

## PHYTOCHEMISTRY AND PHARMACOLOGY OF PLANTAGO OVATA: A NATURAL SOURCE OF LAXATIVE MEDICINE

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### ABSTRACT

*Plantago ovata* Forsk. belonging to the family Plantaginaceae is an annual herb indigenous to the Mediterranean region specially Southern Europe, North Africa and West Asia. In India, it is cultivated as a cash crop in Gujarat, Rajasthan, Punjab and Haryana states. Various medicinal properties have been attributed to this plant in traditional system of medicine. On account of its mucilaginous husk the plant also finds variety of industrial applications. It can be grown on different types of soils, has moderate water and nutrient requirements and fits well in the cropping system. The distribution, traditional uses, industrial applications and agronomic, Chemical and pharmacological aspects of the plant crop are reviewed in this paper.

**KEYWORDS:** *Plantago ovata*, Distribution, Pharmacognosy, Chemistry, Agronomy.

### INTRODUCTION

*Plantago* is a large genus comprising of 200 species including herbs or sub-shrubs distributed mostly in the temperate regions and a few in tropics. About ten species are recorded in India, of which *Plantago ovata* is important for its seeds. The common name *Isabgol* of the plant is derived from two Persian words 'Isap' and 'ghol' meaning a horse ear, referring to the characteristic shape of its seed <sup>[1]</sup>. *Plantago ovata* Forsk. (Family Plantaginaceae) is a stemless or sub-caulescent soft hairy or woolly annual herb which attains a height of 30-45 cm. Leaves narrowly linear or filiform appearing whorled due to the short terete stem. The spikes are 1.2-4 cm long and about 0.5 cm broad, cylindrical to ovoid in shape and bear between 45-70 flowers. Flowers are bisexual, tetramerous, anemophilous and protogynous and as such favouring out crossing. The fruits are ellipsoid capsules, about 8 mm long, obtuse, membranous, glabrous, upper half coming off as a blunt conical lid and seeds are ovoid-oblong, boat-shaped, smooth,

rosy-white being concave on one side and convex on the other. The concave side of the seed is covered with a thin white membrane produced by fusing of outer layer of ovule together with the inner epidermis, forming the seed coat <sup>[2]</sup>. The seed epidermis is made of polyhedral cells whose walls are thickened by a secondary deposit which is the source of mucilage. On mechanical milling, the coating of seed provides the husk, a membranous covering of the seed, white to light pink in colour, translucent and odourless. The husk absorbs moisture and forms a tasteless mucilaginous substance which constitutes the drug <sup>[3]</sup>. The seed and husk of the plant are of great medicinal and commercial importance. In industrial sector, seeds of the crop are referred as Blonde Psyllium seed or Indian Psyllium seed. Psyllium seeds obtained from another plant *Plantago psyllium* Linn. is known in commerce as Spanish or French Psyllium seeds. However, most of the world supply of psyllium seeds comes from *Plantago ovata* <sup>[4]</sup>.

## DISTRIBUTION

It is commonly distributed in the Mediterranean coastal region, Sinai, Isthmus desert, East of the Nile, North Africa. India, Iran, Pakistan, countries of the Arabian Peninsula and West Asia, extending up to Sulej and Sind in West Pakistan <sup>[5]</sup>. It is also distributed throughout Arabia on sandy and silty soil; often in shady and damp locations <sup>[6]</sup>. The crop was introduced to India during 16th century, the era of Muslim settlement in middle ages. In India, it is cultivated as a cash crop in the Mehsana, Palampur and Banaskantha districts of Northern Gujarat <sup>[7]</sup>, parts of southern Rajasthan and to a very small extent, in Patiala and Hisar districts of Punjab and Haryana states of the country. On a limited scale, it is cultivated in some areas of West Pakistan<sup>[8]</sup>.

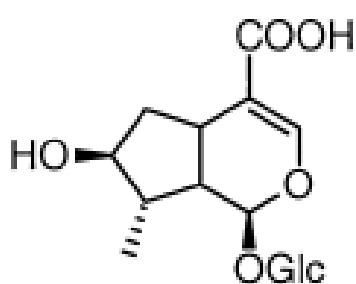
## Traditional Medicinal Value

In traditional system of medicine, dried seed and husk are regarded as emollient, demulcent and safe laxative particularly beneficial in habitual constipation, chronic diarrhoea and dysentery <sup>[9,10]</sup>. Seed husk of blonde psyllium has been used in European and Asian herbal medicine for chronic constipation since the 16th century <sup>[11]</sup>. It does not irritate the intestine and is specific in its use when mucous membrane is disturbed by inflammatory affection. Seeds are considered as cooling and diuretic and recommended for use in febrile conditions and in the affections of kidney, bladder and urethra. A decoction of seeds is prescribed in cough and cold and a poultice of crushed seeds are useful to rheumatic and glandular swellings <sup>[11]</sup>. In Yemen soaked seeds are used as a poultice on boils and ulcers and as a cosmetic for hair <sup>[12]</sup>. A slight degree of astringency and some tonic property may be imparted to the seeds by application of a moderate

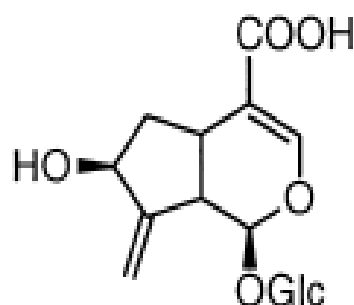
degree of heat and it is said that this remedy cures the chronic diarrhoea of European and native children on failure of other medicines <sup>[13]</sup>. The plant is regarded as a remedy for various ailments in traditional system of medicine in different parts of the world. Its seeds are accredited for their usefulness in healing dysentery, enteritis and gastritis <sup>[14]</sup>. In India, decoction of dried seeds is taken orally for diarrhea <sup>[15]</sup> and as a demulcent. Seeds are taken externally as an emollient poultice, for constipations, and for gastric complaints <sup>[16]</sup>. Water extract of the dried seed is used externally in Iran for its inflammatory and emollient effects. Mixed with coconut juice, it is used as a diuretic. Dried seeds are taken orally for diarrhea and indigestion associated with bile secretion abnormalities. Mucilage of the dried seed is used externally as an emollient. Seed coat of the dried seed is taken orally as a bulk laxative. Acetic acid extract of the dried seed is used externally for rheumatoid arthritis and gout. Infusion of the dried seed is taken orally for urinary tract inflammations <sup>[17]</sup>. In Spain, leaf is taken orally by infusion for cold <sup>[18]</sup> whereas in Thailand, hot water extract of the dried seed husks is taken orally as a demulcent and for diarrhea <sup>[19]</sup>. Having grown in arid and semi-arid part of India, it is popularly called as Desert Indianwheat. and is traditionally used as a medicine in South Asia, but nowadays it is widely used throughout the world as a medication. Being native to Mediterranean regions including North Africa, Europe and Pakistan, desert indianwheat is able to grow in a wide range of agroclimates; however, it is limited to arid zones because of its low water demand <sup>[20]</sup>.

### Phytoconstituents of *Plantago Ovata*

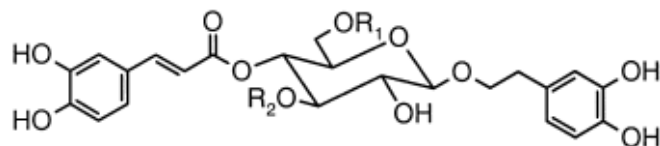
Psyllium husk contains a high proportion of hemicellulose, composed of a xylan backbone linked with arabinose, rhamnose, and galacturonic acid units (arabinoxylans). Phytochemical investigation of *Plantago* species revealed their high potential to produce a wide array of secondary bioactive metabolites, i.e. iridoids, phenols, polysaccharides, sterols, alkaloids and cumatines that have utilities as supplemented food and as drug to treat human diseases <sup>[21, 22]</sup>.



5, 6, 8-Epiloganic Acid



Gardoside



**Plantamajoside (R1=H, R2=Glc)**

**Fig 1: Phytochemicals isolated from *Plantago* species** <sup>[22]</sup>

The seed consists of 35 percent soluble and 65 percent insoluble polysaccharides (cellulose, hemicellulose and lignin). Psyllium is classified as a mucilaginous fiber due to its powerful ability to form a gel in water. This ability comes from its role as the endosperm of the *P. ovata* seed, where it functions to retain water in order to prevent the seed from drying out. Psyllium seeds contain over 30% of hydrocolloidal polysaccharide (mucilage) in the outer seed coat, fixed oils, tannin, aucubin glycoside (iridoid), sugars, sterols and protein. This mucilage is colloidal in nature and its composition varies with the conditions of preparation <sup>[23]</sup>. It is mainly composed of xylose, arabinose and galacturonic acid with rhamnose and galactose. Two polysaccharide fractions have been separated from the mucilage. One of them is soluble in cold water and on hydrolysis yields D-xylose (46%), an aldobiouronic acid (40%), L-arabinose (7%) and insoluble residue (2%); the other fraction is soluble in hot water forming a highly viscous solution which sets to a gel on cooling and yields on hydrolysis D-xylose (80%), L-arabinose (14%), aldobiouronic acid (0.3%) and trace of D-galactose <sup>[24]</sup>. In addition to mucilage, seeds contain a semi drying bright yellow coloured fatty oil (5%), small amounts of aucubin and tannin and an active principle exhibiting acetylcholine like action. The constituent fatty acids in the oil are linolenic, 0.2; linoleic, 47.9; oleic, 36.7; palmitic, 3.7; stearic, 6.9; and lignoceric 0.8 %. The amino acids reported in the seed are valine, alanine, glycine, glutamic acid, cystine, lysine, leucine and tyrosine. The dehusked seed is found rich in starch. Seeds also contain various bases, sugars, sterols and protein. Wild collected seed yield less mucilage than the cultivated species <sup>[2, 25]</sup>.

The efficacy of isabgol is entirely due to the large quantity of mucilage present in the husk which swells into a jelly like mass with cold water. It relieves constipation by mechanically stimulating the intestinal peristalsis. The mucilage has been found to be practically unaffected by the digestive enzymes and bacteria and passes unchanged through the intestine. During its passage, the mucilage lines the mucous membrane and exercise a soothing and protective action as a demulcent, emollient and lubricant <sup>[26, 27]</sup>. The toxins present in the gut are absorbed by the gel of the mucilage and thus are prevented from absorption into the system. The seeds in the

dose of 5-15 g are soaked in water for several hours before being taken since as such they may cause irritation in inflammatory condition of the alimentary tract, and may lead to spasm and an increase in constipation <sup>[8, 25]</sup>. As the retention of seeds in the intestine may also form a nucleus for mechanical obstruction, the seed husk (dose 0.5-20 g) is preferred to whole seeds especially in acute conditions <sup>[11]</sup>. The mucilage acts in very much the same way as liquid paraffin, but is considerably cheaper and is free from the injurious effects viz., malignant diseases of colon, eczema and paraffin pains etc. produced by the habitual use of paraffin <sup>[2]</sup>. The action of the drug would therefore appear to be purely mechanical as the large amount of mucilage contained in the superficial layer of the seeds is shown not to be acted on the digestive enzymes and therefore passes through the small intestine unchanged <sup>[10]</sup>.

### Pharmacological Actions

*Plantago ovata* is a well-known medicinal plant in the treatment of inflammatory bowel disease (IBD). *P. ovata* seeds ameliorated the development of colonic inflammation in transgenic rats as evidenced by an improvement of intestinal cytoarchitecture, significant decrease in some of the pro-inflammatory mediators and higher production of short-chain fatty acids <sup>[27]</sup>. Alcoholic extract of the seeds exhibit cholinergic properties. It has been found to decrease blood pressure in anaesthetized cats and dogs, inhibit the isolated and perfused hearts of rabbits and frogs and stimulate the movement of intestine of rabbits, rats and guinea-pigs. The activity of the extract on smooth muscle is inhibited by atropine. The seed oil has shown the property of reducing cholesterol level of serum in rabbit <sup>[2, 3]</sup>. The use of linoleic acid-rich oil obtained from embryo has been suggested as a dietary hypocholesterolemic agent in place of corn oil. Feeding of the embryo oil as dietary supplement for lowering serum cholesterol level gave encouraging results in experimental animals <sup>[28]</sup>. Adding husk of isabgol to the diet of patient suffering from atheromatous heart diseases showed significant reduction in the frequency of anginal attack <sup>[29]</sup>. The glucoside named aucubin, found in the seeds is physiologically inactive. The tannins which are present in appreciable quantities have little action on entamoeba or bacteria <sup>[2, 25]</sup>. The ethanol and acetone extract of *P. ovata* showed good antibacterial activity against *E. coli* <sup>[30]</sup>.

*P. ovata* seeds have also been found to reduce the level of cholesterol. Seed husks of *P. ovata* are currently used in the pharmaceutical industry <sup>[31, 32]</sup>. Rozaeipoor et al. (2000) <sup>[33]</sup> showed that an extract of *P. ovata* seeds significantly affected the immune system of rabbits. It caused a reduction in anti-HD antibodies as well as an increase in the number of white blood

cells and spleen leukocytes. The aqueous extract of *P. ovata* seeds reduced hyperglycaemia in type 1 and 2 diabetes in rats. These properties show that this extract can be used in diabetes treatment [34]. Treatment with *P. ovata* seed coat preparations increases and stabilises the level of HDL- cholesterol, thereby reducing the risk factors of cardiovascular system diseases [35]. Prolonged intake of fennel extract or Plantago seeds-supplemented diets retards obesity. The effect that was accompanied by improvement of BMI, amelioration of the dyslipidemia, hyperinsulinemia and hyperleptinemia, modulation of glycemic status and reduction of the oxidative stress in high-fat diet-induced obesity in rats. The observed effects of fennel extract or Plantago seeds could be attributed to their properties such as hypolipidemic, antioxidant and anti-inflammatory. Thus fennel extracts particularly methanolic extract or Plantago seeds may be useful in treating obese patients with hypercholesterolemia and hyperglyceridemia [36]. More over considering the extracts of *P. ovata* especially methanolic it was more effective against gram positive bacteria [37]. Dried seed husks, administered orally to adults at a dose of 3.5 g/person, decreased the bioavailability of carbamazepine [38]. Husks, administered to African green monkeys fed a high cholesterol diet at a concentration of 10% of diet showed anti-atherosclerotic effect [39]. Seeds, administered orally to adults with mild hypercholesterolemia found to reduce LDL cholesterol by 8% and total cholesterol by 6% [40]. Consumption of psyllium-enriched cereal as part of a low-fat diet improved the blood lipid profile on hypercholesterolemic adults [41]. Water extract of the dried seed, reported to exhibit weak antibacterial activity against *Streptococcus pyogenes* [42]. Dietary psyllium fiber, administered to type 2 diabetes patients before meals, produced no significant changes in patient's weight. Psyllium seed husk administered to genetically diabetic mice at a dose of 2.5% of diet found to produce higher levels of insulin [43]. Fasting plasma glucose, total cholesterol, low-density lipoprotein (LDL) cholesterol, and triglyceride levels showed a reduction, whereas high-density lipoprotein (HDL) cholesterol increased significantly after the treatment [44]. The active constituent, aucubin, in combination with caffeic acid, chlorogenic acid, ferulic acid, *p*-coumaric acid, and vanillic acid, exhibited weak antileukemic activity on human leukemia and lymphoma cell lines. Water-insoluble compounds, such as triterpenoids (oleanolic acid and ursolic acid), monoterpene (linalool), and flavonoid (luteolin) produced strong activity [45]. Water extract of the dried seed, at various concentrations showed anti-nematodal activity against *Meloidogyne incognita* [46]. Oral administration of dried seeds powder before feeding produced a significant increase in sense of fullness and a decrease in fat consumption [47]. Fiber reported to produce a higher total bile acid pool size also lowered the hydrophobicity of the bile acid pool [48]. Wheat bran and

psyllium (1:1), at a total level of 18% dietary fiber, offered the highest protection against colon tumor development <sup>[49]</sup>. Seed bran was found active against *N*-methylnitroso-induced carcinogenesis in the breast, greatest effect was obtained with coadministration of wheat Bran <sup>[50]</sup>. Isaptent, prepared from granulated *Plantago ovata* seed husk has been found to be an acceptable cervical dilator in females irrespective of age, parity, and gestation period of the subjects with no apparent damage to the cervix and the vaginal flora remained unchanged in the randomly selected subjects <sup>[51]</sup>. Mucilage, administered orally to human adults indicated weight-reducing effect of mucilage <sup>[52]</sup>. The characteristics of mucopolysaccharides granulate derived from husk in relation to fluid absorption, bacterial adherence, biocompatibility, stimulation of macrophages, irritancy response, and allergenicity showed an optimal profile, supporting the good clinical performance in wound healing <sup>[53]</sup>.

### Industrial and Commercial Utilization

The isolated mucilage powder of *P. ovata* exhibits faster drug dissolution and improved bioavailability, and it was stated that the isolated mucilage powder can be effectively used as disintegrants and superdisintegrant in tablet formulations <sup>[54, 55]</sup>. The literature confirms that seed husks of *P. ovata* have found application in the cosmetics industry <sup>[32]</sup>. In India, most of the husk processing factories are located in Gujarat state <sup>[7]</sup>. Isabgol husk commonly known in commerce as Bhusi or Sat isabgol, is available in market in various grades. The quality of husk is determined by its size, colour, and presence of red scrapings on the upper layer of the kernel, husk powder and dust. Husk of large size, white colour and free from red scrapings fetches good return. Seed husk is packed under three qualities viz., 50, 60 and 70 mesh clean; at present most of the exports consists of 70 mesh clean <sup>[2]</sup>. India is the largest producer and the main supplier of psyllium seed and husk to the world market. USA is the chief importer of isabgol seeds and husk <sup>[56]</sup>. The crop has a large export demand in USA and Western Europe and about 90% of the production is exported to these countries <sup>[57]</sup>. It has also been noted that growing of this crop in winter season will not affect the production of succeeding monsoon crop and thus fits well in the cropping system. The seed husk finds variety of industrial applications. It is the main constituent of a number of laxative preparations containing sodium bicarbonate and various flavours used in modern medicine. On account of the remarkable property of mucilage from seed husk as a thickener, it could be used as such in food industries. It is employed as a basic stabilizer in ice-creams and as an ingredient of chocolates and other food products. It is also used for sizing purpose and as a base in cosmetics. The husk has been found to be served as a good binder and disintegrant in compressed tablets. On treatment with hot caustic soda solution and subsequent

neutralization, the seed husk produces jelly which provides a substitute for agar-agar. Psyllium seed gum has been used to prepare dry dentifrice powder and germicidal lubricating gels. It has also been successfully employed in composition for petroleum well acidization. Water resistant explosive compositions can be prepared with psyllium seed gum alone or in admixture with other gums<sup>[4]</sup>. When mixed with guar, seed husk can be used as a cattle feed particularly in cases of lactating animals. The dehusked seed is around 69% by weight of the total seed crop which is used as a bird-feed<sup>[2]</sup>.

## CONCLUSION

In view of the wide industrial application and market demand, cultivation of isabgol may be a profitable agro-practice for the farmers. The plant has been cultivated in India and Pakistan for hundreds of year. It is desirable to intensify work for improvement of this crop plant so as to develop varieties which can produce higher yield of seeds as well as mucilage. Appropriate techniques need to be developed to improve the traditional process of milling of seeds and to explore the possibilities of preparing newer high valued commercial products out of the seeds and husk of the crop in the benefit of cultivators and plant based industries.

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