



# Exploring The Multifaceted Benefits Of Psyllium Husk: A Review Of Its Pharmaceutical, Pharmacological, And Nutritional Properties

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**Abstract:** Psyllium (*Plantago ovata*), a rich source of soluble and insoluble dietary fiber, boasts an impressive nutritional profile. Native to Persia and extensively cultivated in India, psyllium husk contains up to eight times more soluble fiber than oat bran, rendering it highly effective for various health applications. Its multifaceted benefits extend to pharmaceutical applications, where it serves as a natural disintegrant, gelling, suspending, and emulsifying agent, enhancing drug formulation and delivery. The bioactive compounds present in psyllium exhibit a broad spectrum of biological activities, including antioxidant, anti-inflammatory, antimicrobial, anticancer, and cardioprotective effects, which collectively contribute to disease prevention, health promotion, and overall well-being. Traditionally employed to treat constipation, diarrhea, and hypercholesterolemia, psyllium husk has demonstrated potential in managing obesity, diabetes, and heart disease, contributing to healthy aging. Despite its extensive health benefits, research on incorporating psyllium into food products remains limited. This review aims to highlight psyllium's pharmaceutical and pharmacological attributes, emphasizing its potential in innovative food formulations to support global health and well-being. Developing psyllium-fortified, low-calorie food products could address public health concerns while promoting nutritional awareness. Adequate water intake alongside psyllium consumption is essential to maximize its therapeutic efficacy. **Keywords:** Psyllium husk, dietary fiber, pharmaceutical applications, bioactive compounds, obesity management, diabetes management, food fortification, health benefits.

## INTRODUCTION

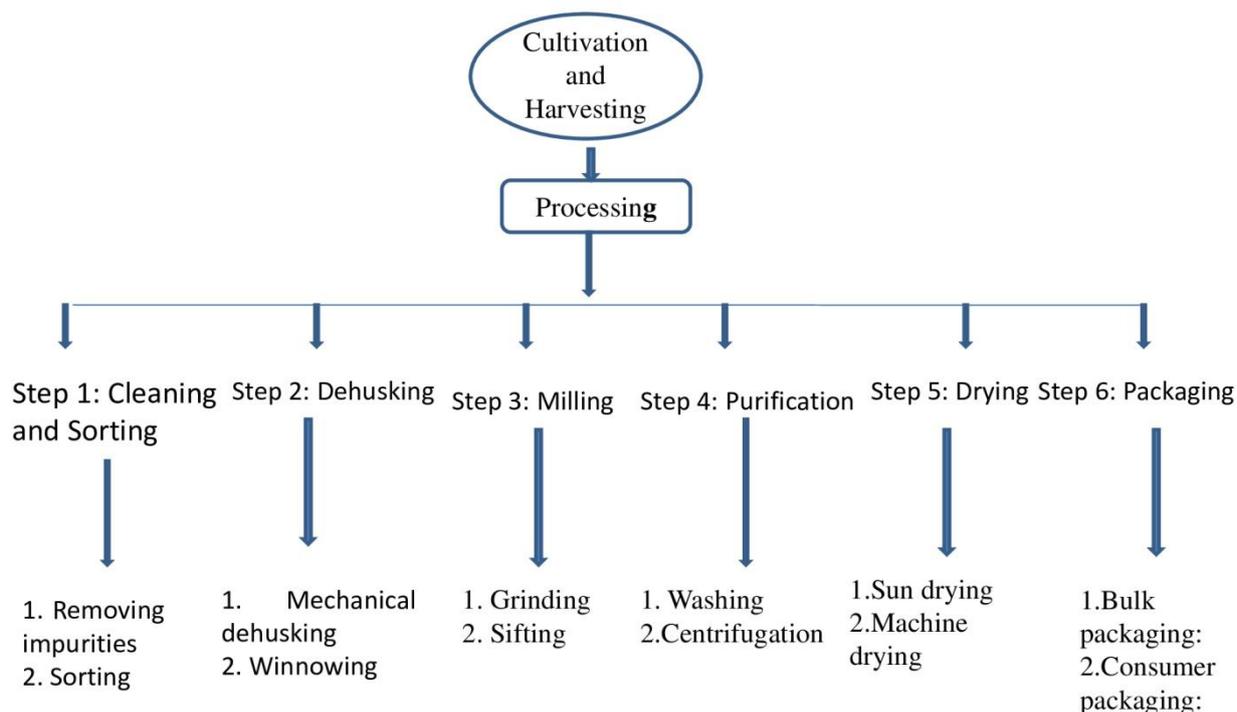
Psyllium (*Plantago ovata*), native to Persia (modern-day Iran), is primarily cultivated in western India, particularly in Gujarat and Rajasthan. (1) The term "Psyllium" encompasses husk (outer seed layer, seed (inner kernel) and whole plant (entire *Plantago ovata* plant). Psyllium is a superior source of dietary fiber, offering a blend of soluble and insoluble fiber. (2,3) The soluble fiber content in psyllium husk is approximately 8 times greater than that found in oat bran. (4,5) The pharmaceutical properties of Psyllium fibers make them ideal for developing innovative, low-calorie food products supporting overall health and well-being. (6)

Psyllium, also known as Ispaghula, encompasses several *Plantago* species, notably: *Plantago ovata* (Indian Psyllium), *Plantago psyllium* (French Psyllium), and *Plantago indica* (Spanish Psyllium). (7) The seeds of these *Plantago* species contain mucilage, a soluble fiber forming a gel-like substance when mixed with water. (8)

Psyllium's global popularity stems from its versatility and efficacy.(6) Traditional Ayurvedic Uses of Psyllium husks are in skin irritations (e.g., eczema, acne), hemorrhoids, constipation, diarrhea and digestive issues (e.g., bloating, gas).(9) The growing consumption of Psyllium in Europe and the USA reflects a rising interest in natural health solutions and preventive care.(10)

India's dominance in the psyllium market is expected to continue, driven by its favorable climate, extensive experience, and large-scale production capacity. (11) Gujarat and Rajasthan are indeed the leading psyllium-producing states in India. Gujarat is largest producer of psyllium in India (60-70% share). Rajasthan contributes significantly to India's psyllium production, accounting for approximately 20-30% of the country's total output. (12,13) Other notable psyllium-producing states in India include Maharashtra, Madhya Pradesh, Uttar Pradesh, and Haryana. (14) Steps involved in manufacturing of Isabgol husk are shown in figure 2.

### Steps involved in manufacturing Isabgol (Psyllium) husk



**Figure 1:** Steps involved in manufacturing of Isabgol husk

### COMPOSITION AND PROPERTIES OF ISABGOL HUSK

**Chemical Composition:** Psyllium husk contains a variety of chemical constituents, as shown in table 1, below:

**Table 1: Chemical constituents of Isabgol husk** (11,15, 16)

Sr. No.	Constituent	Description
1.	Soluble fiber (mucilage)	70-80%
2.	Insoluble fiber	10-20%
3.	Proteins	5-10%
4.	Carbohydrates	10-15%
5.	Minerals (potassium, magnesium, calcium)	2-5%
6.	Phenolic compounds (flavonoids, phenolic acids)	1-2%
7.	Saponins	0.5-1%

A study investigated the antioxidant potential of *Plantago ovata* leaf and husk extracts by analyzing their total phenolic content. The results revealed significant free radical scavenging activity, high total phenolic content (TPC) in husk extracts and high antioxidant activity in leaf extracts. The study demonstrated the extracts' potent antioxidant properties, suggesting that *P. ovata* extracts hold promise as a valuable supplement in healthcare. (17) The authors warrant further exploration for their therapeutic benefits.

Studies have shown that *Plantago ovata* seeds and husks are rich repositories of bioactive compounds, mainly composed of fatty acids, amino acids, polyphenols, and flavonoids. These bioactive compounds contribute to the medicinal properties of *P. ovata*, exhibiting anti-inflammatory, antioxidant, and antimicrobial activities. The presence of these compounds underscores the potential of *P. ovata* as a valuable supplement in healthcare, warranting further exploration for its therapeutic benefits.(18)

*Plantago ovata* boasts an impressive profile of bioactive compounds. The psyllium husks are particularly notable for their rich fatty acid profile, which features linoleic acid, oleic acid, and palmitic acid as key constituents.(19) Moreover, the seeds, husks and leaves demonstrate significant antioxidant activity, attributed to their high content of phenolic compounds. Furthermore, husks and seed extracts have been found to contain terpenes, such as saponins, which contribute to *P. ovata*'s potential medicinal properties.(20)

Polysaccharides extracted from *Plantago ovata* seeds and psyllium husks hold significant promise for the nutraceutical industry. Notably, these polysaccharides exhibited exceptional antioxidant capacity and anticancer properties, necessitating further research for the development of groundbreaking formulations. By leveraging their bioactive potential, researchers can create effective dietary supplements, establishing *P. ovata*-derived polysaccharides as compelling natural health solutions.(21)

Isabgol is primarily composed of polysaccharides, accounting for approximately 85% of its content. This complex polysaccharide is comprised of four main monosaccharide units as shown in table 2: (18)

**Table 2: Complex polysaccharide of Isabgol husk**

Component	Percentage
D-xylose	62
L-arabinose	20
L-rhamnose	9
D-galacturonic acid	9
Total Polysaccharides	85

The remaining 15% of Isabgol's composition consists of non-polysaccharide materials. This unique polysaccharide profile contributes to Isabgol's remarkable medicinal properties. The structural composition of the polysaccharide found in psyllium husk was elucidated by Purohit and Rathore. (15) The polysaccharide's backbone is comprised of a linear chain of  $\beta$ -D-xylose residues in the pyranose ring form. Attached to this backbone are three disaccharides side chains, each featuring a terminal  $\alpha$ -D-galactouronic acid linked to O-2 of  $\alpha$ -L-rhamnose. These side chains are connected to the xylose residues at either O-2 or O-3 positions. Notably, the backbone exhibits both (1 $\rightarrow$ 3) and (1 $\rightarrow$ 4)  $\beta$ - linkage, although the precise sequence and distribution of these linkages and sidechains remain to be determined.

### PHARMACEUTICAL PROPERTIES OF ISABGOL HUSK:

**Disintegrant action:** *Plantago ovata*, commonly known as psyllium, exhibits disintegrant properties, making it a valuable excipient in pharmaceutical manufacturing.(22) The mucilage in *Plantago ovata* undergoes hydrolysis, releasing polysaccharides that are responsible for its disintegrative properties. This natural disintegrant action enables the breakdown of tablets and capsules, facilitating rapid drug release and absorption. As a result, *Plantago ovata* has become an attractive alternative to synthetic disintegrants in the development of various pharmaceutical formulations.

Tablet disintegration is a critical process in the pharmaceutical industry, particularly for oral solid dosage forms like tablets, as it ensures the efficient release and absorption of the active pharmaceutical ingredient (API) into the bloodstream.(23) This process involves the breakdown of a tablet into smaller fragments upon contact with a liquid, typically in the digestive system. Disintegrants, substances added to tablets to promote breakup, play a key role by swelling, wicking water, or expanding to facilitate tablet disintegration. Additionally, tablet formulation, including binder type and compression force used during manufacturing, significantly impacts disintegration.(23) Understanding and controlling these factors is vital for ensuring medication efficacy and safety.

Researchers examined the potential uses of psyllium husk powder, a natural superdisintegrant, for manufacturing orodispersible tablets of meloxicam. Direct compression was employed to prepare tablets containing psyllium husk at various concentrations. The study demonstrated that psyllium husk significantly enhanced tablet disintegration time and drug release, making it a promising natural alternative to synthetic superdisintegrants.(24)

A study by Jha and Chetia (25) assessed the in vitro-in vivo performance of fast-dissolving glipizide tablets utilizing treated *Plantago ovata* husk. The tablets were prepared by direct compression and subjected to in vitro evaluations, assessing disintegration time, wetting time, hardness, friability, swelling, and drug release. The findings indicate that treated *Plantago ovata* exhibits significant potential for rapid disintegration, meeting the requirements for fast-disintegrating tablets (FDTs).

Conventional tablets pose significant challenges for patients with dysphagia, leading to noncompliance due to choking risks. To address these limitations, fast-disintegrating tablets (FDTs) were developed using natural gums, enabling easier administration. FDTs were prepared via direct compression with various natural gums to achieve rapid onset and immediate hypoglycemic action. Notably, formulations incorporating guar gum demonstrated disintegration within one minute, meeting the official requirements for dispersible tablets.(26)

Jha and Chetia (27) developed and statistically analyzed fast-dissolving tablets containing glipizide, utilizing *Plantago ovata* husk as a natural excipient. A direct compression method transformed powder blends of pregelatinized *Plantago ovata* husk, microcrystalline cellulose, and soluble starch into tablets. These tablets underwent evaluations for disintegration time, hardness, friability, drug entrapment efficiency, and content uniformity. A 3<sup>2</sup> full factorial design optimized two critical formulation variables: pregelatinized *Plantago ovata* husk concentration and compression force. Multiple linear regression analysis indicated that fast-dissolving tablets require higher concentrations of pregelatinized *Plantago ovata* husk combined with optimal compression force.

### **Gelling agents**

Gelling agents are substances used to create a gel-like texture in various products, such as food (pectin, agar, carrageenan, gelatin), pharmaceuticals (sodium alginate, carbomer, xanthan gum) and cosmetics (carrageenan, xanthan gum, guar gum).(28)

Noguerol et al., (29) investigated the physicochemical, nutritional, optical, and mechanical properties of psyllium fibre gel-based foods. Psyllium fibre's health benefits are closely tied to its gelling properties, making understanding its functional properties and gelling capacity crucial for its potential incorporation as a dietary fibre source. The study compared two psyllium fibre samples: *Plantago* husks and *Plantago* powder. *Plantago* husk showed superior hydration properties, while *Plantago* powder exhibited higher phenol content and antioxidant activity. Notably, both samples displayed similar gelling properties. Rheological and textural analysis revealed effective gelling at 4-7% concentrations across temperatures (65°C and 5°C). The results indicate *Plantago* husks and *Plantago* powder have suitable characteristics as functional ingredients, minimizing negative impacts on food sensory and structural properties.

Abbas et al., (22) examined the feasibility of utilizing *Plantago ovata* (PO) husk as a pharmaceutical excipient. The husk was analyzed for its pharmaceutical attributes, encompassing flow, compressibility index, and swelling index. The investigation revealed a high swelling index of 380% for the intact husk, which decreased to 310% after pulverization, indicating a significant impact of particle size on swelling behavior. Furthermore, orodespersible tablets were prepared with varying concentration (2.5-15% w/w) husk. Pre-compression analysis showed that the powder blend demonstrated excellent flow properties, indicating that PO husk enhances the theoretical characteristics of the blend.

Dhawale et al., (30) explored the potential of Isabgol Husk, derived from *Plantago ovata*, as a cost-effective gelling agent in sugarcane callus induction. This study investigated the efficacy of an Isabgol-agar admixture in tissue culture media for commercially valuable crops like sugarcane (*Saccharum* spp). Results showed that combining Isabgol husk with agar reduced gelling agent costs by approximately 47.5%. Notably, media gelled with Isabgol husk yielded similar responses to agar-solidified media in sugarcane callus induction. Replacing conventional agar (0.8%) with Isabgol (1.5%) produced comparable callus formation. Isabgol husk's polysaccharide and colloidal properties, resistance to enzymatic activity, and excellent gelling ability make it an ideal alternative. Even after autoclaving, the husk remained suspended, forming a gradient upon medium solidification, with no softening observed during the culture period.

### **Suspending agent**

Suspending agents are essential components in various formulations, preventing sedimentation or settling of solid particles in liquids. These agents, including natural gums (agar, carrageenan, pectin), synthetic polymers (methylcellulose, carboxymethylcellulose), and starches (cornstarch, potato starch), enhance viscosity, stabilize suspensions, and control flow.(31,32)

Sutradhar et al., (11) investigated the biochemical, phytochemical, and pharmacological properties of Ispaghula Husk, revealing its multifaceted medicinal and pharmacological potential. This natural remedy exhibits valuable features, including mucilage, gelling, super-disintegrant, and suspending properties. Additionally, *P. ovata* demonstrates various pharmacological effects, such as anti-constipation, anti-

diarrheal, wound-healing, hypocholesterolemic, and hypoglycemic activities. Due to its versatility and efficacy, *P. ovata* holds promise for developing diverse medicinal products and serves as a safe and effective ethnobotanical solution for various health issues.

Rao et al., (33) investigated the rheological properties of Psyllium polysaccharide (PPS) and its efficacy as a suspending agent. Spray-dried psyllium seed extract was utilized to prepare PPS mucilage at varying concentrations, with paracetamol as the model drug. Rheological analysis revealed thixotropic behavior and hysteresis loop formation. Compared to sodium carboxymethyl cellulose (Na CMC), PPS mucilage demonstrated suitable viscosity, pH, resuspendability, and sedimentation volume in paracetamol suspensions. The study concluded that Psyllium polysaccharide has promising potential as a natural suspending agent.

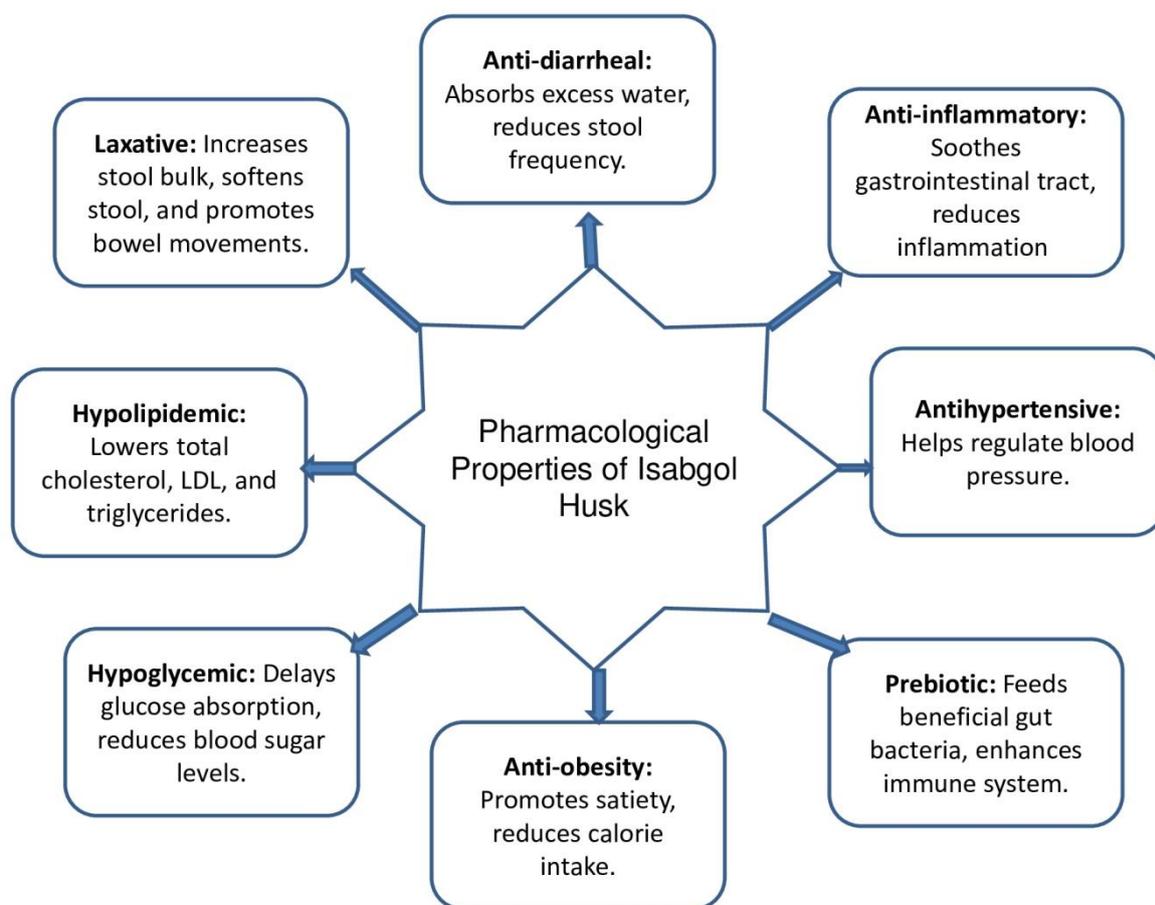
### Emulsifying agent

Emulsifying agents are crucial components in various formulations, facilitating the mixing of immiscible liquids, such as oil and water. These agents reduce surface tension, creating stable emulsions. (34)

Fu et al., (35) investigated the effects of varying husk powder of Psyllium (PHP) concentrations on the stability and properties of PHP-soybean oil emulsions. The study evaluated emulsifying stability, rheology, microstructure, and oxidative stability of emulsions with PHP concentrations ranging from 0.3% to 0.6 % (w/w). Results revealed that increasing PHP concentration enhance dapparent viscosity, emulsion stability, storage modulus, and loss modulus, while reducing surface tension, emulsion droplet size, peroxide value, and thiobarbituric acid reactive substance value. Cryo-scanning electron microscopy showed that PHP formed a network structure around oil droplets, contributing to improved stability and oxidative resistance. These findings suggest that PHP is an efficient emulsifier for creating stable oil-in-water emulsions, holding promise for food industry applications.

### PHARMACOLOGICAL PROPERTIES OF ISABGOL HUSK:

*Plantago ovate* has many pharmaceutical properties as shown in figure 2:



**Figure 2: Pharmacological properties of Isabgol husk**

### Obesity and satiety

Deng et al., (36) conducted a comparative study on the effects of psyllium husk and orlistat treatments in mice with high-fat diet (HFD)-induced obesity. Although orlistat induced greater weight loss, psyllium husk demonstrated superior efficacy in reducing serum and hepatic cholesterol and triglyceride levels. However, orlistat had undesirable side effects, increasing food and water intake, serum triglycerides, and decreasing

glucose tolerance in obese mice. In contrast, psyllium husk offered a cost-effective and safer alternative for managing HFD-induced hypercholesterolemia and non-alcoholic fatty liver disease, making it a promising natural remedy for metabolic disorders. Obesity and overweight individuals are prone to insulin resistance, a precursor to diabetes, due to increased adipose tissue mass.(37) Fortunately, psyllium has emerged as a promising natural solution for weight loss and improved metabolic health. Consistent findings from various studies demonstrate psyllium's potential in facilitating weight reduction, underscoring its potential as a complementary approach to managing obesity-related disorders.

Brum et al., (38) conducted a study to evaluate the satiety effects of psyllium in healthy individuals. Nineteen men and 11 women received three different psyllium doses (3.4g, 6.8g, and 10.2g) or a placebo before breakfast, lunch, and dinner for three consecutive days. Satiety levels were evaluated at specified intervals: before and after meals, and at 30-minute increments over a four-hour period. Results showed that higher psyllium doses led to greater satiety, with 10.2g and 6.8g doses demonstrating comparable efficacy. Pre-meal psyllium supplementation was well tolerated, significantly reducing hunger, increasing fullness and decreasing the desire to snack between meals.

A 12-week study involving 51 patients with type-2diabetes and chronic constipation demonstrated the efficacy of psyllium in promoting weight loss. (39) Patients were randomly divided into two groups, consuming either psyllium-enriched cookies (2.5g psyllium, 55.5kcal per cookie) or placebo cookies (56.4kcal per cookie) twice daily. The psyllium group received 10g of psyllium daily. Results showed that participants consuming psyllium cookies were more likely to experience significant body weight reduction compared to those receiving placebo cookies.

### **Anti-inflammatory and wound healing**

Anti-inflammatory agents and wound healing promoters are crucial for maintaining overall health. Anti-inflammatory agents reduce inflammation, alleviating symptoms associated with conditions like arthritis, diabetes, and cardiovascular disease. They work by inhibiting pro-inflammatory molecules, promoting tissue repair, and restoring balance to the immune system. Wound healing promoters, on the other hand, facilitate the recovery process after injury or surgery. They enhance collagen synthesis, improve tissue strength, and accelerate the healing cascade, minimizing scarring and promoting optimal tissue regeneration. Together, anti-inflammatory and wound healing agents play vital roles in restoring tissue integrity, reducing pain, and improving quality of life.(40,41)

Reddy et al., (41) investigated the anti-inflammatory and antibacterial properties of Isabgol leaves and seeds against periodontal pathogens. In an in vitro study, aqueous extracts of Isabgol demonstrated significant antibacterial activity against specific periodontal pathogens using the tube dilution method. Additionally, the extracts exhibited anti-inflammatory effects by inhibiting matrix metalloproteinases (MMP-2 and MMP-9) through zymogen gel electrophoresis. The findings suggest that Isabgol is effective in combating periodontal disease by targeting both bacterial pathogens and inflammatory mediators, highlighting its potential as a natural therapeutic agent for periodontal health.

*Plantago ovata*, rich in dietary fiber and mucopolysaccharides, has emerged as a promising therapeutic agent for inflammatory bowel diseases due to its remarkable anti-inflammatory properties. Notably, a study demonstrated that supplementing transgenic rat with 5% psyllium seeds significantly reduced pro-inflammatory mediators associated with colitis. Furthermore, the mucopolysaccharide content in *Plantago ovata* exhibits beneficial effects on wound healing by facilitating wound cleansing and promoting tissue repair. These findings underscore the potential of *Plantago ovata* as a natural remedy for managing inflammatory bowel diseases and enhancing wound healing. (42, 43,44)

Research has demonstrated the gastroprotective effects of *Plantago ovata*, specifically its aqueous extract, in preventing peptic ulcers and gastrointestinal damage. A study by Bagheri et al., (45) revealed that the aqueous seed extract of *Plantago ovata* significantly protected against gastric ulcer induction in rats, reducing gastrointestinal lesions and liver damage. The study attributes this beneficial effect to the soluble fiber's viscosity and solubility, which may help shield the mucosa and mitigate ulcer formation.

### **Hypoglycemic and hypocholesterolemic:**

Substances or agents exhibiting hypoglycemic and hypocholesterolemic effects have significant benefits for managing metabolic disorders. Hypoglycemic effects refer to the ability to lower blood glucose levels, improving insulin sensitivity and glucose metabolism. This is particularly beneficial for individuals with diabetes or prediabetes. Hypocholesterolemic effects, on the other hand, involve reducing total cholesterol and low-density lipoprotein (LDL) or "bad" cholesterol levels in the blood. By combining these effects, certain natural compounds or pharmaceuticals can help regulate blood sugar levels and lipid profiles, mitigating the risk of cardiovascular disease and other metabolic complications. (46)

A 16-week interventional study conducted by Bacha et al., (47) investigated the impact of psyllium husk fiber, combined with lifestyle modification, on insulin resistance in centrally obese school teachers in Malakand, Khyber Pakhtunkhwa. One hundred twenty participants (ages 40-60) were divided into four groups: control, lifestyle modification (LSM), psyllium husk fiber (PSH), and combined LSM & PSH. Fasting serum analysis revealed significant reductions in fasting blood glucose and insulin resistance, as measured by HOMSA-IR, following the intervention. Notably, combining psyllium husk fiber with lifestyle modifications demonstrated enhanced benefits in mitigating insulin resistance, highlighting the potential of non-pharmacological approaches in managing metabolic disorders.

The global prevalence of cardiometabolic diseases (CMDs) has reached alarming levels. Fortunately, increasing dietary fiber intake, particularly through psyllium supplementation, has shown promise in mitigating associated risk factors. Psyllium husk, a widely used dietary fiber supplement, has been extensively studied for its therapeutic properties, including antioxidant, anti-tumor, antidiabetic, hypotensive, anti-inflammatory, neuroprotective, antidiarrheal, and antiviral activities. In a comprehensive review, (9) examined the potential of psyllium in treating CMDs, such as hyperlipidemia, diabetes mellitus, hypertension, hyperuricemia, and obesity. The review highlights psyllium's mechanisms of action and its application in food systems, underscoring its potential as a natural, adjunctive therapy for managing cardiometabolic health.

Isabgol husk, a rich source of soluble fiber, has been shown to have a positive impact on cardiovascular health. By binding to cholesterol in the digestive tract, Isabgol prevents its absorption into the bloodstream, leading to reduced LDL (bad) cholesterol levels.(48) This reduction in LDL cholesterol levels significantly minimizes the risk of heart disease.

Additionally, Isabgol's soluble fiber helps moderate blood pressure, promoting overall heart well-being. Studies have consistently demonstrated the benefits of soluble fiber in lowering blood pressure and reducing cardiovascular risk. Incorporating Isabgol into a heart-healthy lifestyle, which includes a balanced diet and regular exercise, can effectively maintain cardiovascular health and reduce the risk of heart-related issues. (49, 50)

Research conducted by Chen et al., (9) encompassed 24-week controlled clinical studies, involving over 1500 participants, to investigate the cholesterol-lowering effects of psyllium. The studies revealed that daily psyllium supplementation, ranging from 6 to 15 grams, significantly reduced total cholesterol levels by 2-20% and LDL (bad) cholesterol levels by 6-24%. These findings unequivocally demonstrate psyllium's efficacy in managing hypercholesterolemia and promoting cardiovascular well-being.

Ashooriyan et al., (51) explored the potential of *Plantago ovata* (P. ovata) polysaccharide as a natural pill coating in developing rapid dissolution tablets for hypertension treatment. Their study demonstrated that formulations incorporating P. ovata polysaccharide disintegrated swiftly and completely, leveraging its swelling properties.

Psyllium is classified as a functional fiber due to its non-digestible carbohydrate composition, primarily consisting of arabinose and xylose monosaccharides that form arabinoxylans. This active fraction creates a viscous gel, which has been linked to various physiological health benefits.(52,53) Upon mixing with water, psyllium forms a gel-like mucilage, increasing viscosity and potentially interfering with fat and cholesterol absorption. This mechanism can lead to reduced blood cholesterol concentrations, supporting psyllium's role in promoting cardiovascular health.

Diabetes, a chronic disease marked by elevated glucose levels, arises from the body's inability to produce or effectively utilize insulin.(54) This debilitating condition has alarming consequences: every 6 seconds, diabetes claims a life, according to the International Diabetes Foundation. Furthermore, projections indicate that over 415 million individuals will be diagnosed with diabetes by 2040, underscoring the urgent need for effective management and prevention strategies.(55)

Isabgol, a soluble fiber, slows down sugar absorption in the digestive tract, preventing rapid blood sugar spikes and promoting stable glucose control.(56) This benefit is particularly significant for individuals with diabetes or those at risk of developing the condition. By slowing down glucose absorption, Isabgol helps regulate postprandial blood glucose levels. Regular monitoring of HbA1c levels, a crucial indicator of blood sugar management, can help track the effectiveness of Isabgol supplementation and overall diabetes management.

Consuming dietary fiber has been shown to have numerous health benefits, including reducing the risk of coronary heart disease and diabetes. Consuming more than 26g per day of psyllium husk may significantly reduce the risk of developing type 2 diabetes mellitus, with a potential risk reduction of up to 18%. (57) Psyllium, a rich source of soluble fiber, has been specifically demonstrated to reduce blood glucose levels.

Studies have consistently shown that daily psyllium consumption significantly lowers blood glucose level (57,58) highlighting its potential as a natural adjunct therapy for managing blood sugar.

A study conducted by Abutair et al.,(59) investigated the effects of psyllium supplementation on glycemic control in 40 type 2 diabetes patients, aged 35, over 8 weeks. Participants consumed 3.5g of psyllium diluted in 100ml water, 15 minutes before lunch and dinner, totaling 7g daily. Results showed significant reductions in fasting glycemia and HbA1c rates, indicating improved glycemic control. Notably, lowered HbA1c levels suggested sustained blood sugar management over several months. These findings underscore the potential of psyllium's soluble fiber as a supplementary tool for controlling type 2 diabetes, yielding positive outcomes in a relatively short period.

The targeted delivery of nutrients to the distal ileum triggers the ileal brake mechanism, yielding significant benefits. This mechanism slows down gastric emptying and intestinal transit, consequently reducing hunger and food intake.(60)

Incorporating psyllium into the diet offers a straightforward and effective approach to regulating blood lipids, insulin, and glucose levels, particularly in overweight and obese individuals. This, in turn, reduces the risk of developing metabolic syndrome, cardiovascular disease, and type-2 diabetes. Notably, psyllium has distinct advantages over other dietary fibers, including poor fermentability, minimizing flatulence and abdominal bloating, high tolerability, ensuring ease of consumption and wide availability, with global marketing. These benefits make psyllium an attractive adjunct therapy for managing metabolic health. (3)

**Laxative:** Isabgol husk, a soluble dietary fiber, forms a gel-like texture when mixed with water, effectively softening stools and treating constipation. Its natural laxative properties promote increased stool bulk, regular bowel movements and relief from straining and bloating. Incorporating Isabgol husk into one's diet can lead to significant improvements in digestive health and reduced symptoms of constipation. (6)

Isabgol, a natural laxative, alleviates constipation by adding bulk to stool, softening it for effortless passage and promoting regular bowel movements.(6) The soluble fiber in psyllium husk absorbs excess water in the digestive tract, helping to alleviate diarrhea by thickening stool, reducing the frequency of bowel movements, and promoting a more solid consistency. By facilitating smoother bowel movements, Isabgol reduces rectal strain, lowering the risk of painful hemorrhoids often caused by excessive straining.(61)

### **SAFETY AND TOXICITY CONSIDERATIONS**

Isabgol, a natural laxative, is generally considered safe when consumed appropriately. However, potential safety concerns include allergic reactions, gastrointestinal upset at high doses, and interactions with medications such as blood thinners, diabetes medications, and cholesterol-lowering drugs. Additionally, inadequate fluid intake may lead to choking or intestinal obstruction, and rare cases of intestinal blockage have been reported. To minimize risks, it is essential to consume plenty of water with Isabgol, follow recommended dosages (typically 1-2 tablespoons per day), and monitor for adverse effects.(62,63)

### **REGULATORY STATUS**

Isabgol, commonly known as psyllium husk, has garnered worldwide regulatory recognition. The US FDA classifies it as generally recognized as safe (GRAS) for use in food products (FDA, 2020), while the European Food Safety Authority (EFSA) endorses it as a safe food ingredient (EFSA, 2010). In India, Isabgol is recognized as an Ayurvedic medicine under the Drug and Cosmetic Act, 1940 (Ministry of Health and Family Welfare, 1940). Furthermore, the World Health Organization (WHO) acknowledges psyllium husk as a safe and effective laxative (WHO, 2013), and it meets the International Organization for Standardization (ISO) standards for quality and safety (ISO, 2015), solidifying its global acceptance. (64)

### **CONCLUSION**

Increased fiber intake is consistently linked to better health, reduced chronic disease risk, and healthy aging. While psyllium husk is primarily used to treat constipation, diarrhea, and hypercholesterolemia, it offers numerous hidden benefits when consumed in recommended amounts. Beyond its well-known uses, psyllium husk supports diabetes management, weight loss, obesity reduction, and mitigates high blood pressure and heart disease. However, despite extensive research on its health benefits, few studies have focused on developing psyllium-fortified food products. To address public health concerns and promote healthy eating, it is essential to highlight psyllium husk's nutritional value and explore its incorporation into household food products, emphasizing the importance of adequate water intake to maximize its benefits.

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