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REVIEW ARTICLE

Medicinal Significance and Uses of Orchid Tree (*Bauhinia variegata*)

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ABSTRACT

Background: Plants extracts are traditionally used in the treatment of quite a large number of ailments. Orchid tree (*Bauhinia variegata* L.) is traditionally used for the treatment of several diseases.
Objective: The aim of this review was to highlights some therapeutic effects of the products obtained from the extracts of orchid tree with their potential therapeutic properties.
Methodology: Review of literature to summarize the role of *B. variegata* in treatment and management of numerous diseases was performed. Search engines such as Google Scholar, Pub med, Web of Science etc. were used. The keywords *B. variegata*, diseases, medicinal, therapeutic, antidiabetic, antioxidant, antimicrobial were used.
Results: Different phytochemicals such as tannin, terpenoids, cardiac glycosides, saponins, flavonoids, kaempferol and reducing sugars are present in several parts of the plant. Quercetin, rutin, apigenin and glucoside are flavonoids that are present in different parts of *B. variegata*. It has immune-modulatory, anti-bacterial, anti-carcinogenic, anti-diabetic, hepatoprotective, anti-inflammatory and antioxidant activities.
Conclusion: Orchid tree (*B. variegata*) is a source of quite a large number of phytochemicals with great therapeutical properties and effects. The root extract has cholesterol and lipoproteins lowering properties. Stem and root extracts are also rich in flavonoids and effective in blocking HMG-CoA. With these properties, the orchid tree is a target plant for future research for exploring a greater number of phytochemicals with their health improving properties and effects.

INTRODUCTION

All over the world several plants are used to heal a variety of human disorders. *Bauhinia variegata* L., commonly known as Orchid tree or Mountain ebony, is also included among these thousands of medicinal plants. It belongs to the family Fabaceae and is native to Asia. Each part of *B. variegata* has its own set of therapeutic properties. The presence of several vigorous components such as proteins, steroids, tannins, flavonoids, resins, carbohydrates and cardiac glycosides is confirmed with phytochemical screening in *B. variegata* leaves, stem, flower and bark extracts. Pharmacological studies revealed that *B. variegata* has antimicrobial, anticancer, anti-inflammatory, antiulcer and hepatoprotective activities (Tshidino and Montsho 2017; Kumar *et al*. 2019). This review highlights some medicinal properties of *B. variegata.*

ANTIMICROBIAL ACTIVITY

Antimicrobial compounds play critical role in lowering the worldwide problem of infectious disorders. The growth and spread of multidrug resistant strains among some pathogenic bacteria, on the other hand, is rise as a major public health concern. Still, only a few effective antimicrobial compounds are present. In health care services fungal and bacterial infections make up the majority of illnesses. Though, 90% of these diseases are caused only by the bacterial infection.

A large variety of therapeutic plants have been acknowledged as significant suppliers of natural antibacterial substances. Different phytochemicals are produced in the plant's secondary metabolism that makes the plants effective against microbial resistance and diseases. *Salmonella typhi* and *Escherichia coli* are resistant to synthetic antimicrobial agents, however these microbes

are sensitive to extracts of different parts of *B. variegata.* Different phytochemicals extracted with ethanol from the bark of the *B. variegata* was efficient against gram-negative and gram-positive bacteria and also useful against fungus infections (Ahmed *et al.* 2012). *B. variegata* has dynamic antimicrobial activity because of the presence of different subordinate metabolites such as flavonoids, terpenoids, tennis and alkaloids.

Phenolic compounds inhibit the microbial activity through reaction with -SH groups or protein interaction, in this reaction phenolic compounds cause enzyme inhibition by oxidizing compounds (El-Moula *et al*. 2019). In different plant extracts, flavonoids are present which show antimicrobial potential. These plant-derived flavonoids can also be effectively used to fight against human pathogens. Flavonoids are hydroxylated phenolics constituents and are produced by plants in response to bacterial diseases (Mishra *et al.* 2013). Several plants developed flavonoids are very important in the treatment of bacterial diseases because these compounds use different mechanisms for treatment than those of synthetic drugs. Plasma membrane of bacterial cell performs different functions for the maintenance of the cell including lipid biosynthesis, osmoregulation, process of transport and respirations, as well as peptidoglycan synthesis and cross-linking. Plasma membrane integrity plays crucial role in performing all above functions and any interruption in membrane can indirectly or directly leads to dysfunction of metabolism and at the end death of bacterial cell occur. Antimicrobial agents that derived from the plants are the big available source for treatments. Plant-based antimicrobials have a lot of therapeutic capability as they can fix the problem without adverse effects that synthetic antimicrobials have. Today, more research and development of plant-based antimicrobials is required (Gunalan *et al.* 2011).

ANTIDIABETIC ACTIVITY

For the treatment of diabetes mellitus, herbal medications play a crucial role. Medicinal plants have been shown to offer potent anti-diabetic activities with no destructive side effects. These plants are rich source of antidiabetic chemicals which increase pancreatic tissue efficiency by releasing insulin secretion or by inhibiting the absorption of glucose in the intestine. According to the literature there are almost 410 scientifically proved therapeutic plants with antidiabetic activities but only 109 of them have been studied with their complete mechanisms. Carbohydrate metabolism and assimilation, tricarboxylic acid cycle, glycogen synthesis and breakdown, glycolysis, synthesis and release of insulin, gluconeogenesis and cholesterol synthesis have all been found to be modulated by extracts of several therapeutic plants (Jacob and Narendhirakannan 2019). Plants' antihyperglycemic action is mostly related to their capability to reestablish the function pancreatic tissue by inhibiting glucose absorption in the intestine, increasing insulin secretion, or facilitating different metabolites in insulin dependent diabetes mellitus. Different tissues and cells often develop a resistance to the endogenic insulin that's why most diabetic people are suffering from the non-insulin dependent diabetes. By the use of herbal medicinal substances, resistance of the cells can be converted into sensitivity (Choudhury *et al.* 2018).

Recently, it has been revealed that leaves of *B. variegata* contain proteins that have insulin-like properties. This protein is found in chloroplasts of the leaves and has the same amino acid sequence as bovine insulin. When injected into diabetic rats, this protein may be able to control the levels of glucose into the blood. This protein may be responsible for decreased level of blood glucose. The leaves consist of roseoside, a main metabolite which exhibits insulinotropic activities (Shahana and Nikalje 2017).

A study was conducted by Shahana and Nikalje (2017) in which oral administration of hydro-alcoholic, aqueous and ethanolic extracts of *B. variegata* bark and leaves showed considerable antidiabetic activity. After the administration it was seen that extracts of plant improved the glucose metabolism and lowered the high level of glucose in blood at different doses. During *in vitro* research, it was found that an ethanolic extract of *B. variegata* leaves and its primary ingredient roseoside enhanced insulin production in the β-cell line. Bark extracts regenerated the β-cells and normalized the level of blood glucose.

The hypoglycemic effect of plant is due to the presence of flavonoids which is shown the property of insulin production besides having the ability to improve the redevelopment of β-cell and inhibit the enzyme cyclooxygenase. In non-diabetic and diabetic rats, the effects of plant extracts were assessed on serum lipid profile such as low-density lipoproteins (LDL), high-density lipoprotein (HDL), total cholesterol, phospholipids, very low-density lipoprotein (VLDL), very high-density lipoprotein (HLDL), triglycerides and blood glucose level. After this assessment it was seen that there is effective improvement in high-density lipoproteins and significant reduction in low-density lipoproteins and cholesterol. The result of this study proves that the *B. variegata* have an incredible hypoglycaemic effect (Fig. 1).

After treatment with ethanolic leaves extract of *B. variegata,* glucose levels of plasma in both kinds of diabetes were observed to be considerably lower. The antidiabetic activity of ethanolic extract was comparable to that of glipizide medicine. The activity of ethanolic extract in reducing plasma glucose levels was seen without a significant change in plasma insulin level. Ethanolic extracts of *B. variegata* leaves do not have any expressive side effects on liver enzymes like alkaline phosphatase, alanine amino transferase and aspartate amino transferase in both types of diabetes. In diabetic rats, ethanolic extracts of leaves significantly increase the level of albumin and total proteins. These extracts also improve the function of kidney by reducing the levels of blood urea nitrogen (BUN) and creatinine (Gurjar *et al.* 2018).

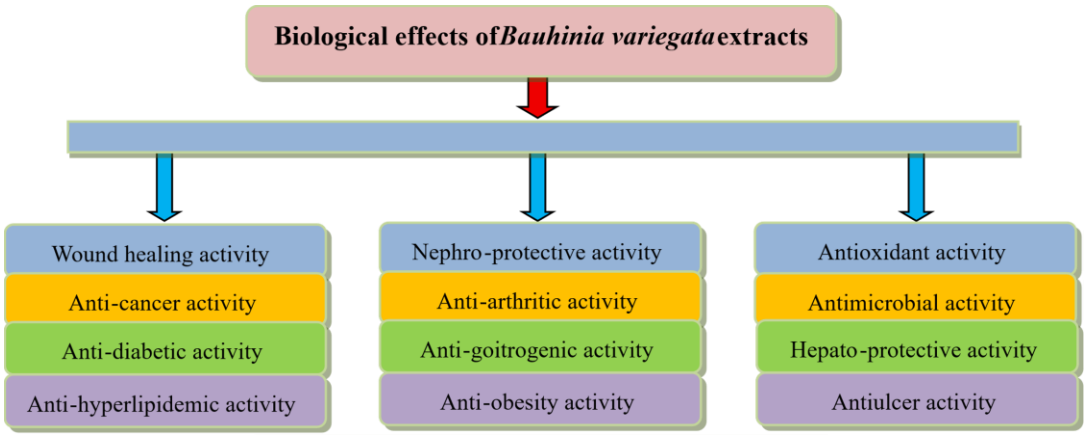

Fig 1: Therapeutic properties and effects of *B. variegata* plant extracts

The antidiabetic effect of *B. variegata* bark extract was as good as the metformin, which lowers both postprandial hyperglycaemia and fasting by the promotion of insulin facilitated exterior glucose utilization and metabolism in adipose tissues. Skeletal muscles provide some endogenic insulin through the upregulation of glucose transporter. However, detailed mechanism of hypoglycaemic activity of *B. variegata* bark extracts is unknown. It is possible that the extract works in the same way that metformin does or enhancing insulin activity at the cellular level. In previous investigations, antidiabetic herbs showed antihyperglycemic activities in diabetic rats by boosting insulin action or glucose homeostasis or promoting glucose metabolism. The antihyperglycemic activity of *B. variegata* bark extract could be explained by a similar mechanism. The occurrence of insulin-like proteins in *B. variegata* leaves extract is the reason of hypoglycemic effects of leaves. The bark extract, on the other hand, had no such hypoglycemic impact. Important antihyperglycemic activities were observed in *B. variegata* bark extracts, which could be due to improved glucose metabolism (Kumar *et al.* 2012).

ANTIOXIDANT ACTIVITY

In recent years, isolated compounds from the plant or the antioxidant potential of herbal plant extracts, has grabbed the people's attention because of the statement that free radical have been linked to a variety of disorders as well as the ageing progression. In many biological routes, free radical reactions particularly with the involvement of oxidative radicals have been shown that giving elevation to a different type of disorders by causing damage to nucleic acid, lipids, membranes and proteins. In the origination and development of several disorders including cardiovascular diseases, inflammatory damage, atherosclerosis and cancer, reactive oxygen species play a significant role. All oxygen-using organisms produce reactive oxygen species due to the regular metabolic activities (Saraswathy *et al.* 2011).

The antioxidant property of *B. variegata* ethanol root extracts was achieved by free radical scavenging *in vitro* using the chemicals super oxide, (DPPH) 1,2-diphenyal-1,2 picrylhydrazyl and nitric oxide (Rajani and Ashok 2009). When compared with other extracts, the ethanolic extracts had much higher antioxidant activity. Antioxidant property of any herbal plant is dependent upon the occurrence of whole phenolics molecules. The antioxidant property of plant extracts is proportional to the quantity of total phenolic content present. Both the ethanolic and aqueous extracts of roots had significant antioxidant property by scavenging a range of free radicals such as nitric oxide (NO), 1,2-di phenyl 1,2-picrylhydrazyl (DPPH) and superoxide (SO) (Kumar *et al*. 2020).

Pandey and Agarwal (2009) found the antioxidant property in the *B. variegata* methanolic extract by suppressing the production of thiobarbituric acid reactive substances (TBARS) *in vitro*. They discovered flavonoids, tannin, and other phenolic compounds in plant extracts. Fractions and crude extracts of *B. variegata* were also used to test the antioxidant activity of plant. According to the study, in comparison to traditional quercetin, the elements of ethyl acetate, n-hexane and methanol show different scavenging efficacy.

In another study, the antioxidant and DNA-protective properties of a methanol extract from tree bark were evaluated. The findings revealed that methanolic extract has significant antioxidant activity and may protect pBR322 DNA from oxidative impairment. In the bark of B. variegata different compounds like flavonoids and phenols are present that play significant role in antioxidant activity DNA protection. The separation of bioactive phytoconstituents such as lupeol, sitosterol, quercetin, and kaempferol was achieved through chemical analysis of a methanolic extract from the stem of *B. variegata*. These phytochemicals extracted from plants have been thoroughly investigated and are known to exhibit significant biological activity (Kumar *et al.* 2020). Because of its reducing capacity, radical

neutralization and strong binding leaf extracts *B. variegata* could counteract oxidative impairment (Mishra *et al*. 2013). As compared to stem bark and leaf extracts of plant, extracts from floral buds show most powerful antioxidant property (Pandey 2017; Shahana and Nikalje 2017).

ANTICANCER ACTIVITY

Cancer is a term used to describe a group of disorders in which aberrant cells divide uncontrollably and can infect neighbouring tissues. Cancer is the biggest reason of mortality in all over the world, and it has a significant social impact. It is a significant impediment to extending life hope in the twenty-first century. The World Health Organization (WHO) claims that, cancer claimed the lives of 9.6 million people last year. Cancer is the most serious medical problem confronting our world today. It is becoming more common over the world, and the mortality toll continues to rise. It has become so common that we will almost certainly all be affected by it at some point in our lives, whether we get cancer to ourselves or know someone who suffer from cancer. The nature and phase of cancer determine the treatment options. The majority of patients receive a mix of therapies, such as radiation therapy and chemotherapy along with surgery (Yun *et al*. 2021).

Therapeutic plants and traditional drugs are inexpensive, effortlessly accessible and sometimes free of cost. Ethnopharmacological studies on therapeutic plants, which have historically been used to cure cancer, were lately examined using scientific databases. However, in rural regions, the finding of unfamiliar shrubberies that may be used for the treatment of cancer is still a hot subject (Agyare *et al*. 2018).

Ethanolic extracts of plants had a substantial role in cytotoxic and anticancer activities, as well as being useful in the reduction of liver cancer and human cancer lines (Naeem and Ugar 2019). Extracts of different parts of Kachnar have the ability to reverse tumor induced alterations in the proteins and different haematological parameters. Similarly, they discovered that giving extract of Kachnar to people orally reduced the growth of solid tumours (Lim 2014).

Different compounds extracted from plants stimulate cell death and cell cycle arrest in many tumor cells and show anticancer activities. Cancer can be treated more effectively by the combining of *B. variegata* extracts and chemotherapy as compared to only plant extract. These extracts from plants decrease the volume of cancer cells and increase the survival time of organisms, also reduce the cancer doubling time. In the assembly of different cellular developments such as proliferation, cell differentiation and apoptosis, glutathione play a significant role in cancer inhibition. Any instabilities in the level of glutathione lead to the development of many human sicknesses as well as cancer. Reduced levels of glutathione cause cancer because susceptibility to oxidative stress is raised. Treatment of cancer with *B. variegata* extracts raised the level of glutathione and restored the antioxidant contents in the body. Anticancer activity of *B. variegata* may be because of the free radicals and antioxidant scavenging ability (Pandey 2017).

An *in vitro* study discovered that extracts of *B. variegata* inhibited the growth of several cell lines, indicating that it was anti-tumor. In another study it was stated that methanol extracts of plant leaves at different doses of 300, 600 and 900 mg/kg showed anticancer activity by maintaining the composition of chromosomal abnormalities and micro molecules in cyclophosphamide induced cancer in cells of bone marrow in experimental rats (Singh *et al*. 2019).

There are several reports present, revealed that different phytochemical compounds such as phenols, polyphenols and flavonoids aids as a growth inhibitor or toxic to the cancerous cells because of their biological connections with the further biological developments, different enzymes and proteins. Furthermore, flavonoids have the impressions on signal transduction in angiogenesis and cell proliferation that's why also show the anticancer activities. The stem flavonoids of *B. variegata* found to exhibit cytotoxic effect against lymphoma, leukaemia, Dalton's ascetic and a variety of other cancer cell lines. It has been stated that against the ovarian cancer cell lines flavonoids in *B. variegata* have been found to be extra selective. In the future, further extensive study on the separation and categorization of exact chemical medieties from the leaf extract of *B. variegata* as well as biological tests, could lead to the development of a harmless anticancer drug (Mishra *et al*. 2013).

HEPATOPROTECTIVE ACTIVITY

Liver serves as significant organ for the detoxification of different cellular waste materials. Thus, liver dysfunction (hepatopathy) can progress to multi-organ stoppage and, ultimately, death of organisms occurs (Pani *et al.* 2011a, b). Hepatoprotective substances can be found in large quantities in herbal medicines. In the treatment of numerous liver ailments, mono- and polyherbal formulations have been employed. In experimental rat, ethanolic extract of *B. variegata* stem showed the hepatoprotective activities against the liver tumor that was induced by N-nitrosodiethylamine. N-nitrosodiethylamine-induced liver tumors were suppressed by ethanolic extract of plant stem, as evidenced by a reduction in N-nitrosodiethylamine-induced raised levels of lipid peroxidase, total bilirubin, oxaloacetate transaminase, serum glutamate, glutathione peroxidase, gamma glutamate trans peptides, pyruvate transaminase and alkaline phosphatase (Al-Snafi *et al.* 2019).

Hepatotoxins raise total lipid levels in the liver. In carbon tetrachloride (CCl_4) intoxicated rats, alcoholic extract of *B. variegata* bark showed great hepatoprotective

activity. In these rats, whole lipid content in liver and blood increased significantly but after the treatment with stem bark extract of plant their concentrations returned to normal level. This is a strong sign that the liver cells' functional integrity was improved. The liver's ability to produce albumin is harmed by CCl_4. As a result, the protein level of serum drops in such situations. The hepatoprotective activity of *B. variegata* bark extract and its usage as a liver tonic was further confirmed by the restoration of protein concentration to normalcy (Negi *et al.* 2012).

Gul *et al.* (2021) administered methanolic flower extract of *B. variegata* to CCl4 intoxicated rats, which showed considerable hepatoprotective movement. Concentrations of several enzymes and bilirubin increased after administration of CCl_4. However, after ingesting methanol flower extracts bilirubin and levels of different enzymes decreased. Reportedly, the function of cells is improved by flavonoids present in *B. variegata* and can block hepatocytes cellular leakage caused by CCl_4. Correspondingly, with bilirubin, the ranges of AST, ALP, ALT and GGT were effectively controlled with numerous dosages of flower extracts. Flower extracts of *B. variegata* were also useful in the treatment of hepatocyte pycnosis, inflammation and breakdown of liver cells, which are caused by CCl_4. Histological studies revealed that *B. variegata* has the potential for the medication of liver cell damage because of the presence of flavonoids.

NEPHROPROTECTIVE ACTIVITY

In vivo study of *B. variegata* demonstrated that ethanolic extracts of plants are related with nephroprotective activities. In a study in rats, in which nephropathy was artificially induced by the use of cisplatin, it was reported that giving the ethanol extract of *B. variegata* at different doses of 400 and 200 mg/kg for 14 days extensively reversed the impacts of cisplatin. The plant extract raised the output of urine volume, body weight and also lowered the blood concentration of the urea and creatinine at the dosage of 400mg/kg. Histological destructions were lower in rats treated with the extracts of *B. variegata* as compared to intoxicated rats. Statistical significance of nephroprotective activity of BV-treated group and the polyherbal drug cystone (standard group)-treated group (both the groups were compared against toxic control) were found almost equal as both groups gained same level of significance (P<0.001) against the toxic group in most of the parameters including serum urea and creatinine (Kumari *et al*. 2021).

The repressive impact of *B. variegata* leaves on lipase and amylase enzymes was investigated during the research that is directed by Patil *et al*. (2017). Salivary gland and pancreas release the α-amylase which is participating in carbohydrates breakdown. In herbal medicines obtained from medicinal plants inhibitors of α-amylase is present which is found to be very advantageous in lowering the hyperglycaemia of post prandial. Alpha amylase inhibitors improve hyperglycaemia by reducing carbohydrate ingestion and glucose absorption, which reduces the uptake of glucose into adipose tissues and decreases triacylglycerol production and storage. Pancreatic lipase hydrolyzed the dietetic lipids into 2-monoacyalglycerol and fatty acids for their intestinal absorptions. Therefore, diet induced obesity can be significantly treated by inhibiting the activities of pancreatic lipase and α-amylase which are digestive enzymes. By using varied doses of extracts, the inhibitory effect of *B. variegata* leaves extract against pancreas and lipase enzyme was determined. On pancreatic lipase and α-amylase, numerous solvent extracts of plant revealed a dose dependent inhibitory action. Highest α-amylase repressing activity represented by the methanolic extracts of *B. variegata* as compared to acetone extract. Similarly, methanol extracts inhibited lipase activity the most, while acetone extract inhibited it the least (Patil *et al*. 2017).

WOUND HEALING ACTIVITY

Any damage or break to the anatomical, functional or cellular stability of the living cells is defined as the wound. The process which involves the repairing of soft tissues such as the skin after wound is known as wound healing process. An inflammatory reaction starts after an injury, and group of cells beneath the skin are activated to produce more collagen protein. After the production of collagen epithelial tissue is regenerated at the site of injury (Rajput and Gohil 2020). *B. variegata* plays a vital role in wound healing that has been used for many years as a healing agent (Naeem and Ugar 2019). Tannins and flavonoids are present in *B. variegata* extract which stimulate the wound curative activity by their antioxidant potential and antimicrobial properties. Triterpenoids can also boost collagen production, which aids in wound healing (Rajput and Gohil 2020).

For the stimulation of the wound healing process lectins act on immune system cells, angiogenesis pro-inflammatory response and collagen synthesis by moderating the release of growth factor and inflammatory cytokines (Cagliari *et al.* 2018). From *Bauhinia* species, just a single lectin protein has been confirmed for the wound healing activity (Cagliari *et al*. 2018). Recently, a recombinant isoform of *B. variegata* lectin (rBVL-1) became available through cloning in *Escherichia coli*. This isoform has similar amino acid and DNA sequence to other familiar Caesalpinoideae lectins. Healing possibilities of *B. variegata* lectins (nBVL) and recombinant lectins (rBVL-1) can be investigated on skin wounds that are artificially induced (Negi *et al*. 2012).

Pro-healing activities are also present in the recombinant isoform of the lectins. Subsequent phenotypic change of fibroblast into myofibroblasts and discharge of different growth factors could explain the experimental speed of wound healing. Even in inflammatory phase fibroblast produce large amount of collagen at injury site and carry out quicker wound shrinkage (Negi *et al*. 2012).

ANTI-HYPERLIPIDEMIC ACTIVITY

Dyslipidemia is characterized by irregular levels of lipoprotein and lipid in the blood. Dyslipidemia is frequently caused by accumulation of high amounts of lipids in the different tissues and blood, an illness known as hyperlipidemia, which is a primary basis of cardiovascular and insulin resistance disease. The appearance of a pro-inflammatory response and hyperlipidemia in the body are due to the increased ingestion of n-6 fatty acids and saturated fats in the diet (Bettadahalli *et al*. 2020).

For the development of heart and circulatory problems hyperlipidemia is a most common risk factor (Kumar *et al*. 2011). Disorders of plasma lipoproteins and instabilities to lipid metabolism are closely linked to the congestive heart failure and atherosclerosis (Rajani and Ashok 2009). Hyperlipidaemia can be treated with a variety of synthetic medicines. Plants' antihyperlipidemic action is significant in lowering the risk of cardiovascular disease. Plant extracts or phytochemical components are sometimes more effective than established hypolipidemic drugs (Asija *et al*. 2016). *B. variegata* stem and root extracts showed an important lowering effect in low-density lipoproteins and cholesterol. This proves that *B. variegata* not only decreases the production rate but may also decrease the absorption of body cholesterol.

Flavonoids are rich components of root and stem extracts that block the activity of HMG-CoA. *B. variegata* ethanolic and aqueous extracts of stem and root decrease the levels of triglyceride by triggering the lipoprotein lipase (LPL). Lipoprotein is a leading enzyme associated with the metabolism of triglyceride. Additionally, very low-density lipoprotein concentrations were also reduced *by B. variegata* extracts. Extracts of *B. variegata* increased the level of high-density lipoprotein and showed defensive action. Increased high-density lipoprotein causes the breakdown of cholesterol and triglyceride in the liver (Rajani and Ashok 2009).

CONCLUSION

The information gathered from various sources has revealed that *B. variegata* is a source of quite a few phytochemicals with great therapeutical effects such as regulating the blood, glucose, lipids and lipoprotein levels. Different parts of plant leaf, root, stem, stem bark, floral parts show therapeutic effects and control different ailments. For instance, stem and root extracts are rich in flavonoids and effective in blocking HMG-CoA. Root extract has cholesterol and lipoproteins lowering properties. With the abovementioned effects, *B. variegata* is a target plant for exploring more phytochemicals with their health improving properties and effects.

AUTHOR CONTRIBUTIONS

AA completed the literature search; IS assisted in write-up, rephrasing and final draft preparation; FH designed and supervised the work and finalized draft of manuscript.

CONFLICTS OF INTEREST

We, the authors have “no conflict of interest”

DATA AVAILABILITY

The data will be made available on a fair request to the corresponding author

ETHICS APPROVAL

Not applicable

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