

# Multidimensional Uses of Medicinal Plant Kachnar (*Bauhinia variegata* Linn.)

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## ABSTRACT

*Bauhinia variegata* Linn. (Kachnar) (Fabaceae- Leguminosae) is popular ornamental plants, commonly known as Cow's paw. *Bauhinia variegata* is a widely used as medicinal plant distributed in the tropical regions. According to WHO third world countries depends mainly native medicinal plants for their health purpose. various part i.e. flowers, buds, stem, roots, bark, seeds, leaves have been used since ancient times for the treatment of a wide range of diseases. It is used traditionally in dysentery, diarrhea, hemorrhoids, piles, edema, laxative, anti-helmintic, astringent, anti-leprotic, wound healing, anti-goitrogenic, anti-tumor, antidote for snake poisoning, dyspepsia and carminative disease. It have numerous chemical values and is rich phytochemicals such as flavonoids, tannin, kaempferol, terpenoids, saponins, reducing sugars steroids, cardiac glycosides and quercetin. Studies on the medicinal and biological importance of *B. variegata* have been reported. In modern studies and scientific knowledge on the biological/ medicinal properties is demonstrate that *B. variegata* used as a anti-bacterial, anti-helmintic, anti-arthritis, anti-inflammatory, anti-diabetic, immunomodulatory, hepato-protective, anti-oxidant, trypsin inhibitor and anti-carcinogenic activity. *B. variegata* can be used as molluscicidal agent against harmful vectors/pests. The present review highlights the current status of researches on the advancement of pharmacological/ biological aspect of *B. variegata* and their multidimensional use in various diseases.

**Keywords:** *Bauhinia variegata*, Anti-microbial, Anti-oxidant, Anti-diabetic, Anti-carcinogenic, Molluscicidal.

## INTRODUCTION

For the last four decades, ethnobiology has emerged as alternative discipline that can play prominent role. A

number of chemically diverse plants have been isolated today. The knowledge and advancement of plant properties and its uses

over synthetic have ecofriendly, biodegradable and hence are less likely to accumulate in the environment. Plant *Bauhinia variegata* (Fabaceae) is called Kachnar in Hindi, commonly known as Rakta Kanchan in Sanskrit and Mountain Ebony in English. It was planted in garden, park and roadsides as ornamental plant in many warm temperate and subtropical regions. It was native to Southeast Asia and grows in tropical and subtropical climate<sup>1, 2</sup>. *Bauhinia variegata* is distributed in sub-himalayan and outer himalaya of the Punjab and Sikkim state, India. It is also found in Burma and China. It is also distributed in most tropical countries, including Africa and South America<sup>3,4</sup>. *Bauhinia variegata* consist about 300 species is medium sized, deciduous tree which remain leafless in the month of January-April and in that period flowering of the tree starts<sup>4</sup>. The genus includes trees, vines and shrubs that are frequently planted for their showy flower and ornamental foliage. Leaves are bifoliate. *B. variegata* is known to restore fertility to acid and degraded soils because of its ability to fix nitrogen<sup>5</sup>. The various parts of the plant viz., flower buds, flowers, stem, stem bark, leaves, seeds and roots are practiced in various indigenous systems of medicine and popular among the various ethnic groups in India for the cure of variety of ailments<sup>6 & 7</sup>.

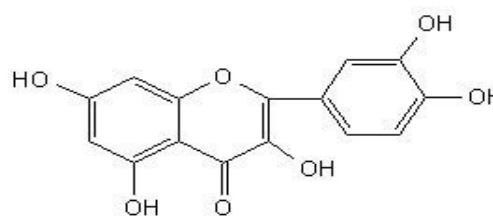
#### Taxonomic hierarchy

Kingdom: Plantae  
 Division: Tracheophyta  
 Class: Magnoliposida  
 Order: Fabales  
 Family: Fabaceae  
 Genus: *Bauhinia*  
 Species: *variegata*

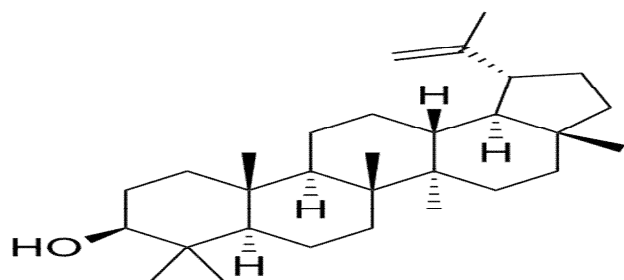
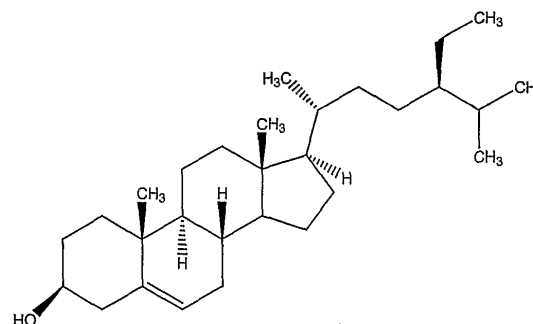
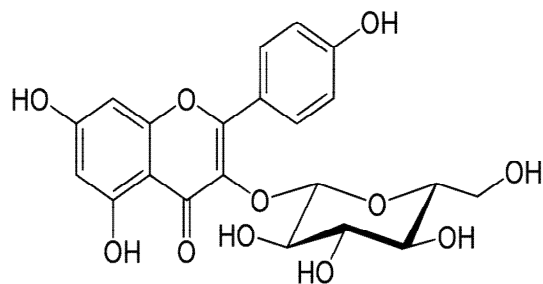
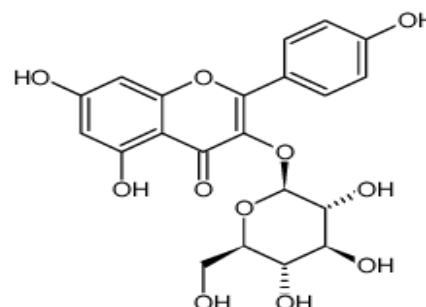
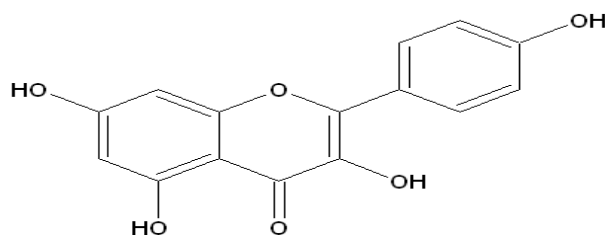
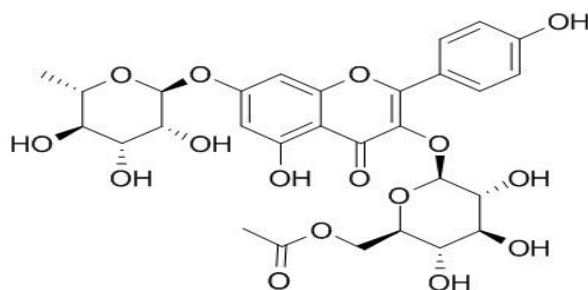
#### Phytochemical constituent

The main constituent of *B. variegata* parts are-

- I. An aerial part contains Kaempferol, Ombuin, Kaempferol 7, 4-dimethyl ether- 3-o-  $\beta$ -D-2 glycopyranoside, triterpene, Kaempferol-3-o- $\beta$ -D-glycopyranoside, isorhamnetin-3-o- $\beta$ -D-glycopyranoside and hesperidin<sup>8 & 9</sup>.
- II. Stem bark of *B. variegata* has contain quercitroside, Kaempferol-3-glucoside, lupeol and betasitosterol isoquercitroside, rutoside myricetol glycoside and Kaempferol glycosides<sup>10, 11, 12, 13 & 14</sup>. Zhao *et al.*,<sup>15</sup> isolated a new phenanthraquinone, 2,7-dimethoxy-3-methyl-9,10 dihydrophenanthrene-1-4, dione (Bauhinione) from *B. variegata* stem extract.
- III. Leaves contain lupeol, alkaloids, oil, fat, glycoside, phenolics, lignin, saponins, terpenoids,  $\beta$ -sitosterol, tannins, kaempferol-3- glucoside, rutin, quercetin, apigenin, apigenin-7-o-glucoside amides, carbohydrates, reducing sugar, protein, vitamin C, fiber, calcium and phosphorus<sup>11, 16 & 17</sup>.
- IV. Seeds contain protein, fatty oil-containing oleic acid, linoleic acid, palmitic acid, and stearic acid<sup>18</sup>. Reddy *et al.*<sup>19</sup> noted a new flavones in root extract of *B. variegata* is (2s)-5,7-dimethoxy-3'-4'-methylene flavone.



**Quercetin**

**Lupeol****β- sitosterol****Peonidin-3-glucoside****Kaemferol- 7, 4- dimethylether-3-O-β-D-  
glucopyranoside****Kaemferol****Kaemferol-3-O-6-O-acetyl-glucoside-7-O-  
rhamnoside**

#### Source of Literature

Literature search on multi-dimensional uses of medicinal plant *Bauhinia variegata* from different sources of electronic and print scientific journals. Materials searched from PubMed resources, e-libraries such as NIH, CDC and book wealth of India. Ayurved, Unani and Charak samhita contains beautiful literature of plants and their role in biological system of Indian traditional system has been cited.

#### Medicinal, Biological and therapeutic value

Nature has been source of medicinal agent since time immemorial and man has been dependent on plant products for his needs. The importance of herbs in the cure of human ailment cannot be neglected. Phytomedicines used to cure several diseases is well acknowledged in indigenous tradition system Ayurved, Unani and Charak samhita with growing awareness for the last 3 decades; it was needed to explore the

potentiality of plant derived products against several diseases<sup>17</sup>.

Modern medicine based on traditional system only after chemical and/or clinical test. Synthetic drugs cause's side effects as a result, people are more interest to use natural products obtained from plants<sup>20</sup>. It has been estimated that 56% of the active compounds for medicines in the British National Formulary are natural products<sup>21</sup>. Standardization and formulation of the plant product is necessary to describing the isolation, identification and qualification of active ingredient in plant materials. These plants are an important source of producing medicinal valuable bioactive secondary metabolites which are great importance for the health purpose of human beings<sup>22, 23 & 24</sup>.

Indigenous traditional system of medicine various parts of the plant *B. variegata* are used as anti-helmintic, astringent, anti-leprotic, anti-microbial, liver tonic and in the treatment of dysmenorrhoea. Plant is also useful for treatment of skin diseases, wounds, edema, dysentery, ulcers, eye disease, piles, hemorrhoids and an antidote against snake bite<sup>25</sup>. The Ayurvedic has documented the use of the stem bark in treating lymphadenitis and goiter<sup>26</sup>. *Bauhinia* leaves and bark have been used frequently in folk medicine as a remedy for different kinds of the pathologies, particularly, infections and diabetes<sup>27,1, 2</sup>.

## Biological Effects

### Anti-inflammatory activity

Non woody aerial part of *B. variegata* shows the anti-inflammatory activity against inhibiting the lipopolysaccharides, with interferon  $\lambda$  induce nitric oxide (NO) and cytokines<sup>37</sup>. Ethanol extract of *B. variegata* root shows the anti-inflammatory activity by non-immunological carrageenan induced hind

paw edema method<sup>37,57</sup>. These activities may be due to their content of tannins, steroids, flavonoids and carbohydrates. Sosa *et al.*<sup>58</sup> carried out a bioassay using the inhibition of croton oil-induced ear edema in mice and identified a 2:1 mixture of ursolic and oleanolic acids as the strongest antiphlogistic effects, with potency similar to that of indomethacin. Triterpenic acids have long been noted as anti-inflammatory activity<sup>38 & 59</sup>. Boonfong *et al.*<sup>60</sup> isolated several new secondary metabolites from the root of *B. variegata* especially bibenzyls and dihydrodibenzoxepins. It has significant anti-inflammatory activity. A new triterpene- saponin 23-hydroxy-3 $\alpha$ -[O-alpha-L-1C4-rhamnopyranosyl-(1'4')-O-alpha-L-4C1-arabinopyranosyl-oxy]olean-12-en-28-oic acid and O-alpha-L-1C4-rhamno pyranosyl-(1'4')-O-beta-D-4C1-glucopyranosyl-(1'6')-O-beta-D-4Cglucopyranosylester, were isolated from the leaves of *B. variegata*. It was found nontoxic (LD<sub>50</sub>) and to have significant anti-inflammatory activity<sup>61</sup>. It also showed anti-nociceptive effects which are more potent than the reference drugs (REF). Anti-inflammatory agents isolated from *B. variegata* plant were six flavanoids namely, kaempferol, ombuin, kaempferol 7,4'-dimethylether 3-0- $\beta$ -D-glucopyranoside, kaempferol 3-0- $\beta$ -D-glucopyranoside, isorhamnetin 3-0- $\beta$ -D-glucopyranoside and hesperidin together with one triterpene. Caffeate, 3 $\beta$ -trans-(3,4-dihydroxycinnamoyloxy) olean-12-en-28-oic acid were isolated from the non-woody aerial parts of *B. variegata*. These compounds were evaluated as inhibitors of some macrophage functions involved in the inflammatory process, significantly dose-dependent inhibition of lipo polysaccharide (LPS) and interferon (IFN)-g induced nitric oxide (NO), and cytokines (tumour necrosis factor (TNF)- $\alpha$  and interleukin (IL)-12<sup>37</sup>. Bairagi *et al.*<sup>35</sup> screened out the methanol and aqueous

fraction of the *B. variegata* bark contained flavones glycosides and flavonoids. It shows acute anti-inflammatory activity at 200mg/kg and 250 mg/kg orally in rats. Shaha *et al.*<sup>39</sup> reported that the anti-inflammatory activity of leaf extract of *B. variegata* in *in vitro*.

#### Anti-oxidant activity

A different part of *B. variegata* has been reported to contain quercetin, rutin, apigenin and epigenin 7-O-glucoside<sup>16</sup>. Flavonoid and quercetin are potent antioxidants and known to modulate the activities of various enzyme systems due to their interaction with biomolecules<sup>62</sup>. Ethanolic and aqueous extracts of *B. variegata* root produced significant antioxidant activity carried out by *in-vitro* scavenging of free radicals using 1, 2-diphenyl-1-2-picrylhydrazyl (DPPH), nitric oxide and superoxide<sup>53</sup>. It may be the flavonoids and other phyto chemicals present in the plant extracts<sup>49</sup>. Ethanolic extract produced significantly greater antioxidant activity than other extracts<sup>49</sup>. *In vitro* antioxidant and free radical scavenging potential are of methanolic extracts of *B. variegata*<sup>50</sup>. Different parts of *B. variegata* like leaf, bark and flowers have free radical scavenging activity by hydroxyl radical scavenging method. All extracts have different level of antioxidant activity. Amongst all extracts methanol was found to be good solvent for extraction and having good antioxidant activity<sup>50 & 51</sup>. IC<sub>50</sub> value of *B. variegata* leaf, stem bark and floral buds are 17.9, 19.5 and 17.2 µg/ml, respectively. The Reducing power of extracts was carried out with ascorbic acid as a standard reducing agent<sup>51</sup>. The percent free radical scavenging activity gradually increases with increasing concentrations of *B. variegata* extracts in DPPH radical scavenging assay. Dose dependent antioxidant activity pattern was also observed in phosphomolybdate assay<sup>63</sup>.

Antioxidant activity was directly correlated with the amount of total phenolic contents in the extracts. *B. variegata* in L-dopa extract has shown the highest FRAP values<sup>63</sup>. Sharma *et al.*<sup>49</sup> studied that both ethanolic and aqueous extracts of root of *B. variegata* possesses significant antioxidant activity by scavenging of various free radicals such as 1,2- di phenyl 1-2 picrylhydrazyl (DPPH), superoxide, nitric oxide. Its observed the various extract of the plant product significant DPPH (1,2- di phenyl 1-2 picrylhydrazyl) is a lipophilic free radical from a stable diamagnetic form with electron or hydrogen radical. Pandey *et al.*<sup>51</sup> observed antioxidant activity by inhibiting of TBARs. Methanolic extract of *B. variegata* possesses significant free radical scavenging, hydroxyl radical scavenging and antioxidant activity in *in vitro*. They confirm the presence of phenolic compound flavonoids, tannin etc.

#### Anti-diabetic activity

Presence of insulin like protein in leaf, stem bark of *B. variegata* is widely utilized in popular medicine, as an anti-diabetic agent<sup>27</sup>. The leaves and stem-bark of *Bauhinia* used in different phyto preparation to lower blood glucose levels<sup>64 & 65</sup>. Pandey *et al.*<sup>51</sup> and Kumar and Yadav<sup>66</sup> noted the antidiabetic potential of the plant *Bauhinia* in mammal. Ethanol extract leaves of *B. variegata* show the hypoglycemic activity as well as antidiabetic activity<sup>67</sup>. Lino *et al.*<sup>41</sup> showed aqueous and organic solvent ethanol and hexane extract of *Bauhinia* in a model of alloxan-induced diabetes in rats caused reduced glucose, triglycerides, total cholesterol and high density lipid (HDL) cholesterol levels. Morikawa<sup>68</sup> also found in his observation that aqueous extract of *Bauhinia* leaves exhibited hypoglycemic activity in normoglycemic mice, he suggested that this action may be related to the presence of

glycosyl flavonoids and several natural flavonoids exhibit an antidiabetic activity. The presence of insulin-like molecule was demonstrated in the leaves, where a 'chloroplast protein' was found that has a partial amino acid sequence identical to that of Bovine insulin. This protein found to act as hypoglycemic activity when it is injected in alloxan induced diabetic mice<sup>27</sup>. Frankish *et al.*<sup>69</sup> antidiabetic activity was noticed a major metabolite of the ethanolic extract of leaves; roseoside, demonstrates insulinotropic activity toward pancreatic  $\beta$ -cells of the INS-1 cell line and may act in conjunction with the chloroplast protein to contribute to the overall antidiabetic properties. Dewangan *et al.*<sup>42</sup> isolated and identified a bioactive carbohydrate D-pinitol (3-o-methyl D-chloroinositol) from the ethanolic extract of *B. variegata* leaves. The compound pinitol is belonging to group of cyclic polyol. It is natural product of cyclic polyol group was responsible for hypoglycemic activities<sup>70</sup>.

#### Anti-microbial activity

*B. variegata* plant could be utilized as an alternative source of antimicrobial drugs. Methanolic, chloroform and aqueous extracts of *B. variegata* fractions shows anti-bacterial activity against both gram positive and gram negative bacteria namely- *Bacillus cereus*, *Staphylococcus aureus*, *Klebsiella pneumonia*, *Escherichia coli*, and *Pseudomonas pseudoalcaligenes*<sup>33</sup>. Anti-bacterial activity in methanol extract is more potent than aqueous extract<sup>32</sup>. The alcoholic extract of leaves of *B. variegata* showed maximum antimicrobial activity compared with other organic solvent extracts<sup>13</sup>. The methanol extract from both *in vivo* and *in vitro* generated plants of *B. variegata* were tested against a number of microbes, only *Escherichia coli* and *Pseudomonas aeruginosa* were found to be resistant at a concentration of 50  $\mu\text{g}/\text{ml}^2$ . Ethanolic

extract of *B. variegata* stem bark act as antimicrobial activity against *B. subtilis*, *S. typhi*, *S. dysenterial*, *S. aureus*, *P. aeruginosa* and *Vibrio cholera*<sup>34,71</sup>. Achenbach *et al.*<sup>72</sup> showed that several metabolites particularly the flavonoids (2s)-3,4-dihydroxy-7-methoxy flavan and (2s)-7,4-dihydroxyflavan caused significant inhibition of pathogenic fungi such as *Botrytis cinerea*, *Claviceps viridis*, *Coprinus cinereus*, *Rhizoctoria saloni* and *Saprolegnia asterophora*. Maillord *et al.*<sup>73</sup> confirmed that the dichloromethane extract of *B. rufences* caused antifungal activity against *Cladosporium cucumerium*. Ali<sup>74</sup> and Kumar *et al.*<sup>75</sup> have reported that the broad spectrum of antimicrobial activity of plant *Bauhinia* due to the presence of phenol metabolites. Filho<sup>4</sup> and his research group has evaluated antimicrobial potential of plant *Bauhinia* against pathogenic fungi and bacteria. Evaluation of anti-fungal potential of this plant is active against dematophytes such as *Microsporium camis*, *Trychophyton metagrophytes*, *T. rubrum* and *Epidermophyton flaccosum*.

#### Anti-tumour / Cytotoxic activity

Raj Kapoor *et al.*<sup>36</sup> and Gupta *et al.*<sup>76</sup> noted anti-tumour activity of ethanolic extract *B. variegata* against dalton's ascetic lymphoma (DAL) on Swiss albino mice. Ethanolic extract of stem bark of *B. variegata* shows the chemoprevention and cytotoxic effect against N-nitrosodiethylamine induced liver tumour in rats and human cancer cell lines at a dose of 200  $\text{mg}/\text{kg}$ <sup>44</sup>. Oral administration of ethanolic extract of *B. variegata* effectively suppressed liver tumour induced by N-nitrosodiethylamine induced elevated level of serum glutamate pyruvate transaminase (SGPT), serum glutamate oxaloacetate transaminase (SGOT), alkaline phosphatase (ALP), total bilirubin, gama glutamate transpeptidase (GGTP), lipid peroxidase

(LPO), glutathione peroxidase (GPX), glutathione-s-transferase (GST)<sup>44</sup>. Ethanolic extract of bark, seed and leaf has been noted to be cytotoxic against human epithelial larynx cancer and breast cancer<sup>77</sup>. Pandey and Agarwal<sup>44</sup> observed anticarcinogenic and antimutagenic potential of *B. variegata* methanolic extract on Swiss albino mice using a skin carcinogenesis and melanoma tumour model, along with micronucleus and chromosomal aberration tests. He found that the significant prevention of skin papilloma model, with delayed appearance and reduction in the cumulative number of papillomas in the DMBA + *B. variegata* + croton oil treated group as compared to the DMBA + Croton Oil group. C57 Bl mice which received a 50% methanolic extract of *B. variegata* extract at the doses of 500 and 1,000 mg/ kg body weight for 30 days showed increase in life span and reduced the tumour size significantly<sup>44</sup>. Pandey and Agarwal,<sup>44</sup> noted in antimutagenicity studies, a single application of *B. variegata* extract at doses of 300, 600 and 900 mg/kg dry weight, 24 hours prior the administration of cyclophosphamide (at 50 mg/kg) significantly prevented micronucleus formation and chromosomal aberrations in bone marrow cells of mice, in a dose dependent manner. Tewari *et al.*<sup>77</sup> investigated the traditional use of *B. variegata* against anti tumour activity. The anti tumour potential of *B. variegata* was studied by 3-(4,5 dimethyl thiozole-2-yl)-2.5- diphenyl trtrazodium bromide (MTT) and sulpherhodamine B (SRB) the two cancer cell line (Hep-2, HeLa) and one normal cell line (BRL3A). The result of MTT and SRB showed seven extract of cytotoxic to the cancer cell line and less toxic towards normal cell lines. The preliminary Phytochemical screened out flavonoids asantitumour activity. *In vitro* cytotoxicity on Ehrlich Ascitic Carcinoma (EAC) mouse cell lines responses almost

with the same degree of inhibition for the ethanol extract, derived from both *in vivo* and *in vitro* sources<sup>2</sup>.

#### Anti-arthritic

Raj Kapoor *et al.*<sup>78</sup> investigated the anti-arthritic activity of ethanolic extract of *B. variegata* by the oral administration of ethanolic extract at the tested dose level of 250 mg/kg on complete Freund's adjuvant (CFA) induced arthritis in rat for 15 days. At the end of 15 days, the rats were sacrificed, their blood was collected and then serum was separated. After that various parameters such as alanine amino transferase (ALT), alkaline phosphatase (ALP), total cholesterol and triglycerides were estimated. In the level of various antioxidant enzymes were also evaluated in liver and kidney of normal, arthritic control and extract treated rats such as catalase, glutathione peroxidase (GPx), superoxide dismutase (SOD) and lipid peroxidase (LPO). The result of these studies shows that administration of this significantly Paw Edema volume in rat and altered the biochemical parameters and also level of various antioxidant enzymes which got affected in arthritic rats. From this study, it was concluded that the ethanolic extracts of this plant showed significant antiarthritic effect in rats<sup>47</sup>.

#### Anti-Obesity

Balamurugan and Muralidharan<sup>79</sup> investigated the anti-obesity effect of methanolic extracts of stem and root bark of *B. variegata* by oral administration of methanolic extracts at the tested dose level of 200 and 400 mg/kg in female rats fed with hyper caloric diet for 40 days. At the end of 40 days, various parameters was evaluated such as body weight (BW), feed intake, high density lipoproteins (HDLP), low density lipoproteins (LDLP), triglycerides, total cholesterol, brain serotonin level. The results of these studies

showed that administration of this extract significantly brought down the increased level of total cholesterol, triglycerides, LDLP and there was increased in the level of HDLP, brain serotonin level<sup>79</sup>. This was attributed to the presence of  $\beta$ -sitosterol in the stem and tendency to release the serotonin level in the brain. Thus this finding showed a significant anti-obesity activity<sup>79</sup>.

### Pesticidal Properties:

#### Anti-helmintic activity

Aqueous and Chloroform extract of bark of *B. variegata* were investigated for their anti-helmintic activity against *Pheretima posthuma* and *Ascardia galli*. All extracts exhibited a dose dependent (25, 50 and 100 mg/ml) inhibition of spontaneous motility (paralysis) and time of death of the worms<sup>35</sup>. Extract obtained from bark not only killed the *Pheretima posthuma* but also killed the *Ascardia galli*. The observations were comparable with standard drug piperazine citrate at a concentration of 20 mg/ml and distilled water as control. Maximum vermicide activity was shown by both extract at the concentration of 100 mg/ml. From the experiment performed, it can be said that the aqueous and chloroform extract of bark of *B. variegata* bearing a potential anthelmintic activity<sup>35</sup>.

#### Insecticidal activity

Plant extract act as an effective measure for controlling insect pest like *Plutella xylostella*. *B. variegata* var. candida is a promising source of edible wild vegetable flowers with plenty of nutrients. This plant may serve as a potential source for low cost proteins. The tree is susceptible to 'Brown Root Rot' caused by *Phellinus noxius*<sup>80</sup>. The abundance of phytophagous mites is higher, being *Lorryia formosa* Cooreman the dominant species<sup>81</sup>.

#### Molluscicidal activity

Singh *et al.*<sup>28</sup> & <sup>29</sup> reported that *Bauhinia variegata* leaf is a potential source of molluscicides against snail *Lymnaea acuminata* and *Indoplanorbis exustus*. These snails are the intermediate host of liver fluke *Fasciola hepatica* and *Fasciola gigantica*, which causes 94% fascioliasis in the buffalo's population of Eastern Uttar Pradesh in India<sup>82</sup> & <sup>83</sup>. The active molluscicidal component of *Bauhinia variegata* leaf is soluble in organic solvent such as acetone, carbon tetra chloride, chloroform, ether and ethanol. The toxicity of ethanolic extract of *Bauhinia variegata* leaf powder is higher than other organic solvents. Singh *et al.*<sup>28</sup> characterized that quercetin is the active component present in *Bauhinia variegata* leaf by column chromatography and thin layer chromatography. Toxicity of 96h exposure period of column purified fraction of *B. variegata* leaf (LC<sub>50</sub> -5.98 mg/l) against *L. acuminata* is lower than the values of synthetic molluscicides- carbaryl (14.40 mg/l)<sup>84</sup>, phorate (15.0 mg/l)<sup>84</sup>, formothion (8.56 mg/l)<sup>84</sup> and aldicarb (11.50 mg/l)<sup>84</sup>. Plant molluscicides of *Thuja orientalis* fruit powder (255.12 mg/l), *Areca catechu* powder (36.59 mg/l), *Termanalia chebula* fruit powder (93.59 mg/l), *Morus nigra* fruit powder (166.92 mg/l) *M. oleifera* leaf powder (602.75 mg/l),<sup>85, 86 & 87</sup>, respectively. Further, treatment of sublethal concentration (40% and 80% of 96h LC<sub>50</sub>) *in vivo* of column-purified fraction of *B. variegata* leaf and their active component quercetin inhibit the acetylcholinesterase (AChE), acid and alkaline phosphatase (ACP and ALP) activities in the nervous tissue of *L. acuminata*. AChE activity was more inhibited than ACP and ALP in snail exposed to column purified fraction of *B. variegata* leaf and their active component quercetin<sup>31</sup>.



## Other therapeutic value:

### Antihyperlipidemic activity

Ethanollic and aqueous extracts of the stem bark and root of *B. variegata* shows antihyperlipidemic activity against albino rat. It showed significant ( $p > 0.05$ ) reduction in cholesterol and triglyceride level. The very low density lipids (VLDL) level was also significantly reduced, with a significant increase in high density lipid (HDL)<sup>53</sup>.

### Immunomodulatory activity

Ethanollic extract of stem bark of *B. variegata* shows the Immunomodulatory activity on the primary and secondary antibody responses by humoral antibody response for specific immune response. Phagocytic activity test and neutrophil activation test were evaluated by the carbon clearance and neutrophil adhesion test for a nonspecific immune response respectively. Increase in phagocytic index and percentage neutrophil adhesion at the doses of 250 and 500 mg/kg has been noted<sup>45</sup>. The acetone-water, aqueous extracts and isolated compound (tannin) of *B. variegata* stem bark were screened for their possible immuno-modulatory activity by assessing nitro blue tetrazolium test, phagocytosis of killed *Candida albicans*, candidacidal assay, neutrophil locomotion and chemotaxis<sup>46</sup>. All the extracts were tested at concentrations viz. 10 µg/ml, 20 µg/ml, 50 µg/ml, 100 µg/ml and 1000 µg/ml. The acetone:water and isolated compound of *B. variegata* stem bark showed predominantly significant activity on *in vitro* human neutrophils<sup>46</sup>.

### Hepatoprotective activity and anti-asthmatic activity

The some experimental studies have revealed that *B. variegata* showing antiasthmatic and hepatoprotective effect. Ethanollic extract of stem bark of *B. variegata* exhibited significant

hepatoprotective activity against carbon tetra chloride induced hepato toxicity in Sprague Dawbey rats at the dose of 100 and 200 mg/kg. Oral administration of ethanollic extract decreases the level of allenin-s-transferase, alkaline phosphatase (ALP), gamma glutamate transferase, total lipids and increase the level of total protein which increases during the hepato toxicity and decrease the level of total protein<sup>47</sup>. Ethanollic extract of stem bark of *B. variegata* exhibit highly significant reduction ( $p > 0.001$ ) in aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP) and total bilirubin. The ethanollic extract has decreasing the extent of centrilobular necrosis, fatty changes and congestion of sinusoids when compared to  $CCl_4$ <sup>48</sup>.

### Proteinase Inhibitor

Different species of *Bauhinia* seeds inhibit blood clotting enzymes, as well as other serine and cysteine proteinases<sup>88</sup>. Two varieties *B. variegata* seeds, shown to possess through *B. variegata* trypsin inhibitors, viz. *Bauhinia variegata* Candida trypsin inhibitor (Bvc TI) and *B. variegata lilac* trypsin inhibitor (BvITI) are proteins about 20,000, with four cysteine residues forming two disulphide bridges in one polypeptide chain<sup>88</sup>. The complete sequences have been determined by automated Edman degradation of the reduced and carboxymethylated proteins of the peptides resulting from *Staphylococcus aureus* protease and trypsin digestion<sup>88</sup>.

### Nephroprotective

The nephroprotective activity of the ethanollic extract of *Bauhinia variegata* (Linn.) whole stem against cisplatin-induced nephropathy was investigated by an *in vivo* method in rats<sup>52</sup>. Treatment with the ethanol extract of *Bauhinia variegata* at the dose

level of 400 mg/kg body weight for 14 days significantly minimized the serum level of creatinine and urea, decreased urine creatinine and albumin with a significant weight gain, and increased urine output when compared with the toxic group. The histological damages in the *Bauhinia variegata* extract-treated group were minimal in contrast to the toxic rats<sup>52</sup>.

#### Anti-ulcer activity

Ethanollic extract of stem bark of *B. variegata* shows the anti-ulcer activity against gastric ulcer induced by pyloric ligation and aspirin induced ulcer model in rats. Ethanollic extract the volume of gastric secretion, total, free acidity and ulcer index with respect to control which increase during ulcer<sup>36</sup>.

#### Antigoitrogenic

Ethanollic extracts of *B. variegata* shows antigoitrogenic activity against neomercazole induced goiter<sup>54</sup>. From these studies, it was concluded that ethanollic extract of *B. variegata* showed significant antigoitrogenic activity at the dose of 200 mg/day<sup>55</sup>.

#### Wound healing activity

The ethanollic and aqueous extracts of root of *B. variegata* shows wound healing activity against Albino Wister rats at dose of 200 and 400 mg/kg body weight<sup>56</sup>. Both aqueous and ethanollic extracts of root *B. variegata* at both doses produced significant wound healing by excision and incision wound models, which was comparable to that of standard in excision wound model<sup>56</sup>.

## CONCLUSION

On the basis of above literature *B. variegata* are noted in folk medicine against a variety of ailments such as cancer, diabetes, inflammation and infections. Its biological/pharmacological properties of *B.*

*variegata* and active ingredients has well documented in recent years. Considering the overall benefits of the plant it can be advocated as an important medicinal plant for mankind. Now more explore is required to establish the active ingredient which is responsible for the mode of action.

#### Conflict of Interests

The authors declare that there is no conflict of interests.

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**Table 1.** Multidimensional properties of *Bauhinia variegata* plant.

<i>Bauhinia variegata</i> activity	Parts used	Medium	Reference
Molluscicidal	Leaf, stem bark,	Aqueous/ Organic	Singh <i>et al.</i> <sup>28-31</sup> .
Antimicrobial	Leaf, Stem bark	Aqueous/ Organic	Dhale, <sup>13</sup> ; Parekh <i>et al.</i> <sup>32</sup> ; Uddin <i>et al.</i> <sup>33</sup> ; Shahu and Gupta, <sup>34</sup> .
Anthelmintic	Bark	Aqueous/ Organic	Bairagi <i>et al.</i> <sup>35</sup> .
Antiulcer	Stem bark	Organic	Raj Kapoor <i>et al.</i> <sup>36</sup> .
Anti-inflammatory	Leaf, stem bark, root	Aqueous/ Organic	Rao <i>et al.</i> <sup>37</sup> ; Cipek <i>et al.</i> <sup>38</sup> ; Shaha <i>et al.</i> <sup>39</sup> ; Bairagi <i>et al.</i> <sup>40</sup> .
Antidiabetic	Leaf, stem bark	Aqueous/ Organic	Azevedo <i>et al.</i> <sup>27</sup> ; Lino <i>et al.</i> <sup>41</sup> ; Dewangan <i>et al.</i> <sup>42</sup> .
Anti-tumour/ cytotoxic	Stem, bark	Organic	Sinha and Verma, <sup>2</sup> ; Raj Kapoor <i>et al.</i> , <sup>43</sup> ; Pandey <i>et al.</i> <sup>44</sup> ;
Immuno-modulatory	Stem, bark	Aqueous/ Organic	Kritikar and Basu, <sup>45</sup> ; Patil <i>et al.</i> , <sup>46</sup> .
Hepatoprotective	Stem, bark	Aqueous/ Organic	Bodake and Ram, <sup>47</sup> ; Manoj <i>et al.</i> , <sup>48</sup> .
Antioxidant	Leaf, bark, root	Aqueous/ Organic	Sharma <i>et al.</i> <sup>49</sup> ; Mishra <i>et al.</i> <sup>50</sup> ; Pandey <i>et al.</i> , <sup>51</sup> .
Nephroprotective	Stem bark	Organic	Panda <i>et al.</i> , <sup>52</sup> .
Antihyperlipidemic	Stem bark and root	Aqueous/ Organic	Rajani and Ashoke, <sup>53</sup> .
Antigoitrogenic	Stem bark	Organic	Veena <i>et al.</i> <sup>54</sup> ; Srivastava <i>et al.</i> <sup>55</sup> .
Wound healing	Root, Seed	Aqueous/ Organic	Sharma, <sup>56</sup> .