Psyllium Mucilage and Its Use in Pharmaceutical Field: An Overview

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Abstract

Psyllium mucilage or Plantago psyllium ovate is a food grade natural polysaccharide obtained from Plantago psyllium and its mucilage is calm of natural arabinoxylan (arabinose 22.6% and xylose 74.6%). Psyllium mucilage is extracted from psyllium husk. Graft copolymerization is one of the best methods for modifying psyllium, which impart certain functional properties to psyllium without destroying its basic properties. The grafting is initiated through the formation of the free radical centers on the polymer backbone. Psyllium has wide application in many health problems, particularly cholesterol control, colon cancer prevention, high sugar levels in blood and widely used as a laxative.

Keywords: Psyllium mucilage; Husk; Seed; Laxative; Cancer

Introduction

Psyllium husk is obtained from the seed of the Plantago ovate plant. Psyllium is also recognized as ispaghula and isabgol widely used as a laxative. Isabgol comes from the Persian words as band ghoul, meaning “horse flower” which is descriptive of the shape of the seed [1-6]. The plant of isabgol is generally 10 to 18 inches in height, with numerous small and white flowers are shown in (Figures 1 and 2). Normally, psyllium is cultured for its mucilage content, which is a white fibrous material with hydrophilic characteristic. The mucilage can be obtained by mechanical milling/grinding, and is usually referred to as husk [7]. Psyllium is the commonly used word for more than 200 species of the plant genus Plantago which are used commercial manufacturing of mucilage. Plantago psyllium and Plantago ovata are shaped commercially in many European countries, the former Soviet Union and various region of middle Asia. Plantago seeds popular as black, Spanish or French in trade market. Psyllium is obtained from Plantago psyllium and Plantago arenaria [8,9]. Psyllium was an indigenous plant of Persia, currently grown in the western states of India. Gujarat, Rajasthan, Madhya Pradesh, Haryana is main crop psyllium producing states in India. Currently, India is the chief producer as well as exporter of Isabgul husk and Psyllium husk in world. The crop of psyllium is mainly cultivated in Gujarat, Madhya Pradesh and Rajasthan. Among these states, Gujarat is the main center for the production as well as processing, because the environmental conditions of the Gujarat, Rajasthan also has similar status for cultivation and production as the environmental conditions are very conducive for harvesting of these crops. Gujarat and Rajasthan are collectively reported to have an area of about 61,000 hectares under its cultivation [10,11]. India provides main contribution for availability of the psyllium in the world market and USA being the world's largest importer of psyllium husk. Some well-known psyllium global brand names are Meta-mucilage, fiber all, bonvit, konsyl, modane bulk powder, perdiem fiber, serutan, siblan, fybogel. Psyllium husk has long history of its use as traditional and herbal medicines in the Middle East, United States, Europe, India and China. Psyllium is anionic polysaccharide of L - arabinose, D - xylose and D - galacturonic acid. The husk of Plantago psyllium used as the raw material to obtain the psyllium mucilage shown in Figure 3, and used after purification. Its purification is carried out by precipitation in aqueous solution with alcohol and it was finally washed with acetone and dried [12,13]. Psyllium is a natural polysaccharide

Figure 1: Plantago ovata plant.

Figure 2: Psyllium seed.

Figure 3: Plantago ovata plant.


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carried out from *Plantago psyllium* and its mucilage is consisting of arabinoxylan (arabinose 22.6%, xylose 74.6%). The physiologically reactive component of Psyllium husk is exhibit to be a greatly branched arabinoxylan [14,15].

Kumar and Kaith studied *Plantago afr* (Plantago psyllium), *Plantago ovata* and *Plantago indica* (Plantago arenaria) belongs to the family Plantaginaceae and are also used in medicinal since ancient time. It is widely used as a home medicine in all cultures, in many types of diseases, situations like diarrhea, as bulk forming, chronic constipation, non-irritant laxative drug, inflammation of the mucous membrane of gastro intestine and genitourinary tracts, gonorrhea, duodenal ulcer, piles, demulcent as a cervical dilator etc. [1,16,17] Marlett and Fischer investigated that in contrast to arabinoxylans in cereal a grain that is extensively fermented, psyllium husk have a structural application, as yet unidentified, and that hinders its fermentation by typical colonic micro flora [18]. Gupta and Fischer et al. [19,20] investigated that Psyllium has a powerful capacity to obtain a gel in water and through animal and human feeding experiments, so psyllium is a mucilaginous fiber. Psyllium has been exhibiting that a gel producing fraction, amounting to some 55% to 60% of the psyllium husk which is responsible for both the cholesterol lowering activities and laxative. Viscous, non-nutrient polysaccharides, like as β-glucans as well aspectins, low blood cholesterol levels through the similar mechanism as psyllium, but these substances have negligible effects on bowel function. Anderson et al. [21] studied the structure of the arabinoxylan showed in Figure 4. *Plantago psyllium* is a significant herb that has been used in health care for various centuries in South Asia. It is widely used in medicinal characteristics all over the world. Psyllium an ayurvedic herb is found in Iran, India and Afghanistan. It is also native to the surrounding of the Mediterranean, including Northern Africa, Europe and Pakistan. This plant can be grown under a wide range of the arid areas of the world due to its low water requirement. Psyllium husk is a bulking fiber, after ingestion it expands and forms gelatin like mass in the colon by drawing in water. Once this occurs, the husks are able to “undergrowth” the bowels clean and transport waste by the stomach tract. Some population based studies also recommend that enhanced fiber consumption may decrease the risk of colon cancer. Psyllium husk is valued for its nutraceuticals, medicinal and pharmaceuticals applications. It is mostly treated such as laxative, which have a plethora of health benefits and has established to be actual in treating irritable, constipation, diabetes, bowel syndrome, high cholesterol, colon cancer, obesity, atherosclerosis and ulcerative colitis among several other health conditions [20].

**Characterization of Psyllium**

**FT-IR spectroscopy**

Kaith and Kumar [22] investigated that the spectra of Psyllium has broad absorption band at 3401 cm⁻¹ which can be credited to –OH stretching of alcohol (Figure 5). A peak seeming at 2926 cm⁻¹ is due to C-C stretching of alkanes, while the peak at 1050 cm⁻¹ credited to C-O-C stretch of ether. The peaks showing at 896, 714 and 613 cm⁻¹ may be due to polymer chain bending.

**Scanning electron microscopy**

Sen et al. [23] studied the surface morphology of psyllium they were analyzed in scanning electron microscopy (SEM) in powdered form (Model: JSM-6390LV, Jeol, Japan). The surface morphology of psyllium they were analyzed in scanning electron microscopy (SEM) they were found psyllium has smooth and homogenous structure shown in Figure 6.
Psyllium act as a drug delivery carrier

Psyllium belongs to Plantago ovata family of plants. Psyllium seeds as well as husk are widely used in pharmaceutical field as demulcent, emollient laxative, drug therapy on lipid and glucose levels and many other diseases. Many drug delivery devices have been investigated to deliver the drug for therapy, but hydrogels, particularly based on natural polymer, have attracted considerable attention as excellent candidates for controlling release devices or targetable devices of the therapeutic agents. Singh and coworker investigated that Psyllium itself also acts as anti-ulcer agent as well as release of rabeprazole from the drug laden hydrogels may increase the curing potential of the drug delivery device. The haemo compatibility was assessed by learning the blood connections with graft copolymer with reference to thrombogenicity as well as haemolytic potential. Thrombogenicity results specify that graft copolymers are non-thrombogenic as the weight of clot shaped and thrombus percentage for graft copolymer was less than the positive control [14,22,25]. Psyllium is one of the medicinally important gels forming glucose dropping dietary fiber. It reduces hyperglycemia in diabetes by inhibition of intestinal glucose absorption as well as improvement of motility. Since the glucose lowering effect of psyllium was clearly evident when simultaneously administered with glucose, reserve of glucose absorption in the intestine is a likely contributor to the mechanism of action. Psyllium in the diet also develops glucose broadmindedness in diabetes; it has been described for the action of constipation, diarrhea, and inflammation bowel diseases-ulcerative colitis, obesity in children, adolescents and high cholesterol. In view of the pharmacological significance of psyllium polysaccharides to decrease glucose absorption as well as drug delivery strategies based on hydrogels, psyllium, if appropriately tailored to synthesize the hydrogels, can work as the double potential candidates to improve new drug delivery systems [15,26]. In one study the biochemical, nutritional and hematological effects of psyllium has been unshaken. Ispaghula was observed that a daily dose of 11.5 g of ispaghula was well tolerated and the mainstream of opposing events recorded were minor, of short duration and either unconnected or perhaps related to the study treatment. The results from the study suggested that Plantago psyllium ovata could be used with sureness for the long-term action of mild-to-moderate hypercholesterolemia studied with Oliver and coworker [27]. US Food and Drug Administration recently authorized the use of health claims on food products containing soluble fiber from psyllium which associated with a decreased risk of coronary heart disease studied by Anderson et al. [26].

Synthesis Polymer Matrix of Psyllium

Graft and crosslink materials of Psyllium were prepared by free radical polymerization mechanism and microwave irradiation method.

1. Free radical mechanism.
2. Microwave irradiation methods.

Free radical mechanism

Polymeric networks of Psyllium were prepared by the free radical polymerization mechanism in the presence of crosslinker, because crosslinker generate the reactive sites and these active sites can be related both with the radical on the psyllium as well as monomers and form of three-dimensional networks, which were widely used to study the in vitro release of the model drugs. The reaction was carried out with a specific amount of psyllium mucilage, initiator, monomer and crosslinker, in the specific solvent at 50°C temperature for 1-2 h. The final product was precipitated (ppt) in excess of isopropanol and filtered by a sintered glass filter. The ppt was again inaudible in acetone shadowed by filtration and finally the precipitate was dried in oven at 40°C. The homopolymer was removed from the grafted copolymer by using acetone as solvent in a soxhlet extractor until a constant weight was obtained [27].

Microwave irradiation methods

Microwave irradiation is used most efficaciously to improve the procedural limitation in the synthesis of a range of graft modified polysaccharide material. In fact, the increasing interest in green and clean eco-friendly chemistry has interested the use of microwaves in the polysaccharide grafting modification. Thus, microwave irradiation meaningfully reduced the use of poisonous solvents as well as the reaction period in mostly the grafting reaction of interest here, ensuring high yields product selectivity and cleans product formations [28].

Drug Delivery Studies

An extensive diversity of grafted natural polymer psyllium has been used to fabricate in different types of drug delivery system. Among these, colon under bout drug delivery systems have attracted several researcher's due to the separate benefits they current such as near neutral pH, longer transportation time and decreases enzymatic activity. Moreover, in recent studies, colon specific drug delivery systems are ahead significance for use in the action of local pathologies of the colon and also for the universal delivery of protein as well as peptide drugs, Singh et al. investigated, that more colonic concentration of drugs is compulsory for the treatment of the diseases related with the colon. Therefore, a flexible approach is desirable to deliver drugs to the colon for effective therapy. Singh and Sharma et al. also studied that the development in drug therapy is a significance of not only the project of new drug molecules but also the growth of appropriate drug delivery systems. The traditional drug delivery systems do not provide an ideal pharmacokinetic profile, particularly for the drugs, which display high poisonousness and fine therapeutic window. In an ideal case scenario, such a profile can be attained by use of the natural polysaccharides matrix which delivers controlled delivery of drug to preserve the therapeutic level. Among different hydrogels, drug delivery devices, especially based on polysaccharides have concerned considerable attention as a better candidate for controlling release of therapeutic agents [29]. Singh, et al. Studied the modified psyllium with acrylic acid based graft copolymer also used in colon precise drug delivery [30]. The dynamics of model drugs (tetracycline hydrochloride, insulin
and tyrosine) were released from modified psyllium with acrylic acid drug loaded hydrogels, the Crosslink copolymer used in colon exact drug delivery. The released of water-soluble drug entrapped in a hydrogels, befallen only after water penetrate the network to swell the polysaccharides and dissolved the drug, followed by diffusion along the aqueous pathways to the surface of the device. The release of the drug was closely linked to the swelling characteristics of the graft copolymer, which in turn, was a key function of chemical architecture of the graft copolymer. Tetracycline hydrochloride was released from per grams of the drug-loaded hydrogels were investigated in different release medium, the amount of drug release increased in pH 7.4 buffer was higher than and distilled water and pH 2.2 buffer. In pH 2.2 buffers higher amount of release may be more due to the solubility of the drug in this medium was expected. The drug was released quicker in pH 7.4 buffer. Insulin and tyrosine were released from the polymer matrix, the amount of insulin and tyrosine released per gram of the gel was higher in distilled water and pH 7.4 buffers as compared to the pH 2.2 buffer. This observation was explained on the basis of the swelling of the hydrogels. Fifty percent of the total release of the drug occurred in respectively in releasing medium of pH 7.4 buffers, pH 2.2 buffer and distilled water. This observation was very significant for emerging the colon specific drug delivery systems and it was observed from the rate of release and release trends that the release of insulin was occurring only at higher pH which corresponds to the colon studied by Singh et al. in 2007 [31]. Singh et al. [32] in 2008 studied the dynamics of model drug anticancer 5-fluorouracil was released from psyllium and polyacrylic acid polymeric networks. It was also investigated that from the swelling and drug release in the different pH buffer that the graft copolymer was pH responsive and could be oppressed for the delivery of anticancer drug to the colon. The effect of pH on the release profile of 5-fluorouracil was studied in varying the pH of the release medium. The drug was released from per gram of the drug-loaded hydrogels; the amount of drug released in the pH 7.4 buffers and in distilled water was more as compared to the pH 2.2 buffer. This observation was corresponding to swelling trends observed in different pH medium [32]. Singh et al. [33] reported that the tetracycline hydrochloride drug and dynamics of model antibiotic drug rifampicin were released from the modified psyllium with methacrylamide through radiation crosslinked polymerization. The release dynamics of rifampicin was a broad-spectrum antibiotic used to treat Mycobacterium contagions, leprosy and with tuberculosis and also has a role in the handling of methicillin-resistant Staphylococcus aureus in combination with fusidic acid. It was used in prophylactic therapy against Neisseria meningitidis (meningococcal) infection. It was also used to treatment of infection through Listeria species, Legionella pneumophila, Haemophilus influenza and, Neisseria gonorrhoeae Rifampicin prevents DNA-dependent RNA polymerase in bacterial cells by required to its beta-subunit, thus stopping transcription of mRNA and successive translation to proteins. However Rifampicin did not quandy to mammalian nuclear RNA polymerase and therefore does not affect the RNA synthesis in human beings. Rifampicin was also known for its potent effect and ability to prevent drug resistance. It rapidly kills fast-dividing bacilli strains as well as “persisters” cells, which was remained biologically unreactive for long periods of time that permit them to avoid antibiotic activity. The amount of drug was released at pH 7.4 buffer was more as compared to the pH 2.2 buffer. Hydrogels consist of macromolecular chains cross linked to each other to create entangled mesh structure, providing a matrix for entrapment of drugs. When such loaded matrix comes in contact with thermodynamically companionable solvent, relaxation of polymeric backbone takes place. The liquefied drug diffuses into the external discharging medium. More the swelling, faster the release of drug from the polymer matrix will occur [33]. Singh et al. [34] studied that the tetracycline hydrochloride drug was released from the improved psyllium with methacrylamide poly (MAAm) polymeric networks through using N,N-MBAAm as cross-linker and ammonium persulfate (APS) as initiator which used in colon specific drug delivery. The release of water-soluble drug tetracycline hydrochloride obtained only after water penetrates the polymeric networks to swell and dissolve the drug, tracked by diffusion along the aqueous ways to the surface of the device. The effect of pH on the release pattern of tetracycline was studied in varying the pH of the release medium. However, the amount of drug release in pH 7.4 buffer solutions was higher than the pH 2.2 buffer and distilled water. Singh, et al. [35] observed that dynamics model of the drug tetracycline hydrochloride was also released from the modified polysaccharide psyllium with 2-hydroxyethylmethacrylate (2-HEMA) and acrylamide (AAm)-based polymeric networks.

Singh and Sharma studied that the model of antibiotic drug tetracycline hydrochloride was also released from the modified psyllium with poly (vinyl alcohol) and poly(acrylic acid) in different release medium at 37°C using the pH 2.2 buffer, hence these hydrogels were suitable for peptic ulcer caused by helicobacter pylori. The release of antibiotic drug tetracycline hydrochloride from the drug loaded polymer was more observed in pH 2.2 buffer solution [36]. Singh et al. were prepared Psyllium-PVA hydrogels by chemical method, which release profile of the rabeprazole sodium in different release medium at 37°C. The amount of drug released in pH 7.4 buffer was higher than the release in pH 2.2 buffer solution. More release of drug in pH 7.4 buffer may be due to higher swelling of hydrogels, and higher solubility and stability of rabeprazole sodium under alkaline conditions. Thrombogenicity of psyllium-cl-PVA hydrogels clotted formed and thrombus percentage for polymers were 0.275 ± 0.019%, gram per 2 ml of blood and 91.58 ± 6.75%, respectively. It was observed that clot formation was inferior in the membranes than in the governor and for this reason, the polymers were classified as non-thrombogenic. The hemolytic potential of psyllium-cl-PVA. The hemolytic percentage of hydrogen was found to be 4.51 ± 0.37%. Psyllium-cl-PVA hydrogel having haemolytic percentage between 2 and 5% was found to be partially haemolytic [37]. The release dynamics of the classical drugs (salicylic acid and tetracycline hydrochloride) was synthesized by psyllium with polyacrylamide (AAm) based hydrogels. Salicylic acid and tetracycline hydrochloride were released from per grams of the drug loaded hydrogels. The quantity of drug release in pH 7.3 buffer was higher than the release medium of 2.3 pH buffer and distilled water [38]. Water-soluble drug salicylic acid and tetracycline hydrochloride was also released from the modified psyllium with N-Hydroxymethylacrylamide (N-HMAAm) based hydrogels. The release of the drug was closely related to the swelling characteristics of the hydrogen. Salicylic acid tetracycline were in releasing medium of pH 7.3 buffer, pH 2.3 buffer and distilled water [29]. Kumar, modified Psyllium (Psy) with acrylamide (AAm) based superabsorbent; hydrogels were applied for controlling delivery of 5-amino salicylic acid under different pH conditions at 37°C. Psy-cl-poly (AAm)-1A was found to exhibit maximum initial release of drug at pH 9.2 (218 ± 6.55 ppm) followed by the release at pH 7.0 (185 ± 2.09 ppm) and release at 4.0 pH (109 ± 5.51 ppm). Moreover, final release of drug was found maximum in case of alkaline medium (301 ± 7.24 ppm) followed by release in neutral medium (291 ± 7.20 ppm) and then in acidic medium (257 ± 14.10 ppm). The maximum release of drug was found to increase with increase in pH [24]. Prashar, et al. investigated that Psyllium cross-linked with poly acrylic acid (AA) was used for stimulus sensitive drug delivery system as an effective and an alternate...
drug carrier in comparison to artificial backbone based polymers. The electrical stimulus studies were carried using alternative current (AC) source. The swelling behavior of candidate polymer was estimated using artificial biological fluid. Maximum swelling was found in artificial biological fluid. Initially a rapid swelling was reported in the candidate synthetic polysaccharides, which might be because of the detail that the solvent system on electrodissociation ions which easily made an entrance into the gel network and swelling was observed [38].

Use of psyllium in pharmaceutical field

*Plantago psyllium* mucilage or *Plantago psyllium ovata* is a food grade polysaccharide. It has soluble fiber component. Psyllium has wide application in many health problems. Many researchers have investigated amazing health benefits of psyllium mucilage particularly cholesterol control, preparation for colonoscopy procedure, increasing absorption of water during ingestion subsequent to relaxed stools and reduced pain associated with hemorrhoids, colon cancer prevention, high sugar levels in blood, obesity and weight loss, inflammatory bowel disease, and widely used as laxative etc. (Figure 8).

### Reduced the cholesterol levels

Anderson et al. studied, psyllium is widely used to reduce the cholesterol levels. It is a widely accepted statement that elevated plasma cholesterol level is a major factor leading to the development of several lethal diseases, such as cardiovascular disease (CVD) and coronary heart disease (CHD). Although medical technologies improved rapidly in the past many years, CHD is still the leading cause of death in the US and other western countries. They were also investigated that there is a positive association with plasma LDL cholesterol levels and coronary heart disease risk. Intake of dietary fibers known to lower the concentration of LDL in plasma is considered to be highly beneficial. Psyllium drinking has consistently shown significant reductions in plasma LDL cholesterol levels ranging from 10 to 24%. Reports the utility of psyllium, mainly in hypercholesterolemia men, have suggested that it lowers serum cholesterol as an outcome of the binding of bittering acids in the stomach lumen and abridged risk of coronary heart disease. The mechanism of action of psyllium's hypercholesterolemia effects has not been completely elucidated [39,40].

### Diabetes

Brennan studied, that that psyllium may serve as a hypoglycemic agent in healthy human subjects as well as patients with diabetes. It helps control the rise of blood glucose following a meal. They suggested moderate decreases in blood sugar levels after a single quantity of psyllium, with unclear long-term effect [41]. Water soluble nutritional fibers, reduction postprandial glucose concentrations and decrease serum cholesterol concentrations in men with type -2 diabetes. Initial or unrestricter studies suggested that psyllium improved glycemic and lipid control in individuals with type -2 diabetes. The capacity of soluble fibers to decrease the postprandial glucose reaction to meals eaten some hours after fibre ingestion (second meal effect) was shown previously in non-diabetic individuals. It also reduced insulin recruitment in patient with diabetes mellitus [32,42].

### Cancer prevention

Sierra et al. investigated that psyllium has anti-carcenogenic characteristics, especially for breast cancer and colon cancer. Psyllium is used to increase the bulk of stool and reduced the time of transit and also reduced the revelation of the intestinal wall to the deadly compounds, which is found in the stool. Although the underlying mechanisms of psyllium is cancer prevention capability are still not thoroughly clear, a large body of research has been done to reveal the possible effects [32,43].

### Laxation

Many researchers have investigated that psyllium is widely used as a laxative. In many years, psyllium has been used as an effective action towards irritable bowel disease due to its laxative effect. They also study has been conducted to measure the effectiveness of psyllium, and the results were seen to be combined. Kumar et al. studied, similar effect of psyllium on ameliorating bad-tempered bowel syndrome. They observed that the optimum dosage of psyllium for this treatment using three different doses: 10 g, 20 g and 30 g daily. The observation was divided into two parts. In part first, patients were administered 10 g psyllium every day for 17 days, and then the dosage increased to 20 g for the subsequent 17 days and finally, 30 g psyllium were given to patients daily for the last 17 days. In part II, to avoid the potential spill over from single dose to the next one, three different dosages of psyllium were administered in a random order and a one-week washout period was included between the two dosages [17]. By clinical assessments of irritable bowel syndrome in patients, a dosage of 20 g psyllium per day was postulated to be the optimum dosage. The laxative effect of psyllium was considered to be mainly due to its water soluble and gel-forming capacity [44].

### Constipation

The efficiency of fiber and psyllium in exacting, on constipation depends on the chief cause of the constipation. In a study of 50 patients 70 research papers with chronic constipation, the consumption of 10-30 grams daily of a psyllium seed grounding provided bowel relief in 80 percent of participants who had no known pathological cause for their constipation. Only 15 percent of persons with slow shipment responded to psyllium. A slightly greater percentage (40%) of those with disorders of defecation-including reconciling internal prolapse, anismus, and rectal hypersensitivity-found development.

### Hemorrhoids

On the basis the study of many research paper the benefit of psyllium for constipation as well as loose stools, it is not astonishing it would also be of benefit for hemorrhoids. Individuals in the psyllium had major development in reduction of hemorrhage and a dramatic decrease of congested hemorrhoidal cushions. Bleeding on making contact with
stopped after action in the psyllium, while those in the control skilled no difference. It also appear psyllium action for this problem must be done for a minimum of one month and fifty, as a study of 45-days fiber supplementation unsuccessful to show development; whereas, when taken for 30 days major improvement was noted [6].

Side effects of psyllium

Many researchers have investigated that a daily dose of 15 g of psyllium was well tolerated as well as the majority of unpleasant events recorded were minor, for minimum and either unconnected or perhaps related to the study behavior. They were also observed that psyllium husk could be used with self-assurance for treatment of mild-to-moderate hypercholesterolemia. U.S. Food and Drug Administration now authorized the use of health claims on food products from psyllium that state that they were connected with a decreased danger of coronary heart disease. The addition of isabgol to traditional nourishment for people with diabetes is safe, is well tolerated, and improves glycemic and Lipid control in men with type diabetes and hypercholesterolemia [45].

Conclusion

Psyllium is a natural polysaccharide obtained from Plantago psyllium and its mucilage is composed of natural arabinoxylans (arabinose 22.6%, xylose 74.6%). Mucilage is a non-toxic biomaterial, and abundantly found in nature. It has a typical combination of biological activity with mechanical and physical properties, chemical modification, and can convert them into various derivatives. Graft/cross linked copolymerization is a exclusive method among the techniques for improve natural polymers mostly polysaccharides. Graft/ crosslinked copolymerization is an effective method to incorporate desired properties in the available polymer backbone, and these are useful in many applications in diverse fields. This unique characteristic makes them in important bio material for biochemical and pharmaceutical applications.

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