Chapter

Psyllium: A Source of Dietary Fiber

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Abstract

Dietary fiber is commonly known as roughage. Fibers are mostly present in vegetables, whole grain, nuts, legumes, and fruits. This is an indigestible part of the food obtained by plants. It includes polysaccharides such as cellulose, hemicellulose, pectic substances, mucilages, gums and lignin as well. Dietary fiber has beneficial physiological effect on health, so it is included in daily diet to decrease occurrence of several diseases. In this sequence, this chapter describes about the dietary fiber, psyllium commonly known as Isabgol which is prepared from the seed of the *Plantago ovata Forsk* (Psyllium ispaghula). Psyllium is hydrophilic mucilloid, has the capacity to absorb water and increases in volume while absorbing water. Psyllium consists of mixed viscous polysaccharide in which about 35% soluble and 65% insoluble polysaccharides (cellulose, hemicellulose, and lignin) are present. This can be used as gelling, food thickener, emulsifying and stabilizing agents in some food products. Psyllium is a natural biopolymer which has high quantity of hemicelluloses consist of xylan backbone connected with arabinose, galacturonic acid and rhamnose units. Since last many years it is being used as therapeutic agent in several diseases like chronic constipation, inflammation of mucous membrane of GIT tract, duodenal ulcers, piles or diarrohoea etc. It may be source of renewable and biodegradable polymer.

Keywords: Psyllium, hemicellulose, dietary fiber, therapeutic, lignin

1. Introduction

The term Dietary fiber was coined by Hipsley in 1953 who explained it as a plant cell wall constituent which was indigestible [1]. Later, in 1982, Kay defined the dietary fiber as a plant food component present everywhere and consists of substance having diverse morphological and chemical structure and also cannot be affected by human alimentary tract enzymes [2]. Dietary fiber was also defined by American Association of Cereal Chemists as the edible plant's part or analogue carbohydrate that are not digested or absorbed in the human's small intestine and partially or completely fermented in the large intestine [3]. There are several types of dietary fiber available. They may be soluble or insoluble types, or natural or artificial. Among all dietary fibers, psyllium is one of the important dietary fiber. From last several years it has been focused by various researchers because it contains beneficial pharmaceutical properties.

2. Psyllium occurrence

Psyllium is scientifically known as *Plantago* (family Plantaginaceae), a plant native to tropical regions. Psyllium word is commonly used for greater than 200 species of the *Plantago* genus. It is also known as isabgol and ispaghula in common Indian language. Psyllium was indigenous plant of Persia and Isabgol word has come from the Persian word "band ghoul" means "horse flower" which expresses the shape of Psyllium seed [4–6]. This plant is generally 10 to 18 inches short stemmed annual herb which is known by different names in different regional language such as isabgol, aspaghol, ashwagolam, bazarqutuna, aspagol, blond psyllium. This plant is extensively grown in many parts of the world. Normally, psyllium is cultivated for its mucilage substance, which is a white fibrous substance having hydrophilic characteristics. *Plantago ovata* and *Plantago psyllium* species are generally cultivated commercially to manufacture mucilage. The psyllium husk (seed coat) is also commercially employed in food industry as in bakeries, ice creams and candies. India plays a major role to make psyllium available in world market. In India, Gujarat and Rajasthan collectively have an area about sixty one thousand hectares for its cultivation. Some popular global brand names of psyllium are konsyl, modane bulk powder, bonvit, meta-mucilage, perdiem fiber, siblan, psyllium husk, serutan, fybogel etc.

2.1 Psyllium products

2.1.1 Psyllium seeds

Psyllium seeds are dried ripen seeds obtained from *Plantago ovata* plant. It is obtained by cleaning seeds from all dust, wastes, stones, agri farm fibers, iron particles and other impurities. Psyllium seeds are light brown in color and have faint odor. These seeds are made up of 40% of an essential fatty acid, Linoleic acid. Along with that, it may have 18.8% protein content, 19% fiber content and 10–20% triglycerides. It may contain soluble and insoluble fiber. Seed contains mucilage polysaccharide fiber, which is soluble in nature. Psyllium seeds are graded on the basis of purity and quality of the seeds.

2.1.2 Psyllium husk

The psyllium husk is actually the outer coating of seed which is made of mucilage around the seed. This is the main part of the plant which has nutritional value and used to manufacture psyllium products. This consists of proteins, polysaccharides, glycosides, vitamin B1 and choline. It contains high fiber content which is mainly composed of hemicellulose. Hemicellulose is a complex polysaccharide found in grains, vegetables and fruits, and although it is indigestible, but it is partially digested in colon part and nourishes to intestinal flora. Psyllium husk are obtained by processing of removal of outer coating of seed. It contains about 70% soluble fiber content and 30% insoluble fiber content. Husk is white fibrous substance and used in various industries like pharmaceutical, cosmetics and food product. There are various grades of psyllium husk available according to user needs on the basis of purity and mesh size. Psyllium husk is used as raw matter to form psyllium mucilage. It is precipitated with alcohol in aqueous solution and then washed with acetone and dried. Psyllium husk powder is also processed from the husk by using grinder of various particle mesh size.

2.2 Psyllium as a functional food

Psyllium is being used in various commercial industries such as in food, pharmaceutical and other industries. Psyllium is often added to functional food material due to its various physiochemical properties such as meal replacements, breakfast cereals, biscuits, bread and in bakery products. It is also added to shakes, juices, yogurt, syrups, soups and even in ice creams to improve the fiber content of the food. It is also used as a thickening agent in drinks or frozen desserts. Psyllium dietary fiber contains supplementary nutrients and phytochemicals which make it to be taken as whole food and close the fiber gap. The various efforts are going on to improve physiochemical, biological, sensory and functional properties of psyllium to enhance its utilization in food and safety. Psyllium has an extreme water absorbing capacity so it is not dispersed in water or aqueous solutions.

Psyllium has been focused by many researchers giving many approaches to improve its functionality. Food and drug administration (FDA) in 1998 recommended that cholesterol can be lower or attained in adequate amount by including lesser amount of fiber in daily diet. Mucilage present in seed husk has significant property as a thickener that can be used in food industries. It can be used as an ingredient of chocolate and other foods. It can be utilized as a main stabilizer in ice-cream. It improves the taste of mouth and feel of drinks or flavored drinks by making them more consistent and richer. Fiber supplements are demanded by consumers due to its pleasing taste and good storage stability. It can be employed as a foundation of cosmetics and for sizing functions. The psyllium husk has good binding capacity so it can be used as good binder and can be disintegrated in compressed tablets. Psyllium produces jelly like structure when it is treated with hot caustic soda which may be a substitute of agar-agar gel. Psyllium seed gum has been employed to prepare germicidal lubricating gel and dry dentifrice powder. It can also be used as a constituent of petroleum. It can be used as cattle feed and by mixing with jaggery in case of lactating cattle. The de-husked seed may be used as bird feed which is about 69% of the total seed crop weight. Husk has been considered very safe for use in nutraceutical and functional food. The use of psyllium husk in various food products has been approved by FDA [7]. Psyllium seeds have been used for many years in traditional medical prescription. Psyllium supplements are used as fiber formulation in high fiber consumer products including powder, granule, wafer, and capsule forms. Because psyllium has pharmacological effects, it is used to make fortified food.

Psyllium consists of a great amount of soluble fiber which fulfills daily dietary fiber recommendation of the body. The soluble fiber of psyllium effects the body lipids and proteins and related to metabolic processes. Bakery products are manufactured formulating different dosage of psyllium husk up to the possible level without causing harmful change in quality. The varying dosage of psyllium can also be given in hypercholesterolemia considering hormonal status in men and women as pre and post menopausal women. In postmenopausal women, about 15 gm daily dose can significantly decrease total cholesterol level and reduces the risk of coronary heart diseases whereas no significant decrease of total cholesterol was observed in premenopausal women. Psyllium dosage did not affect concentration of triglycerides, apolipoprotein A1 and apolipoprotein B in pre and postmenopausal women. In diabetic patients, higher glucose level and in hyperlipidemia due to more polysaccharide contents psyllium is added in processed food to control weight by its gel forming nature. The presence of bioactive substance arabinoxylan in fiber improves the quality of baking products and marked therapeutic potential. In the patient of celiac diseases, psyllium is added to bread dough with 93% acceptance

rate whereas in non celiac disease patient acceptance rate is 97%. While making bread dough products having chemical composition less than 42.3% fat and less than 32% calories, psyllium can replace gluten in composition. By this way, products made with psyllium fiber contain less fat and lower calories. Psyllium fiber significantly increases water absorption determined by Farinograph (rheological device), simultaneously as increasing its amount. Psyllium contents increases the Falling number (FN) index of wheat flour by increasing its water absorption capacity, in addition to decrease in α amylase activity. Psyllium is studied for the development of "spongy dessert" by adding its mucilage powder which is extracted from the psyllium seeds. This mucilage powder is also added to prepare milk solid dessert made from low fat cow milk. The developed herbal dessert product may contain nutrients low in carbohydrate, high protein and dietary fiber, saturated fats, free from trans fats and lesser calories. It also has the properties to make relief from acidity and constipation.

Psyllium gums and mucilage are naturally occurring biopolymers. Their applications in pharmaceutical, neutriceutical and biotechnological fields are increasing day by day. Psyllium has been successfully used as a thickening agent, colloidal stabilizer, and as a gelling agent for past many years in the food industries as well as pharmaceutical industries. Psyllium mucilage characteristics make them unique for using as a matrix for delivery and/or for entrapment of different drugs types, proteins and cells. Being a natural polysaccharide it is very important in industrial applications.

Psyllium functions as prebiotics which is a substance required for the healthy microbial colonies of probiotics growing in the gut. These are gut microbiome which make an essential ecosystem of microorganism inside the colon. Healthy colony of microorganisms in gut is also necessary for strong immune system and makes your body efficient to fight against infection, maintain healthy cells and tissues and reduce inflammation. In addition to, prebiotics make easier bowel movement in patients suffering constipation. Psyllium husk support the gut microbiome and it is beneficial for gut microflora particularly in constipated patients [8]. Psyllium plays an important role to increase the production of short chain fatty acids such as propionate and butyrate that are required for microbial health. Another characteristic of psyllium is to retain water in the small intestine, in this way water flow increases into the ascending colon.

3. Characterization of Psyllium

Various researchers investigated morphology and thermal behavior of psyllium using spectrophotometric method like FT-IR and thermo-gravimetric analysis. The FT-IR spectrum of psyllium shows an absorption peak at 3401 cm^{-1} which attributes –OH (alcohol) stretching. An absorption band at 2926 cm^{-1} is credited to C-C stretching band of alkanes, on the other hand band at 1050 cm^{-1} is due to C-O-C stretching of ether representing polysacchrarides. The absorption band at 896, 714 and 613 cm^{-1} may be attributed to polymer chain bending [9].

Scanning electron microscopy study of psyllium reveals its surface structural morphology. The powder form of psyllium shows irregular shape matrix of unequal size which are structural constituents of fiber. There are not significant differences in physical structure of fiber and show irregular matrix of protein and fiber. At higher magnifications, the psyllium's complex ultra-structure shows a hard surface deficient with granular structures, which presents proteinaceous and fiber material of psyllium. Micrograph shows presence of small cavities or pores which may affect

the physicochemical properties like water holding and oil absorption capacity of psyllium [9–11].

Thermal characterization reveals broad information about thermal transition and thermal stabilities behavior of psyllium. DSC (Differential scanning Calorimetry) technique is useful for providing thermodynamic property of conformation transition state of polysaccharides. During conformation transition in DSC measurements obtained endothermic peaks show melting of structural domains [11].

4. Physicochemical properties

The physiological properties of dietary fiber are associated mainly with its solubility, viscosity, water-holding capacity, bulking ability, binding ability, fermentability and so on [11, 12].

4.1 Solubility

According to solubility in water, dietary fiber may be of two type i.e. soluble fiber and insoluble fiber. This nature of dietary fiber makes them technologically and physiologically functional. Presence of soluble fiber content increases solubility of dietary fiber and reduce plasma cholesterol and glycemic response [13]. Insoluble fiber content provides porosity and low density which increase fecal bulk when ingested in diet and decrease in intestinal transit. In food processing procedures, use of soluble fiber in food products formulate them more beneficial because psyllium gives viscosity, which makes them able to form gel or they can also act as emulsifiers in comparison to insoluble fiber.

4.2 Viscosity and gel formation

Viscosity is a physicochemical characteristic which is associated with soluble dietary fiber contents like pectins, gums, and glucans. Viscosity and gel formation capacity is linked to soluble fiber's capacity of absorbing water and formation of gelatinous mass [14]. Soluble fiber forms gel and increases the viscosity of gastrointestinal tract contents. This phenomenon may clear the delayed gastric clearance often linked with fiber ingestion. This viscous nature of fiber also gives lubrication of stool [15].

4.3 Water-holding capacity

Water holding capacity (WHC) term is defined as the quantity of water which is held by known mass of dry fibers or hydrocolloid under certain conditions as temperature and time duration of soaking. In general, the polysaccharide contents of dietary fiber are hydrophilic in nature and water is retained on the hydrophilic sites on the fiber on surface or in void spaces of the fiber molecules [16].

4.4 Binding ability

Dietary fiber can trap bile acids secreted in small intestine by gall bladder. These soluble fibers make gel matrix that finally exit in feces. The physical entrapment comes into view in the terminal part of small intestine where bile acids are usually reabsorbed [17].

4.5 Fermentability

The fermentation ability of fiber is highly variable which ranges from non fermentable lignin to almost complete fermentable pectin. The fermentation of soluble fiber takes place to greater extent by colonic bacteria but insoluble fiber are not fermented. The ability of soluble fiber to be fermented makes the psyllium physiologically effective. Plants have different proportions of fiber on the basis of fermentability such as rapidly fermented, slowly fermented and unfermented fiber. Some fruits as apples and bananas and vegetables like beans and potatoes contain rapidly fermented fiber and may contribute less to bulk feces in comparison to other fiber. Psyllium and wheat bran are considered to ferment at slow rate at the entire length of colon and contribute more fecal mass.

4.6 Bulking ability

Insoluble fiber, like lignin and cellulose, generally may remain unfermented by microflora present in colon and take part to increase fecal bulk by forming particles and holding water. Wheat bran is considered as the best bulking agent. Some fermentable fiber as hemicellulose present in cabbage can increase fecal bulk by rising fecal flora. On the other hand, extremely fermentable fiber like pectin shows very little effect to increase fecal bulk.

5. Chemical composition

Psyllium fiber is viscous in nature and beneficial for human health, in prevention as well as treatment of diseases. Psyllium contains soluble and insoluble fiber contents. Psyllium fiber contains mainly mucilage, which is found in seed coat. The mucilage is extracted by grinding of outer coat of the seed. It is clear, colorless and gel forming agent. Psyllium is a mixture of polysaccharides, for example, hexoses, pentoses, and uronic acid. Mucilage is composed of about 15% non-polysaccharides matter such as fat and protein and remaining 85% yields a single polysaccharide containing D-xylose (~62%), L-rhamnose (~9%), L-arabinose (~20%), and D-galactouronic acid (~9%). The ß-D-xylose residues in the pyranose ring form a linear backbone of polysaccharide. Disaccharide side chain is linked with terminal α-D-galactouronic acid and O-2- of α-L-rhamnose. In the polymer backbone, all the three side chains are linked to either O-2 or O-3 of xylose. The backbone has both β (1>3) and β (1>4) glucosidic linkage (**Figure 1**). Total protein fraction is about

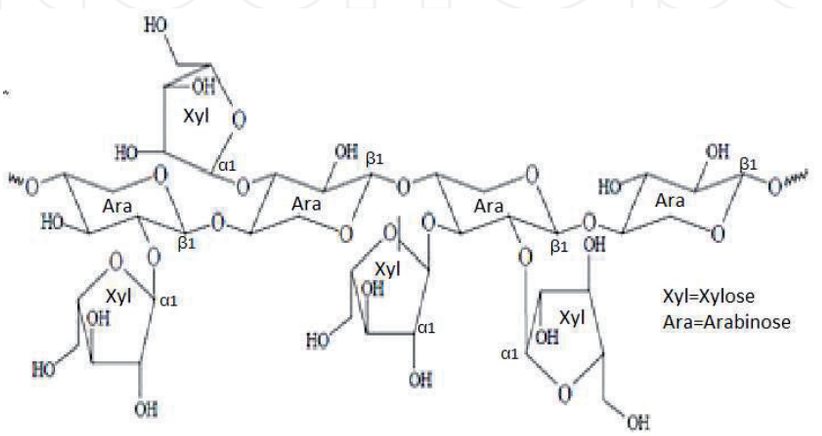

Figure 1.
Arabinoxylan structure.

globulin 23.9%, albumin 35.8%, and prolamin 11.7%. Psyllium seeds also yield oil which has high content of unsaturated fatty acids such as oleic acid (39.1%) and linoleic acid (40.6%) and small amount of linolenic acid (6.9%).

Psyllium husk also has a high quantity of hemicellulose which consists of a xylan backbone associated with rhamnose, arabinose, and galacturonic acid units (arabinoxylans). The seed is composed of 35% soluble fraction and 65% insoluble polysaccharides such as cellulose, hemicellulose, and lignin. Psyllium is a hydrophilic mucilloid and highly branched arabinoxylan polysaccharide consisting of high water holding and gel formation ability. Gel-forming fraction of the polysaccharides consists of xylose, arabinose, and other sugars in trace amount.

6. Drug delivery studies

Drugs are not often administered in the body as only pure chemical substances, but are generally given through drug delivery system (DDS). The DDS should consist of active pharmaceutical component in association with inert or excipients substances. Drugs are transformed to dosage forms by adding one or more substances which may be referred as excipients, essentially these materials must be pharmacologically inert. These ingredients may be used to achieve certain goals such as to modify appearance, improve handling, enhancing physical property like absorption, efficiency, retention time. In different kind of diseases such as chronic constipation, inflammation of mucous membrane of gastrointestinal and genitourinary tracts, diarrhea, and duodenal ulcer, piles, gonorrhea, etc. Psyllium is used as bulk forming, demulcent, non-irritant laxative drug and as a cervical dilator etc. So, the psyllium plays an important role in drug delivery system or pharmaceutical application as well as dietary supplements.

A large number of polysaccharides containing excipients that are obtained from natural sources possess their own importance. They have different properties which makes them to be used in variety of applications like binding agents, suspending agents, coating materials, granulating agents, rising viscosity of aqueous solution and easily dispersible material in pharmaceutical industry. Natural occurring polysaccharides are hydrocolloid polymer, which can be used as gel forming substance, binder, sweetener, flavoring agent, taste masking agent, lubricants to make easy to swallow component. A recent need of this area is to study such natural occurring useful substances which tend to have the property of biodegradability, biocompatibility and non-toxicity.

Psyllium seeds and husk are broadly used in pharmaceutical application as an emollient laxative, demulcent, drug therapy to regulate lipid and glucose levels and various diseases. There are several drug delivery systems have been explored to deliver drug for the therapeutic purposes, for example hydrogel, which is made of natural polymer and proved as an excellent carrier for the drug molecule by controlling its release and target. Psyllium has been attracted by researchers due to having a neutral pH, extended transportation time and reduced enzymatic activity.

Psyllium acts as an anti-ulcer agent itself. Singh and coworker investigated that using psyllium with rabeprazole drug as drug carrier, may increase the drug therapeutic potential [18]. Psyllium fiber is one of the important gel having glucose dropping effect. Psyllium reduces hyperglycemia by inhibiting glucose absorption in intestine and also improves motility. As per pharmacological view, its polysaccharides have significance to decrease glucose absorption. Drug delivery strategies which are associated with hydrogel psyllium and properly modified for

the synthesis of hydrogel can efficiently function as high potential candidate to get better drug delivery systems [19]. Anderson and colleaguesinvestigated use of psyllium for long term action of mild to moderate hypercholesterolemia [16]. Daily tolerate dose of psyllium was observed i.e., 11.5 gm and side effects were for short duration or minor or not related to treatment.

A grafted natural polymer of psyllium has been synthesized and used to formulate in different types of drug delivery system. The haemocompatibility of psyllium was checked by learning the blood relations with graft copolymer with context to thrombogenicity and haemolytic potential also. Thrombogenicity results indicated non-thrombogenic effect of graft copolymer as the thrombus percentage and weight of clot shaped of polymer was in lesser amount in comparison of positive control [20].

In recent studies, colon specific drug delivery systems have been significant. It is investigated that treatment of colon associated diseases requires more colonic concentration of drug in the colon. So, there should be a flexible approach for effective therapy to deliver drug to colon. In conventional therapy system does not complete pharmacokinetic profile, especially for the poisonous drugs having good therapeutic index. Therefore, in ideal situation a good profile can be achieved by using natural polysaccharides matrix which can preserve good therapeutic index as well as controlled drug delivery. The optimum pH for drug release medium was studied for drug loaded hydrogel at different pH medium. The amount of drug tetracycline hydrochloride, tyrosin and insulin were released maximum at pH 7.4 in comparison to pH 2.2 buffer and distilled water. The observation was considerable for colon specific drug delivery systems. Polysaccharides based drug delivery devices can be considerably better candidates than different hydrogels for controlling drug release [21]. It may be used as fabricated acrylic based graft copolymer for colon precise drug delivery. The model drugs as tetracycline hydrochloride, tyrosine and insulin dynamics were let out from tailored psyllium with acrylic acid cross linked copolymer drug laden hydrogel. The tailored psyllium was formed with methacrylamide poly (MAAm), 2-hydroxylethylmethacrylate (2-HEMA), acrylamide (AAm), poly(vinyl alcohol) and poly(acrylic acid) based polymeric networks. In this case, the released contents of water soluble drug get trapped in hydrogel when water moved in the network of swelled polysaccharides and drug get dissolved followed by aqueous pathways along with diffusion to the device surface. The amount of released drug was found more at pH 7.4 buffer solution.

Psyllium was studied for delivery of anticancer drug 5-fluorouracil [18]. Drug could be released in different pH buffer with psyllium and that was pH unresponsive. This drug was released from drug laden hydrogel (per gram) psyllium. The other drug tetracycline hydrochloride and rifampicin could be released from the tailored psyllium which was developed by radiation crosslinked polymerization with methacrylamide. Rifmapicin is a broad spectrum antibiotic used for the treatment of *Mycobacterium* contagions as tuberculosis and laprosy and also it is used against methicillin-resistant *Staphylococcus aureus* bacteria in combination with fusidic acid. Hydrogel composed of crosslinked macromolecular chain which makes entangled mesh structure, forming a matrix for the entrapment of the drugs. When drug laden matrix comes in touch with solvent, polymeric backbone of hydrogel become relaxed and liquefied drug get diffused into the outside discharging medium. The more swelling of gel makes the fast release of drug from the polymer matrix.

Thrombogenicity as well as haemolytic potential of psyllium hydrogels was studied for accessing the blood connection with graft copolymer and found there was very low percentage of clot and thrombus formed. The clot formation was lesser in the membrane in comparison of positive control so these polymer were

classified as non-thrombogenic. Psyllium PVA-hydrogel may be partial hemolytic as studied suggested. Psyllium-poly(acrylic acid) was studied for electrical stimulus sensitive drug delivery system. The swelling property of psyllium hydrogel polymer was measured comparing with artificial biological fluid. Maximum swelling was observed in artificial biological fluid. On electrolysis, rapid swelling was observed due to dissociation of solvent system into ions which made easy entrance into the gel network. Swelling property of graft copolymer was a main function of chemical architecture.

7. Pharmaceutical uses

Psyllium is naturally found swellable biomaterial. It has been used as a traditional medicine since a long time. It is currently being of great interest for utilizing in pharmaceutical industry. Seeds of psyllium are used to thicken tablets and capsules at the time of manufacturing, because it contains hexoses, pentoses and uronic acids. Some studies reported antioxidant properties of psyllium which may be very effective for the treatment of inflammatory bowel disease. Phytochemical studies revealed that biological activity of psyllium attributes to the presence of some secondary metabolic products such as aucubin glycosides, flavanoids, fixed oil contents, tannin, sugar, sterols and proteins as well as hydrocolloidal mucilage which is present in the outer seed coat [22]. It has been found most effective to cure various physiological disorders for example, it reduces blood cholesterol levels thus decrease risk factors of cardiovascular system diseases. Cardiovascular diseases are the number one cause of death globally. Earlier studies showed that psyllium seeds affect the immune system of rabbits by reducing anti-HD antibodies and increases white blood cells amount in the blood as well as spleen leucocytes. It has been also shown the extract of psyllium may be used in diabetes treatment. It can control blood sugar level by reducing hyperglycemic condition in type 1 and type 2 diabetes. This dietary fiber is also used as fiber supplements to regulate bowel function in intestine.

8. Therapeutic benefits

Psyllium is much more beneficial for healthy life. It is extensively considered safe, medically secure and efficient for treatment of certain type of diseases when recommended dose is taken.

8.1 In hepatic diseases

In cell, due to over generation of free radical oxidative stress developed which may lead to cell damage resultantly various disorders can happen as liver dysfunction. The natural antioxidants present in psyllium as polyphenols and flavanoids may prevent cells from oxidative stress and damage. So, it may act as free radical scavenger and may be used to cure various disorders. Mekky and coworkers investigated antioxidant activity of psyllium seeds to protect against CCl_4 (free radical) induced-hepatotoxicity experimentally [23]. It also has enhanced endogenous antioxidant capability of hepatic tissue and inhibited lipid peroxidation.

8.2 Bowel diseases

Psyllium fiber supplementation may be useful to cure irritable bowel diseases, inflammatory bowel disease and ulcerative colitis. This useful effect is most likely

associated with its anti-constipation action. Psyllium fiber when reaches to intestine, is digested by anaerobic fermentation and resultantly short chain fatty acids like butyrate, acetate and propionate are produced, which have antioxidant and anti inflammatory property. Increased concentration of short chain fatty acids may yield high energy to colonic mucosa because they act as a substrate for oxidation. So along with constipation activity increased level of short chain fatty acids have helpful effects on ulcerative colitis and inflammatory bowel disease. Chaplin and colleague showed psyllium supplementation which might be applicable in diseases like hemorrhoids and diverticulitis [24]. It may be beneficial to cure hemorrhoids by reducing bleeding when come in contact and of congested hemorrhoidal cushions [25]. Psyllium dietary fiber supplement regulates bowel function. It may reduce the risk of diseases like diabetes, obesity, and certain gastrointestinal disorders by taking sufficient quantity in daily diet.

8.3 Gastrointestinal disorders

Most dietary fiber sources activate laxation which increase conic contents and stimulate propulsion in intestine. Fiber undergoes for anaerobic fermentation and incompletely fermented or unfermented fibers associate with moisture holds and increases mass of stool. These fibers also function as substrate for microbial growth and this additionally bacterial mass also increases total colonic content [16]. Unfermented gel of psyllium fiber also functions as an emollient and lubricant which leads to easy passage of the stool movement. Psyllium fiber is used widely as a fiber supplement to cure constipation as it increases moisture level and total mass of dry stool. It has been proposed that 1 gram of psyllium fiber can increase 5.9–6.1 gram of stool weight. This was more effective in comparison with oat bran fiber and wheat bran fiber. Psyllium fiber has the great ability to hold water so it has also been shown to slow the time of gastric empty and colon transit. This is the opposite of the preferred effect against constipation but it is beneficial for persons with diarrhea or uncontrolled fecal defecation with liquid stools [26].

8.4 Cardiovascular diseases

Psyllium fiber intake in daily diet reduces risk of coronary heart diseases. It was approved by the US Food and Drug Administration (USFDA) in 1998 under the Nutrition Labelling and Education Act which was linking with study of psyllium fiber. Psyllium fiber has the properties to lower cholesterol. LDL-cholesterol and total cholesterol are recognized as biomarkers or risk factors for heart disease. Program in food safety, nutritional and regulatory affairs (PFSNRA) in 2006 suggested that 7 grams of psyllium soluble fiber intake in diet resulted significant physiologically reduction of LDL-cholesterol which ranges from 0.047% to 0.86% per gram fiber basis.

9. Conclusion

Psyllium is obtained from the seed of the *Plantago ovata Forsk* (Psyllium ispaghula), a rich source of dietary fiber. Psyllium consists of mixed viscous polysaccharide in which about 35% soluble and 65% insoluble polysaccharides (cellulose, hemicellulose, and lignin) are present. Psyllium is a natural biopolymer which has high quantity of hemicelluloses. It may be a source of renewable and biodegradable polymer. The physiological properties as solubility, viscosity, water-holding capacity, bulking ability, binding ability, fermentability make psyllium effective for the

use as medicine and functional food. Psyllium is much more beneficial for healthy life. It is extensively considered safe and secure medically and efficient for treatment of certain type of diseases such as hepatic diseases, gastrointestinal diseases and cardiovascular diseases. Psyllium has been currently being of great interest for utilizing in pharmaceutical industry.

Conflict of interest

The author declares no conflict of interest.

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