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Review Article

Psyllium Husk (*Plantago ovata*) as a Potent Hypocholesterolemic Agent in Animal, Human and Poultry

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Abstract

Medicinal plants have gained great popularity and their importance is realized world over. Psyllium (*Plantago ovata*) is a native plant of India. The hydrophilic mucilloid, water-soluble fiber derived from psyllium husk and seed had been used since ancient times as vital curative agent for constipation, mainly as a part of the traditional Indian Ayurvedic medicine. Psyllium is a rich source of fiber and has numerous other therapeutic impacts such as cholesterol lowering, antidiarrhoeal, laxative, antidiabetic, energy increasing, hemorrhoid remedy, soothing inflammation and weight loss agent. Psyllium husk plays a key role in lowering serum cholesterol, so psyllium is being considered as a potential supportive agent in the therapy of hyperlipidemia. The cholesterol level is lowered in different animal models by the binding of psyllium husk with bile acids in the small intestine and thus reducing its absorption. The husk of psyllium could be used as an additive in milk replacer of the neonatal dairy calves to improve the physiological functions and enhance the performance and health status. Psyllium may also has positive impacts in growth and productive performance of different poultry species. The main aim of this review was to discuss the role of psyllium in managing the hypercholesterolemia in humans and the application of psyllium huskas a safe feed additive in poultry farming for the production of organic and low cholesterol designer egg and meat.

Key words: Psyllium, ispaghula, dietary fiber, hypocholesterolemic, poultry

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Herbs are being considered as an essential part of traditional medicine due to their phyto-constituent substances. The performance of poultry species could be improved by the use of products of herbal plants as additives in their rations. In several countries during the few past decades, there had been stern restrictions on the use of antibiotics as growth promoters in the livestock and poultry production. The consumers are conscious about the presence of antibiotics in egg and meat as well and desire natural supplements such as plant sources as alternatives. Hence, at present, growth promoters from herbal sources are used commonly worldwide for better performance of the livestock and poultry^{1,2,3}. Various studies had been carried out using different plant sources as feed supplements in various livestock and poultry^{4,5,6}. Psyllium (*Plantago ovata*), a native plant of India, commonly known as ispagol/ispaghula⁷ belongs to the family plantaginaceae and had been used as a traditional herbal medicine in allopathic and ayurvedic preparations since ancient times⁸. Its husk and seed containing the water-soluble hydrophilic mucilloid fiber are rich in different primary and secondary metabolites and also many bioactive compounds⁹. India is the main producer of *Plantago ovata* and it is extensively grown in different tropical regions of the world, such as Egypt, China, Iran, Japan, Korea, etc¹⁰.

Dietary fiber is one of nutraceutical important foods that had gained most importance¹¹. It had been reported that consumption of foods containing dietary fiber, may improve the long-term maintenance of low atherogenic low density lipoprotein (LDL-cholesterol)^{7,12}. In the guidelines of the American Heart Association for reducing the risk of cardiovascular disease by dietary and other lifestyle practices, it had been recommended to increase the amount of soluble fiber in the diet to above 25 g d⁻¹ to for effective lowering of total and LDL cholesterol levels¹³.

Psyllium husk which is commonly used as a laxative agent^{14,15}, lowers the serum cholesterol levels and LDL in hypercholesterolemic children and adults¹⁶⁻¹⁹, increases the levels of high density lipoprotein (HDL) cholesterol and also lowers the glucose concentration in diabetic patients²⁰. It had been recommended as an effective adjunct to the diet therapy in reducing the total and LDL-cholesterol concentrations in the adults²⁰ and for those individuals who do not effectively respond to a low cholesterol and low-fat diet²¹. Several published studies on different animals models as well as in humans had confirmed the claim of hypocholesterolemic therapy of Psyllium^{16,19,22}.

The dietary water-soluble fiber had been an effective therapeutic agent as a functional diet component against various disorders like physiological diabetes mellitus, obesity²³, diarrhoea, constipation²⁴, intestinal inflammation, cardiovascular diseases, hypercholesterolemia²⁵ and also act as prebiotic² and antioxidant²⁶. The pharmaceutical impacts of psyllium polysaccharide had been extensively reviewed by Rao *et al.*²⁷.

Chicken egg which plays a vital role in the human diet is considered as a nutritious food containing balanced protein²⁸. Since chicken eggs have substantial amount of cholesterol (about 213-280 mg), it is often recommended by the health advisors to eliminate eggs from the normal diet, especially for people with hypercholesterolemic related disorders²⁹. In addition, consumers are rather reluctant to accept its benefits, since they have a doubt about its cholesterol content, which is believed to be high and affecting their health. Therefore, scientists are in search of new approaches in producing eggs having lower levels of cholesterol³⁰, of which inclusion of psyllium husk in poultry diets is a promising way of lowering cholesterol in the egg yolk as well as in the blood serum³¹. Presently, various dietary fiber products are included in the poultry nutrition to reduce the cholesterol contents in the eggs.

The current review aimed to discuss the efficacy of using psyllium fiber as valuable tool for lowering serum-LDL-cholesterol and serum total cholesterol in humans, animals and poultry. In addition to, it's vital role as low-cholesterol designer for egg and meat and its role in the treatment and supportive therapy for hypercholesterolemia and other human ailments.

GEOGRAPHICAL SOURCE OF PSYLLIUM

In India, psyllium is cultivated in the states such as Gujarat, Punjab, Maharashtra and Rajasthan and in Sindh Province of Pakistan¹⁸. It is raised in Spain and France for the European market. The seeds are produced throughout North Africa, Southern Europe and West Pakistan^{18,19}. Psyllium husk industrial powders are exported to many countries such as USA, UK, France, Indonesia, Germany, Japan, Mexico Canada, Sweden, Spain, Italy, Norway, Korea, Australia, Denmark and Pakistan (Table 1).

BIOLOGICAL BENEFITS OF PSYLLIUM HUSK

Psyllium has many biological effects such as antidiarrheal, relieves constipation, laxative, antidiabetic, increase energy, hemorrhoid remedy, soothes inflammation, weight loss and lower cholesterol effects (Fig. 1).



Fig. 1: Biological benefits of psyllium husk

Table 1: Properties of psyllium's seeds

Characters	<i>Plantago ovata</i>	<i>Plantagoindica</i>	<i>Plantagoafra</i>
Origin	Pakistan, India	Europe ,Mediterranean Egypt	Spain ,Cuba, France
Color	Dull pinkish gray brown	Blackish brown	Brown
Shape	Boat shaped	Elliptical	Elongated ovate
Length	1.8-3.3 mm	2.0-2.5 mm	2.0-3.0 mm
Weight of 100 seeds	0.15-0.19 g	0.12-0.14 g	0.09-0.10 g

MECHANISM OF BLOOD CHOLESTEROL LOWERING BY PSYLLIUM

Cholesterol is a type of lipid molecule which plays a major role in the synthesis of some important hormones, stabilizing cell membranes and other functions. But a high level of cholesterol in the blood (hypercholesterolemia) is a major risk factor for coronary heart disorder that might lead to heart attack. Bile acids are synthesized in the liver from cholesterol and secreted into the small intestine which is the major route of cholesterol metabolism. The major part of the bile acids are reabsorbed in the ileum and recycled back to the liver for further secretion into the small intestine by the enterohepatic circulation and consequently decreasing the rate of synthesis of the bile acids³⁰.

The soluble fiber of the psyllium binds to the bile acids in the small intestine forming a complex which prevents the reabsorption of the bile from the small intestine thereby enhancing the production and secretion of bile acids to replace the lost acids¹⁶. Subsequently, cholesterol is drawn

from the circulation for the production of bile acids, thereby lowering the blood cholesterol levels³². This adsorption of bile acids through a large number of weak binding sites on the polysaccharide structure would lead to an increased fecal excretion of bile acids thereby increasing metabolism of cholesterol to bile acids in the liver, subsequently removing more serum cholesterol concentration level and thus decreasing serum cholesterol concentrations^{22,33} (Fig. 2).

In hypercholesterolemic men, consumption of 10.2 g psyllium per day along with a low-fat diet lowered the serum total cholesterol by 4% and this reduction by the psyllium hydrophilic mucilloid was associated mostly by stimulation of bile acid synthesis and to some extent by reduced cholesterol absorption²¹. It had been shown that bile acid synthesis (7 α -hydroxylase activity) was stimulated by Psyllium ovate in different animal models and also in humans³⁴. The alteration of hepatic cholesterol for bile acid production had been a conventional mechanism for lowering the serum cholesterol whereas the psyllium husk influences the absorption of cholesterol and fat thus contributing to the cholesterol lowering effect³⁵.

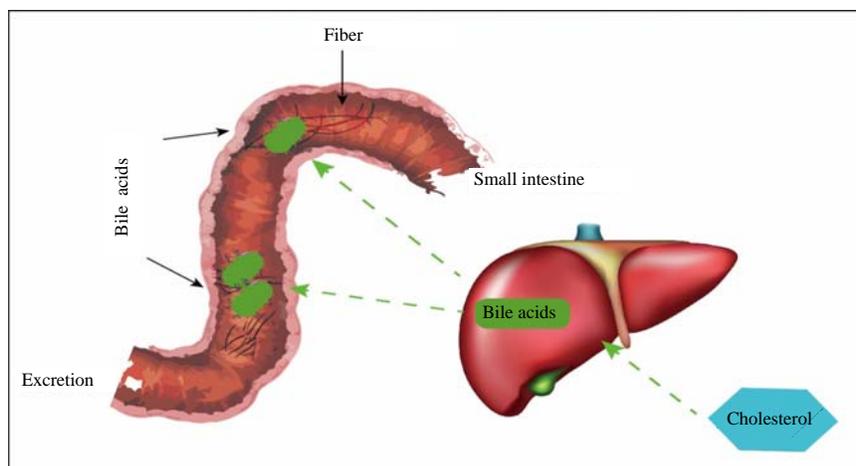


Fig. 2: Mechanism for the cholesterol lowering effect of psyllium husk fiber

PSYLLIUM AS HYPOCHOLESTEROLEMIC AGENT IN HUMANS

Psyllium had been recommended in the regular diet by the health advisors to combat hypercholesterolemia which remain to be the foremost risk factor for coronary heart disease³⁶. The cholesterol reducing effect of psyllium had been confirmed in various studies where it lowers the LDL and total cholesterol levels^{16,19}. It is safe to be used as adjunctive with a low-fat diet in the therapy for moderate or mild hypercholesterolemia^{21,35}. In 8 weeks of experiment where the healthy men and women of 21-70 years old with primary hypercholesterolemia were assigned with psyllium along with the diet Sprecher *et al.*³⁷ observed a decrease in LDL and total cholesterol-concentrations of 5.1 and 3.5%, respectively. A combination of 15 g psyllium supplement and 10 mg simvastatin, showed a cholesterol-reducing impact in hyperlipidemia patients aged 18-80 years as compared to 20 mg simvastatin alone³⁸. Psyllium husk was more effective in lowering the serum cholesterol levels in a population of less than 60 years old as compared to older patients³⁹ and the effect was more significant in men than women¹⁹.

PSYLLIUM HUSK AS HYPOCHOLESTEROLEMIC AGENT IN ANIMAL AND POULTRY

Psyllium ovata reduced the total cholesterol and LDL-cholesterol in rat animal models^{16,35,40}. In diabetic and hypercholesterolemic induced albino rats, treatment with psyllium reduced serum glucose and cholesterol level confirming the anti-diabetic and hypocholesterolemic activity of psyllium¹⁸. Feeding of rats with 10% defatted psyllium husk along with the semi purified diet containing 0.5% cholesterol almost normalized liver size and serum

triglyceride levels with lower serum total cholesterol and higher HDL-cholesterol levels⁴¹. Psyllium husk had been used as a supplement in milk replacer of the neonatal dairy calves which showed a positive effect on the physiological functions with improvement in the performance and health due to increase in the size and scale of the gastrointestinal tract and more lower gut fermentation⁴¹.

Anderson *et al.*¹⁷ showed that low-fat diet run-in, 10.2 g psyllium gave daily, caused a reduction in serum total cholesterol by 4% and a reduction in LDL-cholesterol by 7%, comparing to diet and placebo. In another study, a significant decline in total serum cholesterol was noted in 176 elderly persons who used psyllium for one year⁴².

In white leghorn laying hens, feeding sunflower meal, alfalfa meal, oats, rice mill feed, or wood shavings as dietary fiber source decreased the egg yolk cholesterol compared to that of the hens fed with the basal diet where the effect was more significant in the group fed with either oats or wood shavings and the plasma triglycerides decreased and liver cholesterol increased with increase in the dietary fiber level as theorized by McNaughton⁴³. Moreover, Mukhtar *et al.*³¹ reported that dietary supplementation of *Plantago ovata* is potent hypercholesterolemic tool for the reduction of egg yolk and blood cholesterol levels in layers birds. It was demonstrated that consumption of feed involving dietary fiber, may enhance the long-term maintenance of low atherogenic LDL-cholesterol¹². Psyllium seed husk fiber is widely used to reduce egg cholesterol²⁰.

ROLE OF PSYLLIUM IN THE THERAPY OF OTHER HUMAN AILMENTS

Digestive Function and Metabolism: Psyllium is an effective stool-bulking tool and it has the incongruous

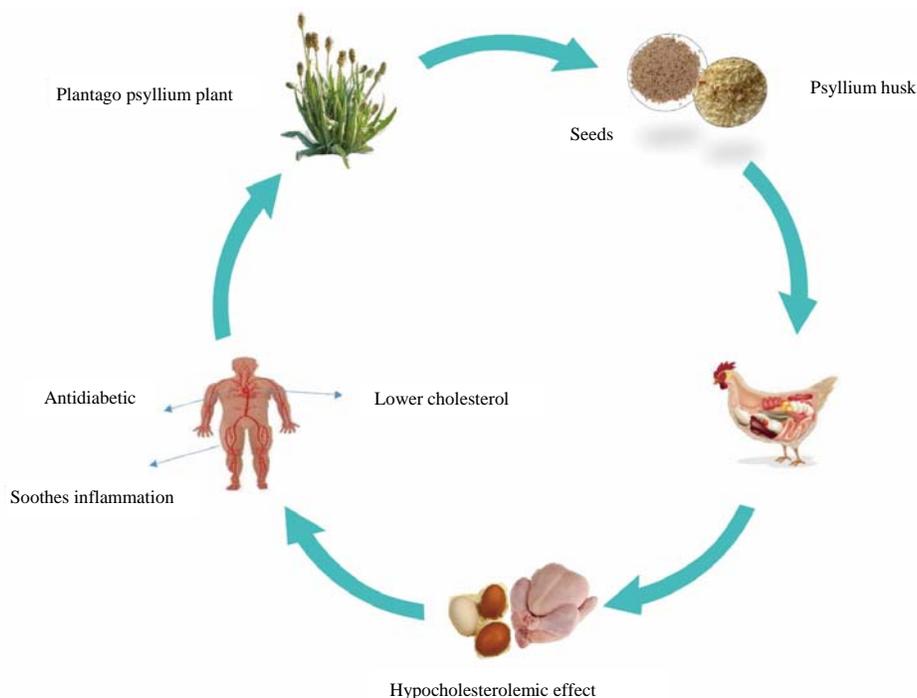


Fig. 3: Flow diagram illustrating the effect of psyllium husk as cholesterol lowering agent

property of relieving both diarrhea and constipation. Psyllium polysaccharides are hydrophilic molecules having the ability to hold water by the formation of hydrogen bonds³⁵. The soluble fibers are able to bind the water by gelation in which water is entrapped within the three-dimensional network of its molecules whereas insoluble fibers hold water like a sponge⁸. The water holding capacity of the soluble fibers affects intestinal transit time and weight of the stool where the hydration of polysaccharides forming viscous gel cause delayed gastric emptying³³. In a placebo controlled trial of persons having liquid stool fecal incontinence with supplementation of psyllium, approximately a 50-percent decrease in the occurrence of incontinent stools was reported where the psyllium group had the highest water-holding capacity of water-insoluble solids and total water holding capacity of the stool⁴⁴. Stool softening could be intensely affected by small increases in water content^{31,45}. It had been established that psyllium had ameliorating effect in diarrhea related disorders⁴⁶ in humans, while it decreased passage time through increased stool volume²⁹ in case of constipation and hence used as a secondary medication for treatment of fecal incontinence and constipation³⁵.

Hemorrhoids: There are several reports that psyllium had been beneficial for the treatment of hemorrhoids and related

disorders. In a systematic review, the authors discussed that minimizing the prolonged straining caused by chronic constipation would be a treatment for symptomatic hemorrhoids and laxatives in the form of fiber would be beneficial for improving symptoms of hemorrhoids, especially bleeding⁴⁷. Addition of the dietary fiber in the way of bulk forming agent psyllium in the diets of patients with bleeding internal hemorrhoids was found to have a significant effect in the reduction of congested hemorrhoidal cushions and improve internal bleeding hemorrhoids⁴⁸. Adequate fiber supplement in the form of 5-6 teaspoonfuls of psyllium husk with 600 mL of water daily coupled with the exact treatment goals could rectify deranged defecation habits thus preventing progression of hemorrhoids and bleeding and the need for surgery in most patients with advanced hemorrhoids⁴⁹. It has been advised that psyllium based fiber supplementation is not suitable for the bowel preparation for colonoscopy in non-constipated patients with presumed hemorrhoidal bleeding and should not be initiated few days prior to endoscopy using a polyethylene glycol preparation⁵⁰. In a study involving the pregnant women, it was recommended that consumption of psyllium powder during the third trimester of pregnancy could significantly prevent constipation, hemorrhoid anal fissure⁵¹ but the safety of using psyllium during pregnancy might be a limitation⁵² (Fig. 3).

Clinical effect: Many researchers reported the use of psyllium husk for the treatment of, constipation, diarrhea, inflammatory bowel disease, diabetes, colon cancer, irritable bowel syndrome and hypercholesterolemia as found in the reports of Majmudar *et al.*⁵³ and Rao *et al.*²⁷.

CONCLUSION

Psyllium could be used for its medicinal impacts for the treatment of diarrhea, constipation, inflammatory bowel diseases, colon cancer, irritable bowel syndrome, ulcerative colitis, hypercholesterolemia and diabetes in humans. The potential of psyllium in the maintenance of human health needs to be exploited further and put into practical use efficiently. In addition, psyllium husk could be used as safe feed additive in livestock and poultry feed and its commercial venture for the production of organic meat and egg which is the future demand need to be tapped significantly. Future studies may be needed to explore more beneficial uses of this remarkable plant for human, animal and poultry.

SIGNIFICANT STATEMENTS

- Psyllium husk is popular bulk forming laxative recommended commonly for treatment of chronic constipation and it is also an effective therapeutic agent in diarrheal related disorders
- Psyllium husk also plays a key role in significantly lowering the serum cholesterol concentrations
- The fiber rich psyllium serves as prebiotic with many other therapeutic effects and used in the supportive treatment in diabetes
- Psyllium could be a potent and safe feed additive in the organic meat and egg production which is the future demand to eliminate antibiotics in poultry industry
- Psyllium could be used as an efficient ingredient in the poultry diets for the production of low cholesterol eggs

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