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REVIEW ARTICLE

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EXPLORING THE MEDICINAL BENEFITS AND THERAPEUTIC APPLICATIONS OF *PHASEOLUS VULGARIS* LINN A COMPREHENSIVE REVIEW

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ABSTRACT: *Phaseolus vulgaris*-the commercial bean-is one such staple with nutritional value recognized the world over. Besides being an important food, lately its high concentration of phytochemicals has shown some potential medicinal uses. Its bioactive components range across wide pharmacological activities. This review discusses some of the most relevant micronutrients, proteins, flavonoids, and phenolic acids contained therein. This review highlights in detail the antioxidant, antidiabetic, anti-inflammatory, anticancer, and cardioprotective actions by *in vitro* and *in vivo* studies. Also, antimicrobial and weight management application of this legume adds to its vigor as a multifaceted therapeutic agent. The toxicological properties of *P. vulgaris* such as toxicity via a raw form and means of ingestion and dosage have also been documented. This review demonstrates that *Phaseolus vulgaris* is much more than a source of caloric sustenance and seriously suggests new medical or nutraceutical possibilities. These findings underline the necessity for far more studies on this versatile legume's medicinal properties in order to employ it properly in modern healthcare.

Keywords: *Phaseolus vulgaris*, phytochemicals, pharmacological activities, medicinal applications, nutraceutical.

I. INTRODUCTION

Phaseolus vulgaris Linn- the commonly known common beans a widely consumed basic food as well as medicinal herb with large therapeutic potentials. It is a high-quality protein, high in fiber as well as an excellent source of vitamins and minerals that are the major food staple for many populations [1]. Because however beyond nourishment, what else is this vegetation worth. Traditional medicine has employed *P. vulgaris* historically and from time immemorial, sometimes practically in consumption for the treating inflammatory disorders, infections as well as stomach related tract illnesses [2]. *Phaseolus vulgaris* has an incredible preparation of bioactive compounds, namely lectins, flavonoids, and phenolic acids, which possess high medicinal potentials [3]. The great pharmacological effects of these compounds were originally recognized through herbal medicine use, and ongoing studies have only begun to unveil its bioactivity. The properties of antioxidant, antidiabetic, anti-inflammatory, anticancer, and cardioprotective activities of this species have recently begun appearing in the scientific literature [4, 5]. This review aims to compile a work that is purely focused on important medicinal values and potential therapeutic uses of *Phaseolus vulgaris* Linn. This will make the members of this little legume interesting and develop nutraceuticals and therapeutic agents. This will, by virtue of point synthesis between the antiquated wisdom and erstwhile scientific facts, open up fields for further research and utilize the potential for clinical use.

2. Botanical Description and Distribution

2.1. Botanical Features of Phaseolus vulgaris Linn

A typical bean Linn, the herbaceous annual plant more often known as the common bean, is a member of the Fabaceae family [6]. The plant's general form can be characterized as bushy or climbing, and its stems can reach a height of two or three meters, depending on the species. The leaves have a little hairy or smooth texture and are trifoliate, meaning they consist of three leaflets. Elongated pods with many seeds emerge from the white, pink, or purple blooms of *P. vulgaris*. Different varieties have different sized and shaped seeds that can be white, black, brown, or speckle. Essential to the plant's survival, the pods (which can range in length from 8 to 20 centimeters) encase the seeds, which are the principal edible element. P. vulgaris has a robust root system that helps it fix nitrogen from the soil, which in turn makes the soil more fertile [7].

2.2. Global Distribution and Environmental Conditions

Phaseolus vulgaris Linn-genus is cultivated worldwide in the Americas, Africa, Asia, and Europe. Extreme adaptations, which reach an epoch of development, ground Phaseolus vulgaris in the Americas [8]. Best in well-drained soils steady in organic content and may thrive in temperate, subtropical, and tropical regions; a rainfall regime of moderate nature along with temperatures of 18-24-degree Celsius fits the

conditions of plant growth and development. The common bean may be rather versatile, but too much heat and excess water may result in loss of harvest [9].

Table 1: Comprehensive Botanical Classification and Features of *Phaseolus vulgaris* Linn. [10]

Category	*Description*
Family	Fabaceae
Genus	*Phaseolus*
Species	*Phaseolus vulgaris Linn*
Common Name	Common bean
Synonyms	French bean, Kidney bean, Haricot bean
Origin	Central and South America
Plant Type	Annual herbaceous
Growth Form	Climbing or bushy
Stem	Thin, green or purple, up to 2-3 meters long
Leaves	Trifoliate, ovate, smooth or slightly hairy
Flower Color	White, pink, purple
Flower Type	Papilionaceous (butterfly-like)
Pod Length	8-20 cm
Pod Shape	Elongated, cylindrical
Seed Color	Varies: white, black, brown, speckled
Seed Shape	Kidney-shaped, oval
Root System	Well-developed, nitrogen-fixing
Soil Preference	Well-drained, rich in organic matter
Optimal Growth Temperature	18-24°C
Parts Used	Seeds, Leaves, Pods

Fig. 1: Botanical illustration of *Phaseolus vulgaris* Linn (showing seeds, pods, and leaves)

3. Phytochemical Composition

The therapeutic qualities of common beans are founded on their rich phytochemical consultation associated with both culinary and health uses. The active ingredients in common beans suggest that they have a role in health-promoting effects. Important phytochemicals thought to help in health and the prevention of diseases include flavonoids, phenolic acids, proteins, fibers, vitamins, and mineral compounds [11].

3.1 Analysis of Key Bioactive Compounds

- Flavonoids are polyphenolic compounds like kaempferol and quercetin; and these have antioxidant and antiinflammatory effects. These properties make them ideal shields against oxidative stress and inflammation making them useful tools in the fight against chronic diseases like atheroma related syndrome and Alzheimer's disease [12].
- Phenolic Acids: Ferulic acid and caffeic acid are examples of strong antioxidants, which are part of this group of chemicals. Antidiabetic research interests them for their presumed role in mediating glucose homeostasis [13].
- Proteins: Common beans are polyphenol-rich plant proteins, which include lectins and phaseolin. Aside from possible antidiabetic properties, they may help to modulate certain immunological functions, helping in metabolic health, thereby reducing common comorbidities of type 2 diabetes like obesity [14].
- Minerals and vitamins: Iron is one of many minerals and vitamins found in *Phaseolus vulgaris*. All aspects of healthy nutrition, including metabolic processes and other bodily functions, depend on these nutrients [15].
- Since of their high fiber content, common beans are a great addition to any diet since they promote healthy digestion, regulate blood sugar levels, and make you feel full on fewer calories [16].

Table 2: Major Phytochemicals in *P. vulgaris* Linn [17]

Compound Type	*Examples*	*Therapeutic Benefits*
Flavonoids	Kaempferol	Antioxidant, anti-inflammatory
Flavonoids	Quercetin	Antioxidant, antihypertensive
Flavonoids	Myricetin	Antioxidant, anticancer
Phenolic Acids	Caffeic acid	Antioxidant, antidiabetic
Phenolic Acids	Ferulic acid	Antioxidant, anti-inflammatory
Phenolic Acids	Chlorogenic acid	Antioxidant, liver protective
Proteins	Lectins	Immune modulation, antidiabetic
Proteins	Phaseolin	Nutritional support, muscle development
Proteins	Glycinin	Antioxidant, promotes satiety
Dietary Fiber	Soluble fiber	Cholesterol-lowering, digestive health
Vitamins	Vitamin B1 (Thiamine)	Energy metabolism, nerve function
Vitamins	Vitamin B6 (Pyridoxine)	Amino acid metabolism, immune function
Minerals	Iron	Hemoglobin formation, energy production
Minerals	Magnesium	Muscle function, bone health
Minerals	Potassium	Blood pressure regulation, electrolyte balance

4. Pharmacological Activities

An ordinary bean is *Phaseolus vulgaris* Linn, which has been obtaining much focus due to its many pharmacological properties; there are now more and more evidences available substantiating these assertions. Hereunder is outlined the principal pharmacological actions attributed to this amazing legume [18].

4.1 Antioxidant Activity

The polyphenols and flavonoids that are main bioactive components of *P. vulgaris* attributed with antioxidant properties [19]. All of these antioxidants work to reduce undesirable levels of free radical harm and oxidative stress, which can change or damage a large number of the long-term health issues. HEPA: common bean extracts act both in vivo (animal studies) and in cell cultures to scavenge radicals including antioxidant properties. These data add to the evidence that P. vulgaris is protective in terms of cellular survival by preventing oxidative stress [20].

4.2 Antidiabetic Effects

For example, many explorations have involved *Phaseolus vulgaris* with respect to antidiabetic properties particularly its ability to modulate blood sugar levels. Bioactive compounds that inhibit α-amylase and α-glucosidase (found in beans) assist in glucose digestion and absorption Clinical studies have demonstrated that P. vulgaris reduces postprandial glycemia, suggesting it as a good choice of food for diabetics and subjects at risk to develop diabetes [21].

4.3 Anti-inflammatory and Analgesic Effects

It has been demonstrated in clinical and pre-clinical studies that *P. vulgaris* possess anti-inflammatory and analgesic properties which could act against pain [22]. These various studies present evidence that common bean extracts can reduce inflammation and pain in animal models. One possible implications of such an effect is the anti-inflammatory properties suggested to exacerbated by attenuation of proinflammatory cytokines which can develop into new therapeutic tendencies in inflammatory situations like arthritis and chronic pain [23].

4.4 Anti-cancer Properties

Studies have figured out the Phaseolus vulgaris, which can retard tumor expansion and cancer cell death by prompting the expulsion method a while ago. Studies in common bean extracts in vitro using cancer cells lines have also showed inhibitory to different malignant, such as breast, colon and prostate cancer. Furthermore, the antioxidants and phytochemicals in *P. vulgaris* improve upon its chemo-preventive properties as well. Hence, it deserves further elucidation of its role in cancer chemoprevention and therapy [24].

4.5 Cardioprotective Activity

There are several ways in which *P. vulgaris* can prevent the vascular heart, and one of these is a reduction in cholesterol levels as well as blood pressure [25]. Experiments on common beans show that it can increase HDL cholesterol and reduce LDL and triglyceride levels in the blood several times over, if one consumes them. The high potassium and fiber content in P. vulgaris gives it a number of heart-healthy benefits, such as: you can lower your risk for cardiovascular illnesses, help keep blood pressure at a healthy level(usda) [26].

4.6 Antimicrobial Activity

Normal beans anti-bacteria activity ordinary bean include a phytochemics that can disrupt the cell wall of microbial and prevent them reproductive. Studies have revealed that the plant is typically rich in antimicrobial, antifungal, antiviral properties which indicates potential usefulness of the plant in a herbal remedy as natural antimicrobials. Promising in fighting infections ranging from *E. coli, Staphylococcus aureus*, and even fungi like Candida albicans is the common bean extracts [27].

Table 3: Summary of Pharmacological Activities of *Phaseolus vulgaris* Linn. [28]

Activity	*Mechanism*	*Evidence/Reference*
Antioxidant	Scavenging free radicals	Study X, Y (in vitro, in vivo)
Antidiabetic	Inhibition of carbohydrate digestive enzymes	Study A, B (human trials)
Anti-inflammatory	Modulation of inflammatory cytokines	Study C, D (preclinical)
Anti-cancer	Apoptosis induction, cell cycle arrest	Study E, F (cancer cell lines)
Cardioprotective	Lowering LDL, regulating blood pressure	Study G, H (animal studies)
Antimicrobial	Inhibition of microbial growth	Study I, J (in vitro)
Anti-obesity	Modulating lipid metabolism	Study K, L (clinical trials)
Neuroprotective	Reducing neuroinflammation	Study M, N (animal studies)
Hepatoprotective	Protecting liver cells from damage	Study O, P (in vitro)
Antihypertensive	Vasodilation and improving endothelial function	Study Q, R (human trials)
Antidepressant	Modulation of neurotransmitter levels	Study S, T (animal studies)
Antidiarrheal	Stabilizing intestinal function	Study U, V (preclinical)
Immunomodulatory	Enhancing immune response	Study W, X (clinical trials)
Antidiabetic	Reducing insulin resistance	Study Y, Z (in vivo)
Cardiovascular	Improving endothelial function	Study AA, AB (human trials)

5. Therapeutic Applications

The plant *Phaseolus vulgaris* Linn has an extensive background in traditional and complementary medicine. Its versatility and effectiveness make it a good candidate for use in nutraceuticals, functional meals, and dietary supplements [29].

5.1 Traditional Uses

Everywhere you look, regular beans have long been a staple in traditional medicine systems. diverse cultures have utilized P. vulgaris for medicinal purposes for a long time, with the plant's seeds, leaves, and pods being used in diverse concoctions [30]. People frequently utilized:

- Because of their high fiber content, common beans have traditionally been used to treat digestive issues like diarrhea and constipation.
- Anti-inflammatory Uses: Arthritis and other inflammatory illnesses have long been treated with P. vulgaris due to its anti-inflammatory characteristics.
- Traditional uses of common beans for blood sugar regulation match their modern status as antidiabetic medicines, and they have a long history of usage in folk medicine [31].

5.2 Modern Applications

Phaseolus vulgaris is gaining more and more attention for its possible uses in contemporary medicine as pharmacology and nutritional science progress [32]. Several health-promoting products incorporate it due to its rich phytochemical profile:

- Nutraceuticals: Research into the possible uses of P. vulgaris extracts in the creation of nutraceuticals with the goals of improving health and avoiding chronic diseases is ongoing. The compounds in question may have antidiabetic, anti-inflammatory, and antioxidant properties [33].
- The use of *Phaseolus vulgaris* in functional foods is becoming more common. Enhanced glycemic management and better cardiovascular health are just two of the many extra health benefits that foods enriched with common beans can give. Customers looking for more nutritious food options would like this [34].
- The Weight and blood sugar and to the support a cardiovascular health particularly stimulating the weight loss etc are some important seconds generating need for common bean extracts based dietary supplements. These nutritional supplements are centered on the therapeutic potential of the bioactive compounds in *P. vulgaris* [35].
- Cutting-Edge Health Solutions: In a bid to promote the use of Phaseolus vulgaris more often, scientists have discovered new uses of this nutritious vegetable especially in functional beers, snacking items and creamy cereals [36].

6. Toxicity and Safety Profile

Consuming *Phaseolus vulgaris* Linn beans in raw or undercooked state may be counterproductive due to the many recognized nutritional benefits associated with the bean. Beans should be cooked before being taken to eat because they contain certain substances that are bad for the body when taken raw [37].

Potential Toxic Effects

1. Phytohemagglutinins: Raw beans are toxic because phytohemagglutinins, a category of lectin, can upset the stomach. Gastrointestinal side effects: stomach upset, vomiting and diarrhoea are some examples of G.I side effects [38]. The mode of these effects lies in the agglutinative action of phytohemagglutinins towards the red blood cells through the membrane lectin-fixed mode of cellular metabolism [39].
2. .Lectins: Other lectins, not only phytohemagglutinins, can be harmful in large quantities if ingested. Raw beans can cause nutrition absorption problems and gastrointestinal distress if consumed in excess, even if lectins have some beneficial health effects [40].
3. Saponins: While beans are usually safe to eat when cooked, they can have a bitter taste and, very rarely, induce hemolytic consequences if eaten in large quantities when raw [41].
4. Other Compounds: Phytic acid, tannins, and protease inhibitors are some of the additional harmful substances that may impact digestion and nutritional absorption in raw beans [42].

Recommended Safe Intake Levels

Properly preparing beans is crucial for safety reasons. Some ways to lessen the dangers of eating raw food are as follows:

- Cooking: To bring phytohemagglutinin levels down to safe levels, boil beans for at least 10 minutes. Beans become safe to eat after being cooked in this way because the dangerous chemicals are denatured.
- One way to make sure beans are safe to eat is to soak them overnight before cooking. This will lower the amount of lectins and saponins in the beans.
- Beans can still cause gastrointestinal problems if eaten in excess, even when cooked correctly. Moderation is key [43].

7. Conclusion

Finally, *Phaseolus vulgaris* Linn is a nutritive and health enhancing plant that may serve a plethora of pharmacological purposes with antioxidant, antidiabetic, anti-inflammatory and antimicrobial properties. Traditional usage as a medicine and scientific confirmation of its effectiveness in enhancing the quality of health and preventing diseases make it likely to benefit from this potential. Nevertheless, more work is needed, starting first with the creation of organized extractions and systematic clinical testing in order to maximize the potential of this remarkable tool and incorporate it properly into today's medical practices. There are high expectations for the future of Phaseolus vulgaris as an exemplar functional food and as the source of new bioactive agents.

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