Review paper

The role and therapeutic effectiveness of *Plantago ovata* husk (psyllium husk) in the prevention and non-pharmacological treatment of gastrointestinal diseases. Part 2. Clinical use of psyllium husk in the treatment of constipation and diarrhea

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Abstract

The results of numerous clinical studies available in the literature allow us to conclude that the fiber deserving the name of the gold standard in regulating bowel movements is the psyllium husk obtained from *Plantago ovata*. The physicochemical properties of psyllium, related to its ability to form a gel in an aqueous environment and its ability to retain water in this mucous-gel structure, mean that preparations containing *P. ovata* husk show therapeutic effects in both constipation (including occasional and chronic) and diarrhea (acute and chronic). Moreover, the results of studies and clinical experiments indicate that the use of *P. ovata* husk in the treatment of bowel disorders is distinguished by significantly higher efficacy compared to pharmacological preparations such as sodium docusate or loperamide. This article presents the evidence available in the recent literature on the therapeutic potential and possible mechanisms of action of *Plantago ovata* husk in the treatment of constipation and diarrhea.

Introduction

The theory on the health-promoting properties of dietary fiber originated from the results of the studies of Trowell and Burkitt, published in the 1970s [1, 2]. More than 40 years ago, these authors suggested that a diet high in fiber could be effective in both the prevention and treatment of numerous conditions: constipation, obesity, diabetes, cardiovascular disease, diverticulosis and colon cancer [1, 2]. In nutritional physiology, depending on the degree of water solubility, fiber is classified as soluble (pectin, some hemicelluloses, alginates, agar, carrageenans, hydrocolloids) and insoluble (cellulose, lignins, most hemicelluloses). According to U.S. Food and Drug Administration (FDA) guidelines, the proportion of soluble and insoluble fiber in a rational diet should be at the level of 75–70% and 30–25%, respectively [3]. Literature data indicate the presence of such a favorable variety of fiber in medicinal plants of the plantain family (*Plantago*). In clinical practice, the most commonly used variety is *Plantago ovata* [3, 4]. *Plantago ovata* is a common medicinal plant widely cultivated in tropical regions of the world, such as India, Iran, Egypt, Afghanistan, North Africa, as well as in China, Spain and the Canary Islands [3–6]. The outer covering of the *Plantago ovata* husk (PO husk, psyllium husk), obtained by cleaning the seeds, contains soluble and insoluble fiber in a 70 : 30 ratio, making products containing psyllium husk an ideal source, beneficial to health, of fiber [6]. It has been shown that the bonds present in psyllium are only slightly hydrolyzed in the human gastrointestinal tract, which is a definite advantage because it does not cause bloating [7–10]. At the

same time, it has been shown that some probiotic bacteria present in the human digestive tract can utilize the oligosaccharides and their component sugars present in *P. ovata* husk as a source of energy [11–14]. Given the above, psyllium is considered a fiber with prebiotic potential [15–17].

Among the best-documented (with the results of clinical trials) therapeutic actions related to the prevention and treatment of gastrointestinal disorders include the beneficial effects of *Plantago ovata* husk in the course of constipation, diarrhea, irritable bowel syndrome, and ulcerative colitis. The results of studies available in the literature further indicate that consumption of *Plantago ovata* husk may reduce the risk of developing colorectal cancer.

Such pleiotropic effects of PO husk are related to the presence in its composition of a highly branched arabinoxylan (which forms a gel in an aqueous environment) and bioactive compounds and their primary as well as secondary metabolites [3–6, 18–23]. Among them, fatty acids, amino acids, polyphenols and flavonoids are most abundant [22, 23].

The following section of the article presents the evidence available in the literature for the therapeutic efficacy of *Plantago ovata* husk in gastrointestinal disorders (constipation, diarrhea).

Plantago ovata husk regulates intestinal function, improves intestinal peristalsis, and reduces risk of and treats constipation

Psyllium husk is approved by the U.S. Food and Drug Administration as an over-the-counter drug for the treatment of occasional constipation, and the research results available in the scientific literature clearly indicate that it is also the most effective fiber for the treatment of chronic idiopathic constipation [24]. PO husk increases the degree of stool hydration, thus normalizing its consistency and increasing the amount of stool. The aforementioned benefits are observed both in the healthy population and in patients with chronic or sporadic constipation.

Chronic idiopathic constipation is the most common type of constipation, diagnosed in more than 90% of patients. Current guidelines for the treatment of idiopathic constipation are based primarily on increasing fluid intake to > 3 l/day and increasing dietary fiber intake to 20–30 g/day, in divided portions [25]. This very general, vague recommendation assumes that all types of fiber, both dietary fiber and isolated fiber, are equally effective in treating constipation. The studies available in the current literature show that this is a misconception that is not supported by clinical data [26, 27].

For decades, wheat bran has been described as the "gold standard in constipation therapy" [26, 28]. Meanwhile, the authors of a meta-analysis of 16 randomized trials published in 2022 provided evidence that psyllium consumed at a dose of > 10 g/day for at least 4 weeks is the most effective fiber for the treatment of chronic constipation [26]. In their conclusion, the researchers highlighted the potential of PO husk as a first-line strategy for treating constipation [26]. A comprehensive meta-analysis of 52 clinical trials published 2 years earlier also suggested that psyllium was the fiber deserving of the gold standard in regulating bowel movements [27]. The cited meta-analysis compared the effects of two isolated fibers (from wheat bran and psyllium) on stool frequency and stool water content in patients with chronic idiopathic constipation (CIC). The authors of the review reported that in patients with CIC, psyllium therapy was 3.4 times more effective in increasing stool output than treatment with insoluble food fiber from wheat bran [27]. Consumption of coarsely ground wheat bran showed a moderate effect on increasing stool in healthy subjects (2.9 g of stool per gram of fiber consumed), while in constipated subjects, the increase in stool after bran consumption was minimal, averaging 1.4 g/g of fiber [27]. Meanwhile, consumption of psyllium husk increased stool output by 4.8 g/g of fiber consumed in a population of idiopathic constipation sufferers and by 5.0 g/g psyllium in healthy subjects [27]. The mechanism of action of coarsely ground wheat bran is related to mechanical irritation of the intestinal wall. The therapeutic effect of psyllium husk, on the other hand, is related to its ability to form a three-dimensional gel in the lumen of the gastrointestinal tract, which does not ferment and remains intact in the various sections of the gastrointestinal tract [27, 29].

The results of clinical trials available in the literature indicate that psyllium husk constipation therapy is also distinguished by its greater efficacy compared to sodium docusate therapy [28]. McRorie *et al.* in a randomized study carried out in a group of 170 patients with chronic idiopathic constipation and hard stools (mean stool water content of 71%) found that consumption of 10 g/day psyllium (in a divided dose of 2 × 5.1 g) increased the mean stool water content to a value of 74% (normal/shaped stool) as early as day 3 of dosing, and the effect of changing the consistency of fecal masses was maintained throughout the 2-week treatment period [28]. In contrast, the stool water content of patients enrolled in the sodium docusate treatment group (at a dose of 100 mg 2×/day) remained below 72% (hard stool) throughout the study period [28].

The scientific literature describes two mechanisms by which *Plantago* fiber shows impressive efficacy in

treating constipation [27, 28, 30]. Both mechanisms are related to the physicochemical properties of psyllium husk described above:

- resistance to fermentation,
- lack of structural susceptibility (remaining intact in the intestinal lumen in association with fecal matter) and
- the ability to bind water and liquefy fecal masses [27, 28, 30].

The first mechanism, the beneficial effect of psyllium husk in the course of constipation, is related to the retention of water in the gel-like structure of psyllium (which it forms in the lumen of the gastrointestinal tract), thus increasing the fluidity of the stool [30]. This is because the consistency of the stool is strongly correlated with its water content. Even a small change in water content (±2%) has a significant effect on stool consistency: a hard stool contains less than 72% water; a properly formed stool about 74%; a soft stool about 76%; a loose stool about 80%; while the water content of a liquid stool exceeds 90% [27, 28].

The second mechanism of the therapeutic effect of psyllium in constipation, reported in the literature, is the alteration of the intestinal environment [7, 31]. The above effect is due to psyllium's ability to promote the growth and proliferation of probiotic bacteria in the intestinal lumen, and increase the production of endogenous short-chain fatty acids (SCFAs) [7, 31, 32]. Colonic bacteria fermenting psyllium produce SCFAs (acetic, propionic and butyric), which exert beneficial clinical effects. SCFAs act as signaling molecules that modulate many physiological processes. Low intake of soluble dietary fiber results in a reduction of SCFA concentrations in the body. The results of clinical studies available in the literature indicate that *Plantago* polysaccharides stimulate the growth of *Bifidobacterium* in the stools of healthy women and lead to the normalization of their titers in the stools of women with reduced *Bifidobacterium* levels [7]. The authors of the cited study suggested that the effect of psyllium husk on the gut microbiota depends on the baseline state of the subjects' microbiota. In another clinical experiment, it was found that consumption of psyllium husk resulted in changes in the composition of the intestinal microbiota in both a group of 8 healthy volunteers and 16 constipated patients, with the observed changes being more significant in the constipated patients [31]. The noted changes included a significant increase after psyllium supplementation of *Faecalibacterium* ssp., *Lachnospira* and *Phascolarctobacterium*, i.e. microorganisms associated with the production of short-chain fatty acids [31]. At the same time, the cited study described a significant association between lower levels of SCFAs and longer transit time of fecal masses [31]. Literature data also suggest that low concentrations of butyrate, through inhibition of mucin secretion, contribute to the development of constipation [33]. Jalanka *et al.* also observed an almost twofold reduction in *Christensenella* after psyllium application and a negative correlation between fecal water content and *Christensenella* count [31]. Analogous results were obtained in previously published studies that showed an association between *Christensenella* and the occurrence of hard stools [34].

Therapeutic effect of *Plantago ovata* husk in the course of diarrhea

The physicochemical properties of psyllium related to its ability to form a gel in an aqueous environment and its ability to retain water in this mucous-gel-like structure make psyllium-containing preparations show therapeutic effects not only in constipation but paradoxically also in diarrhea. The efficacy of psyllium in the treatment of acute and chronic diarrhea has been demonstrated in 4 randomized cross-over clinical trials [35–38]. Two studies evaluated the effect of psyllium on stool consistency in acute diarrhea induced by phenolphthalein (a stimulant laxative) [35, 36].

In the first study, implemented in a group of 9 people, 4 methods of treatment were used: 1) psyllium husk at 18 g/day; 2) polycarbophil at a dose of 6 g/day; 3) wheat bran 42 g/day; and 4) placebo. The duration of treatment with each substance was 4 days [35]. The results of the described experiment made it possible to show that psyllium husk was the only fiber that, by increasing the viscosity of the stool more than twofold, significantly improved its consistency ($p < 0.001$). The researchers noted that the water content of the stool (90.8%) was identical for placebo and psyllium, and emphasized in their conclusion that the therapeutic efficacy of psyllium in diarrhea is due to the retention of excess water in the gel-like structure formed by psyllium in an aqueous environment, thus yielding a soft/formed stool [35]. Calcium polycarbophil and wheat bran had no significant effect in relieving diarrhea symptoms [35].

A second crossover study evaluating the effect of psyllium ingestion on the course of acute phenolphthalein-induced diarrhea involved 6 healthy volunteers (5 men and 1 woman) aged 20–36 years [36]. The study participants received 4 different forms of treatment over a period of 3 days: psyllium at doses of 9, 18 and 36 g/day and placebo [36]. The results showed a dose-dependent change in stool consistency, ranging from semi-liquid in placebo, semi-liquid and soft when treated with psyllium at 9 g/day, soft when consuming psyllium at 18 g/day to soft and formed stool after psyllium at 36 g/day [36]. As in the previous study, despite

the normalization of stool consistency, its water content remained high.

A third randomized cross-over study compared the efficacy of psyllium (10 g/day) and loperamide (maximum 16 mg/day) in 25 patients with chronic diarrhea [37]. Both treatments reduced stool frequency by half, but there was a statistically significant improvement in stool consistency in the group of patients receiving psyllium in combination with calcium (vs. loperamide; $p < 0.05$) [37].

A fourth randomized crossover study evaluated, in a group of 8 volunteers (age 19–23), the efficacy of psyllium (at a dose of 10.5 g/day; 3 × 3.5 g) in relieving symptoms of diarrhea induced by lactulose added 20 ml 3× daily to an isotope-labeled test meal [38]. Psyllium husk, compared to placebo, significantly slowed gastric emptying and passage of fecal masses in the large intestine ($p < 0.05$), without significantly affecting the transit time of food content in the small intestine [38].

Dosage – recommended intake of *Plantago ovata* husk

The most commonly indicated, in clinical trials, dose of psyllium husk showing therapeutic effect is the amount of 10–15 g/day, taken in divided doses (3× daily at about 3.4–5 g) before main meals [10, 27, 39, 40]. Each dose of *Plantago ovata* husk should be consumed after dissolving the product in an appropriate amount of liquid (approximately 150–200 ml). In addition, to avoid complications, it is recommended that the patient drink another glass of water after consuming a dose [39]. It is recommended that *Plantago ovata* husk therapy for all indications other than constipation be started gradually, with a single daily dose of 3.4 g/day for the first week, and then increased by 1 daily dose each subsequent week until the therapeutic goal is reached (i.e., about 10–15 g/day) [10, 27, 39, 40]. This is to eliminate possible gastrointestinal discomfort (e.g., bloating) that may occur after a sudden, significant increase in fiber consumption.

Contraindications to *Plantago ovata* husk therapy

Plantago ovata husk supplementation is contraindicated: in patients with psyllium allergy, in patients with dysphagia or mechanical obstruction of the gastrointestinal tract, and in patients with anatomical changes in the gastrointestinal tract [39, 40]. Preparations from *Plantago ovata* husk should also not be consumed by patients with severe protein or protein-energy malnutrition and in patients who are lying down, in which there is a weakening of the smooth muscles of the gastrointestinal tract with subsequent slowing of intestinal peristalsis [40]. For the same reason, ingestion of psyllium is contraindicated in patients treated with muscle relaxants (baclofen, tolperisone, methocarbamol). The use of psyllium preparations is not recommended in neonates, infants and children under 3 years of age due to the potential choking hazard of available dosage forms [40].

Combining psyllium supplementation with antidiarrheal drugs that have spasmolytic effects and inhibit gastrointestinal peristalsis (atropine + diphenoxylate) may also pose some clinical risks [40].

Conclusions and perspective

The results of numerous clinical studies available in the literature allow us to conclude that the fiber deserving the name of the gold standard in regulating bowel movements is the seed husk obtained from *Plantago ovata*. The physicochemical properties of PO husk, related to its ability to form a gel in an aqueous environment and its ability to retain water in this mucous-gel structure, mean that preparations containing psyllium show therapeutic effects in both constipation (including occasional and chronic) and diarrhea (acute and chronic). Moreover, the results of studies and clinical experiments indicate that the use of psyllium husk in the treatment of bowel disorders is distinguished by significantly higher efficacy compared to pharmacological preparations such as sodium docusate (for the treatment of constipation) or loperamide (for the treatment of diarrhea). This underscores the potential of psyllium husk as a first-line strategy for treating constipation and diarrhea. *P. ovata* husk therapy appears to be a safe and inexpensive intervention. It is important to note that the laxative effect of *P. ovata* husk is a mild one without severe side effects compared to those associated with stimulant laxatives. Furthermore, the consumption of psyllium, apart from regulating defecation, also provides other benefits related to antioxidant, immunomodulatory, antiproliferative, anticancer and antiviral activities. Such pleiotropic effects of *P. ovata* seed husk are related to the presence in its composition of a highly branched arabinoxylan (which forms a gel in an aqueous environment) and bioactive compounds and their primary as well as secondary metabolites (short-chain fatty acids, amino acids, polyphenols and flavonoids). In addition, it is worth noting that the seed husk is odorless and tasteless so supplementation is not burdensome to the patient.

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Conflict of interest

The authors declare no conflict of interest.

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