significant anti-cancer activity and anti-oxidant activity. Methanol leaf extraction is treated against gram-negative and gram-positive bacterial microorganism such as Micrococcus luteus (MTCC 1538), Staphylococcus mutans (MTCC 497), Bacillus subtilis (MTCC 441), Staphylococcus aureus (MTCC 96) as gram positive organism and Klebsiella pneumonia (MTCC 109), Proteus vulgaris (MTCC 426), Escherichia coli (MTCC 443), and Shigella flexneri (MTCC 1457) as gram negative organism. This in-vitro studies of the plant antibacterial activity have been determined through disc diffusion assay, reveals that the extract have maximum inhibition against Bacillus subtilis and Escherichia coli bacteria compare to rest of the bacteria. The anti-
inflammatory activities of J. gendarussa, is examined by treating 1ml of Human Red Blood Cell (HRBC) with different concentration (250, 500 and 1000g/ml) of plant extract through in-vitro by HRBC membrane stabilization method (Nirmalraj et al., 2015). Their investigation manifest that plant has notable anti-inflammatory activities in a dose dependent manner. To evaluate anti-arthritic activity in J. gendarussa the (Putri et al., 2020) took Freund’s complete adjuvant (FCA) and Collagen arthritis induce rat models. In their studies they treated the rat with aspirin and ethanolic extract of leaf from this plant and reported that the leaf extract treated rat shows a significant inhibition of paw edema say about 43% (FCA) and 47% (Collagen) respectively than the aspirin. To postulate the anthelmintic activities in J. gendarussa species, (Nirmalraj et al., 2015) treated the Pheretima posthuma worm with methanolic crude extract of leaf and stem of this plant at different concentration (10, 20, 30, 40 and 50mg/ml), the study was then examined for paralysis time and death time of the worm. The investigation result that the 50mg/ml of methanolic crude extract can paralyze and kill the worm at 35.3min and 70.7min respectively and Albendazole (used as a control) at 17 and 48 mins respectively this evident shows that the plant has anthelmintic properties. (Putri et al., 2020) investigation of immunosuppressive effect, of this plant have been done by testing the crude methanolic extraction of four plants, such as (J. gendarussa, Plumbago indica, Aloe vera, and Aegle marmelos) in different concentrations (50- 150µg/ml), for the lymphocyte proliferation inhibition, through lymphocyte proliferation assay by adding H thymidine. Their study reveal that compared to other plants, J. gendarussa show the increasing amount of lymphocyte inhibition say about 84% in 100µg/ml. This indicates that the plant exhibit immunosuppressive properties.

S. crispus

S. crispus plant also has an indigenous medicinal value that are mainly used in Jamu – Malay medicine and also in tropical Asian medicine. Many researchers has reported in their research about the pharmacological values of this plants that has been discussed below.

In-Vivo studies of (Nurraihana and Norfarizan-Hanoon, 2013) on Streptozotocin – induced hyperglycemic rats elucidated that the aqueous tea extract shows a significant decrease in blood glucose level in the tested rats that show this plant has an anti-diabetic property. According to (Nurraihana and Norfarizan-Hanoon, 2013), 30days oral administration of the plant juice to the normal rats, Sprague Dawley female rats, and Streptozotocin – induced hyperglycemic male rats with the dosage of 2.0, 1.5 and 1.0 ml/kg b.wt shows not only remarkable decrease in the serum blood glucose level but also decrease in the cholesterol and triglyceride level with an increase in the High-Density Lipoprotein cholesterol (HDL) level in the diabetic rats. This reveals that the plant also has a hypolipidemic effect. The anti – microbial effect of the plant has been reported by (Nurraihana and Norfarizan-Hanoon, 2013), by testing the methanol and aqueous crude extract and butanol fractions of the plant against both gram negative and positive bacteria namely Streptococcus faecalis, Staphylococcus aureus, Pseudomonas aeruginosa and Vibrio cholera, exhibit that the fraction and the crude extract of the plant has anti-microbial properties.

Ethanol leaves extract of the plant examined by (Lim et al., 2012) on the kidney and liver function of Sprague Dawley rats with daily dosage of 150, 300 and 600mg/kg for 14 days elucidated that there is no changes in the serum (ALP, creatinine, urea, ALT, AST) biochemical parameters and the kidney and liver of the rats shows a normal functions. (Nurraihana and Norfarizan-Hanoon, 2013) reported the effect of anti-carcinogen of S. crispus extract through apoptotic pathway. By using Apoptosis Detection System Fluorescein, the samples were assessed by Terminal deoxynucleotidyl transferase dUTP nick end labeling (TUNEL) assay and Confocal Laser Scanning Microscope (CLSM) was also used to show that HepG-2 cells expose to the extract result a dose-dependent manner induction of apoptosis. This plant also has wound healing properties that has been reported by (Al-Henhena et al., 2011) by applying topical (100 and 200mg/ml) the ethanol extract of S. crispus plant on the wounded part of posterior neck of male Sprague Dawley rats. The application of the extract (100mg/ml and 200mg/ml) shows that time taken to heal were about 14.80, 13.00days approximately.

CONCLUSIONS

Acanthaceae plants such as A. paniculata, C. nutans, G. pictum, H. alternata, J. gendarussa and S. crispus are known for their biological activities. Ever since from the ancient periods, locals and ethnic groups has a practice of using these plant extracts either in the form of oral infusion or decoction or in the form of topical administration to treat various kinds of ailments. The ethnobotanical value of these plants is known for their anti-inflammatory, anti-oxidant, anti-diabetics, anti-cancer, anti-arthritis properties among medicinal practitioner in Ayurvedic, TCHM
and Unani fields. This review article not only discusses about the botanical and phytochemical properties of these plants, but also it signifies these herbal plant’s importance in both ethnobotanical and pharmacological fields. Thus, it is hoped that this research article would provide more insights into the health benefits of some plants of aca-
thaceae family.

**Conflict of Interest**

The authors declare that they have no conflict of interest for this study.

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