Comparison of the role of fiber in the treatment of functional constipation in children and adults

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RESUMEN

El estreñimiento funcional es uno de los trastornos gastrointestinales más frecuentes en los niños y adultos. El aumento del consumo de agua y fibra son algunas de las recomendaciones más comúnmente dadas a los pacientes. Una mayor ingesta de fibra se puede lograr a través del consumo de alimentos ricos en fibra dietética, o tomado en forma suplementaria. Además de las fibras que ocurren naturalmente en los alimentos, la Administración de Drogas y Alimentos (FDA) de los Estados Unidos ha aprobado más de 14 fibras aisladas o sintéticas para su uso. Hoy en día existen pocas investigaciones que hayan estudiado el beneficio de todos estos tipos de fibra para el tratamiento del estreñimiento en niños y adultos. Esta revisión discute la evidencia de los diferentes tipos de fibra para el tratamiento del estreñimiento funcional en niños y adultos. (NeuroGastroLatam Rev. 2018;2:149-168).

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ABSTRACT

Functional constipation (FC) is one of the most common gastrointestinal disorders in children and adults. Physicians commonly recommend dietary interventions for its treatment including increasing water and fiber intake. Greater fiber intake can be achieved through the consumption of foods rich in dietary fiber, or taken in supplemental form. In addition to naturally occurring fibers in food, the Food and Drug Administration has approved over 14 isolated or synthetic fibers for use. This review discusses the evidence for various fiber types for the treatment of FC in children and adults.

Key words: Functional Constipation. Irritable Bowel Syndrome. Abdominal Pain. Fiber. Children. Adults.

INTRODUCTION

Functional constipation (FC) is a common gastrointestinal (GI) complaint, with a global pooled prevalence of 14%¹. Symptoms of FC include straining while having a bowel movement, lumpy and/or hard stools, the sensation of incomplete emptying after having a bowel movement, the sensation of blockage, and two or fewer bowel movements per week². While FC is not life threatening, a decreased quality of life is commonly reported among sufferers³. In addition, the direct economic costs are estimated to be \$1,912-\$7,522 per year, per person seeking treatment⁴.

First-line medical treatment for FC includes oral laxatives (osmotic, lubricating, or stimulant), or rectal laxatives (suppositories or enema)⁵. However, a 2019 Italian survey study revealed that more than 50% of complementary and alternative medicine users are motivated by a “more natural” way to approach to GI symptoms⁶. Thus, it is important to advance the knowledge of other possible type of treatments including dietary interventions⁷.

In clinical practice, dietary and lifestyle modifications are recommended for the prevention and management of FC. Patients are often encouraged to increase physical activity, as well as the intake of fluid and fiber. Fiber intake can be divided into “dietary fiber” and “functional fiber.” Dietary fibers are naturally occurring in foods, while functional fibers are commonly added to foods or provided as supplements. Together, these fibers are widely available for both prevention and treatment of FC. According to the 2015-2020 Dietary Guidelines for Americans, fruits, vegetables, and whole grains constitute high fiber-containing foods⁸.

Despite fiber being frequently recommended, the efficacy of fiber on FC is conflicting. A 2016 systematic review with meta-analysis included seven individual randomized controlled trials on the effect of fiber supplementation on constipation⁹. It suggested that fiber supplements are moderately effective, but can cause bloating. This review did not include studies in children, nor did it include all the fiber types. Therefore, to reduce

the knowledge gap, we aimed to compare the role of all dietary fibers and functional fibers, in the treatment of FC in children and adults.

LITERATURE SEARCH

PubMed was searched for articles from inception to November 2018. Keywords included were “fiber,” “dietary fiber,” and “functional fiber” in combination with “constipation,” “adults,” “Adolescents,” “pediatrics,” “elderly,” “children,” and “kids.” Relevant systematic reviews and meta-analysis were reviewed to identify possible missed references not identified by the initial PubMed search.

DIETARY FIBERS

Dietary fibers are naturally occurring within fruits, vegetables, and whole grains. A 2008 position statement by the American Dietetic Association (formally known as the Academy of Nutrition and Dietetics) recommends dietary fiber for the prevention and management of constipation. The manuscript suggests that the public should consume adequate amounts of dietary fiber from a variety of plant foods¹⁰. Fiber from plant foods generally consists of nondigestible carbohydrates. Remarkably, there are over 80,000 plant species that are edible for humans, but only about 150 species are actively cultivated for food¹¹ and with varying amounts of fiber and other properties that may influence GI activity. The data on the effectiveness of dietary fiber for FC are mixed. A narrative description of the findings is listed below.

Kiwifruit

Kiwifruit is rich in vitamins and phytochemicals, including Vitamins C, E, K, folate, carotenoids, and potassium¹². Kiwifruit has roughly 3 g of fiber per 100 g of fruit¹². In a recent 2018 trial conducted in adults, the consumption of six capsules of green kiwifruit extract (Zyactinase) significantly increased defecation frequency compared with placebo ($p < 0.001$)¹³. These beneficial effects were noted within the first 24 h of consumption. This data is consistent with earlier studies with kiwifruit. A 2002 clinical trial had elderly people with constipation consume one kiwifruit per 30 kg bodyweight for 3 weeks and noted a significant increase in the frequency of defecation ($p = 0.012$)¹⁴. Similarly, four studies exploring kiwifruit for constipation found positive effects; Chinese adult patients noted a significant decrease in laxative use ($p = 0.003$), and improved their satisfaction of bowel habits ($p = 0.001$), compared to baseline¹⁵. In Taiwan, adults with irritable bowel syndrome (IBS)/C experienced an increase in defecation frequency ($p < 0.05$) with kiwifruit consumption¹⁶. Udani and Bloom found that adults treated with Zyactinase for 4 weeks had greater improvement in defecation frequency than those in the placebo group ($p = 0.020$) and that it was well tolerated¹⁷. Finally, Ansell et al. found that 4 weeks of kiwifruit-derived supplementation, Actazin green and Livaux gold, increased stool frequency in healthy individuals (Actazin-H [$p = 0.014$] and Gold [$p = 0.009$]), though there were no significant differences in the constipated group¹⁸ (Table 1).

Despite the evidence suggesting kiwifruit may benefit bowel health, one study did not

TABLE 1. Clinical trials on kiwifruit for the treatment of functional constipation.

Author	Year Published	Enrolled	Age (years)	Fiber Type	Fiber Dose	Comparator	Length of treatment	Findings
Weir et al. ¹³	2018	70	23-65	Kiwifruit extract	2160 mg daily	Placebo	3 weeks	Kiwifruit extract increased defecation frequency. It significantly induced normal bowel movements as well as symptoms of IBS, such as bloating, flatulence, and abdominal pain
Rush et al. ¹⁴	2002	44	>60	Kiwifruit	One kiwifruit per 30 kg of bodyweight	Control	3 weeks	Kiwifruit consumption lead to an increase in defecation frequency, as well as bulkier and softer stools
Chan et al. ¹⁵	2007	35	≥18	Kiwifruit	Kiwifruit twice daily	None	4 weeks	Kiwifruit consumption was effective for relieving chronic constipation
Chang et al. ¹⁶	2010	60	≥18	Kiwifruit	Kiwifruit twice daily	Placebo	4 weeks	Kiwifruit consumption increased defecation frequency, shortened gut transit time, and improved bowel function
Udani and Bloom ¹⁷	2013	87	18-65	Kiwifruit extract	5.5 g daily	Placebo	4 weeks	Kiwifruit increased defecation frequency and reduced abdominal pain and flatulence
Ansell et al. ¹⁸	2015	29	23-56	Kiwifruit powder	Green kiwifruit powder: 600-2400 mg daily	Isomalt	28 days for each intervention	Kiwifruit powder increased stool frequency in healthy individuals, but those with functional constipation experienced no improvement in bowel movement frequency
Kindleysides et al. ¹⁹	2015	40	20-63	Kiwifruit extract	1 g daily	Placebo	6 weeks	Kiwifruit extract consumption did not improve bowel function or comfort

IBS: irritable bowel syndrome

find its extract to be effective for easing constipation in adults, as there were no differences in defecation frequency over 3 weeks ($p>0.05$) compared with placebo. Although the study design may be responsible for this outlier; the fiber dose was distinctly low (1 g), and there may be compositional differences between fresh fruit and freeze-dried extract¹⁹.

We did not find any studies with kiwifruits in children.

Prunes

Besides kiwifruit, prunes have received early attention as a high fiber fruit beneficial for GI function^{20,21}. Prunes are essentially dried plums and contain about 7.5 g of fiber per 100 g²². A 1955 study in New York demonstrated the effectiveness of prunes for FC; only 4.2% of 187 adult patients given a prune whip yogurt had to resort to laxatives²⁰. Following the completion of the study, the

TABLE 2. Clinical trials on prunes for the treatment of functional constipation.

Author	Year published	Enrolled	Age (years)	Fiber type	Fiber dose	Comparator	Length of treatment	Findings
Ferrer and Boyd ²⁰	1955	194	53-91	Prunes	2.5 ounces of Prune Whip in 5.5 ounces of yogurt	Control	5 weeks	Prune Whip Yogurt consumption led to 95.8% of participants requiring no laxatives during the trial
Stern ²¹	1966	25	59- 86	Prune concentrate + Cascarin	162 mg of prune concentrate + 162 mg of cascarn (tablets twice daily)	Placebo	3 weeks	Prune concentrate consumption led to 22 of the 25 patients to satisfactory results, whereas the placebo was not effective
Sairanen et al. ²³	2008	43	61-92	Yogurt containing galactooligosaccharides, prunes, and linseed	12 g GOS + 12 g prunes + 6 g linseed (daily)	Control	6 weeks	Daily consumption of yogurt containing galactooligosaccharides, prunes, and linseed, increased defecation frequency and reduced the severity of constipation
Attaluri et al. ²⁵	2011	40	18-75	Dried plums	50 g BID	Psyllium	8 weeks	The consumption of dried plums were more effective than psyllium for the treatment of mild-to-moderate constipation
Erdogan et al. ²⁶	2016	72	Mean age=42.9	Plum-derived mixed fiber	5 g BID	Psyllium	4 weeks	Consumption of plum-derived mixed fiber and psyllium was both effective for improving constipation, although mixed fiber was more effective in relieving flatulence, and bloating

participants continued to request the concoction for its ability to relieve constipation and intestinal distress²⁰. A decade later, a 3-week study in Pennsylvania confirmed these findings; a prune concentrate-cascarin combination for the treatment of FC in adults was more effective than placebo, with 88% of the participants reporting satisfactory results²¹. In 2008, a third study involving a prune mixture for constipation in elderly subjects revealed that a yogurt/prune mixture, including 12 g of prunes, was more effective than the control for improving defecation frequency ($p=0.011$)²³. Recently, a 2014 systematic review included four studies that

evaluated the effects of prunes on both constipated and nonconstipated adults²⁴. Only one of the included studies was done in constipated adults; Attaluri et al. showed that 3 weeks of 100 g daily prune consumption resulted in greater improvement in stool frequency ($p=0.006$) and stool consistency ($p=0.02$) compared with 22 g of daily psyllium²⁵. Conversely, when compared to psyllium, a 2016 study found both a plum-derived mixed fiber and psyllium, at equivalent doses, to be equally effective for the improvement of constipation and quality of life; 75% of responders were reported in each group ($p=0.9$)²⁶ (Table 2).

TABLE 3. Clinical trials on mango for the treatment of functional constipation.

Author	Year published	Enrolled	Age (years)	Fiber type	Fiber dose	Comparator	Length of treatment	Findings
Venancio et al. ²⁸	2018	48	>18	Mango	300 g daily	Fiber powder	4 weeks	The consumption of mango improves symptoms of constipation beyond an equivalent amount of fiber

TABLE 4. Clinical trials on mango for the treatment of functional constipation.

Author	Year published	Enrolled	Age (years)	Fiber type	Fiber dose	Comparator	Length of treatment	Findings
Cassettari et al. ³⁰	2018	97	5-15	Banana	Two tablespoons of green banana biomass daily (30 g)	PEG 3350 with electrolytes, and sodium picosulfate	8 weeks	Green banana biomass was effective in the therapy of functional constipation, and to reduce the need of laxatives

We did not find any studies with prunes in children.

Mango

Mangos contain 1.6 g of fiber per 100 g²⁷ and are rich in polyphenols²⁸. One adult study compared mango versus an equal amount of isolated fiber for the treatment of FC. This study showed that 4 weeks of 300 g of mango consumption improved stool form and consistency beyond an equivalent amount of fiber ($p=0.027$)²⁸ (Table 3).

We did not find any studies with mango in children.

Banana

Bananas contain pectin, a water-soluble dietary fiber. They contain 2.6 g of fiber per 100 g²⁹. In clinical practice, those who experience diarrhea are often encouraged to follow the BRAT diet (Bananas, Rice, Apple-sauce, and Toast) to alleviate symptoms.

Interestingly, bananas have also been studied for their laxation properties. A recent study in Brazil demonstrated that green banana biomass (high in resistant starch) is a beneficial adjunct therapy for FC in children and adolescents. Cassettari et al. found that the consumption of green banana biomass led to a statistically significant reduction in straining during defecation, painful defecation, and abdominal pain ($p<0.05$)³⁰ (Table 4).

Banana has not been studied for the treatment of FC in adults.

Papaya

Papaya contains 1.7 g of fiber per 100 g of fruit³¹. Besides the fiber content, interest in papaya has circulated due to its digestive enzymes, such as papain, chymopapain, caricain, and glycyl endopeptidase; these all assist in protein degradation. In 2013, a papaya preparation, Caricol, was administered at 20 ml daily for 40 days to adults, and statistically significant improvements of the

TABLE 5. Clinical trials on papaya for the treatment of functional constipation.

Author	Year published	Enrolled	Age (years)	Fiber type	Fiber Dose	Comparator	Length of treatment	Findings
Muss et al. ³²	2012	139	18-75	Papaya	20 ml daily	Placebo	40 days	Caricol treatment resulted in statistically significant improvements in constipation and bloating

symptoms “constipation” and “bloating” resulted ($p=0$)³² (Table 5).

Papaya has not been studied for the treatment of FC in children.

Fig

Ficus carica, commonly known as fig, contains 2.9 g of fiber per 100 g of fruit³³. A 2016 Korean study found an improvement in defecation frequency per week, in subjects suffering from FC, after an 8 week intervention period ($p<0.0001$)³⁴. In long-term care residents, a natural laxative mixture with 1 cup figs was more effective than daily prescribed laxatives at increasing defecation frequency ($p=0.007$)³⁵. In Iran, adults consuming fig or flaxseed had significant improvements in IBS-C symptoms including frequency of defecation and hard stools compared with a control group ($p<0.05$)³⁶.

Recently, a study in children compared the effects of fig syrup and red sugar for the frequency of stool excretion and pain at the time of excretion and found no significant differences ($p=0.264$)³⁷. Both the fig syrup and red sugar were effective at improving the functional characteristics of constipation in children (Table 6).

Wheat bran

Wheat bran increases stool bulk and thus has been extensively studied for constipation. 100 g of wheat bran contains an impressive 42.8 g of fiber³⁸. In 1982, Graham et al. studied bran in adults with constipation³⁹. The administration of bran was associated with a significant increase in stool weight (157%) and defecation frequency (55%)³⁹. In 1984, Cann et al. demonstrated that 4 weeks of 10-30 g daily bran consumption produced a significant increase in stool weight ($p<0.05$) and the proportion of unformed stools ($p<0.0001$) in adults with constipation⁴⁰. 1 year later, another study with similar methods had equivalent results. In a cross over design, Arffmann et al. found that the daily intake of 30 g of coarse wheat bran significantly ($p<0.05$) increased the stool weight and shortened the intestinal transit, versus 30 g of placebo⁴¹. Despite these findings, a 1988 meta-analysis in adults showed that wheat bran is only partially effective for relieving of constipation in adults⁴².

Since the 1980s, more recent studies have shown much lower doses to be effective for the treatment of constipation. Badiali et al. found that 20 g of daily bran treatment was more effective than placebo in improving bowel frequency and transit time ($p<0.001$)⁴³. In England, 153 adult low fiber consumers

TABLE 6. Clinical trials on fig for the treatment of functional constipation.

Author	Year published	Enrolled	Age (years)	Fiber type	Fiber dose	Comparator	Length of treatment	Findings
Baek et al. ³⁴	2016	109	19-39	<i>F. carica</i>	3 paste packs daily	Placebo	8 weeks	The consumption of <i>F. carica</i> paste increased defecation frequency, reduced colon transit time, and improved consistency, and abdominal discomfort
Hale et al. ³⁵	2007	45	65-100	1 cup raisins + 1 cup pitted prunes + 1 cup figs + 1 cup dates + 1 cup currants + 1 cup prune concentrate	2 tablespoons twice daily	Prescription laxatives	8 weeks	The consumption of the natural laxative mixture was more effective than daily prescription laxatives at producing normal bowel movements
Pourmasoumi et al. ³⁶	2018	150	18-70	Flixweed or fig	30 g of dried flixweed or 45 g of dried fig	Control	4 months	The consumption of flixweed or fig improved IBS-C symptoms, including frequency of pain, distention, frequency of defecation, and hard stools
Tajik et al. ³⁸	2018	60	2-10	Fig syrup	2 g/kg daily	Red sugar	4 weeks	Both the fig syrup and red sugar were effective at improving constipation in children

IBS: irritable bowel syndrome, *Ficus carica*: *F. carica*

(under 15 g daily) consumed breakfast cereal containing at least 3.5 g of wheat bran for 14 days and found significant improvements in ease of defecation ($p=0.0061$) and feeling of constipation ($p=0.0002$) compared to baseline⁴⁴.

In children, there is much less literature on the role of wheat bran in the treatment of FC. One study evaluated the bowel habits of children treated with bran for the treatment of constipation over 24 months. The median bran intake was 20 g daily, and 21 children out of 28 were noted to be recovered by the end of the study (75%)⁴⁵ (Table 7).

FUNCTIONAL FIBER

The term “functional fiber” indicates that the fiber has been extracted from its natural source for the human benefit⁴⁶. These isolated, nondigestible carbohydrates are commonly added to foods or supplements to boost its fiber content. Recently, in 2017, the Food and Drug Administration (FDA) approved seven nondigestible carbohydrates (beta-glucan soluble fiber, psyllium husk, cellulose, guar gum, pectin, locust bean gum, and hydroxypropyl methylcellulose) to be listed as fiber on nutrition labels⁴⁷. Additional nondigestible carbohydrates that are considered fibers

TABLE 7. Clinical trials on bran for the treatment of functional constipation.

Author	Year Published	Enrolled	Age (years)	Fiber Type	Fiber Dose	Comparator	Length of treatment	Findings
Graham et al. ³⁹	1982	10	Adults	Wheat bran	20 g daily	Corn bran	Unknown	Bran consumption was associated with a significant increase in fecal weight, bowel movement frequency, and decrease in intestinal transit time
Cann et al. ⁴⁰	1984	38	19-61	Bran	10-30 g daily	Placebo	4 weeks	Bran consumption led to an increase in gut transit time, increase in daily stool weight, but no change in stool frequency
Arffmann et al. ⁴¹	1985	20	Adults	Bran	30 g daily	Placebo	12 weeks	The consumption of bran significantly increased stool weight and shortened intestinal transit time
Badiali et al. ⁴³	1995	29	20-65	Bran	20 g daily	Placebo	8 weeks	The consumption of bran improved defecation frequency and transit time
Lawton et al. ⁴⁴	2013	156	18-50	Bran	3.5 g daily	None	14 days	The consumption of bran led to significant improvements in constipation, bloating, and digestive discomfort
Maffei et al. ⁴⁵	2011	28	0.25-15.6	Bran	10-20 g daily	None	24 months	The consumption of bran led to amelioration of constipation in 75% of participants

include mixed plant cell wall fibers, arabinoxylan, alginate, inulin, and high amylose starch⁴⁷. Galactooligosaccharides, polydextrose, and resistant maltodextrin/dextrin are pending FDA consideration for declaration as fiber⁴⁷. For the purpose of this review, all isolated or synthetic non-digestible carbohydrate based fibers are grouped.

Glucomannan

Glucomannan is a nonabsorbable fiber, commonly used for the treatment of constipation. It is thought to act by absorbing water to form a bulky fiber⁴⁸. An early Italian study demonstrated a statistically significant improvement in mouth-to-cecum transit time in constipated adults treated with 1 g TID of oral glucomannan⁴⁹. Similarly, a multicenter

study showed that adults with chronic constipation had statistically significant improvements in bowel movement frequency with the treatment of 1 g of glucomannan TID for 1 month⁵⁰. Two later studies in Taiwan with similar design confirmed these findings^{51,52}.

In children, three studies have evaluated the role of glucomannan in the treatment of FC^{48,53,54}. A 2017 systematic review and meta-analysis captured these randomized controlled trials and concluded that glucomannan moderately increases the defecation frequency of children with constipation but is not associated with a reduction in stool consistency or overall improvement in the rate of successful treatment⁵⁵ (Table 8). More clinical trials exploring the effects of glucomannan on FC are needed.

TABLE 8. Clinical trials on glucomannan for the treatment of functional constipation.

Author	Year published	Enrolled	Age (years)	Fiber type	Fiber dose	Comparator	Length of treatment	Findings
Marzio et al. ⁴⁹	1989	31	Adults	Glucomannan	1 g TID	Placebo	10 days	Consumption of Glucomannan led to a statistically significant decrease in gut transit time
Passaretti et al. ⁵⁰	1991	93	17-80	Glucomannan	1 g TID for 1 month, followed by 1 g BID for 1 month	None	2 months	Consumption of Glucomannan led to a statistically significant improvement in defecation frequency
Chen et al. ⁵¹	2006	8	21-54	Glucomannan	4.5 g daily	Placebo	21 days	Consumption of Glucomannan led to an increase in defecation frequency, possibly by increasing the stool bulk
Chen et al. ⁵²	2008	7	45.9±2.7	Glucomannan	4.5 g daily	Placebo	21 days	Consumption of Glucomannan promoted bowel movement frequency by 30%
Staiano et al. ⁵³	2000	20	5.7±4.2	Glucomannan	100 mg/kg twice daily	Placebo	12 weeks	Glucomannan significantly increased defecation frequency
Chmielewska et al. ⁵⁴	2011	80	3-16	Glucomannan	2.52 g daily	Placebo	4 weeks	Consumption of Glucomannan was not more effective than placebo at achieving ≥3 stools per week with no soiling
Loening-Baucke et al. ⁵⁵	2004	46	4.5-11.7	Glucomannan	100 mg/kg of body weight daily	Placebo	4 weeks	The consumption of Glucomannan in children led to significantly fewer complaints of abdominal pain than placebo

Psyllium

Psyllium, or ispaghula, has water-holding abilities and is a bulk-forming fiber, with 70 g of fiber per 100 g⁵⁶. Three studies compared ispaghula to lactulose in adults all with mixed findings⁵⁷⁻⁵⁹. An early 1991 study in England found ispaghula and lactulose both to be effective for chronic constipation⁵⁷. Dettmar

et al. found ispaghula husk to be an effective treatment for constipation compared with lactulose. In the ispaghula group, stools were reported to be normal in 55% of occasions, versus 43% in the lactulose group, and 39% in the laxative group⁵⁸. On the other hand, Quah et al. found lactulose had better efficacy than the fiber for the treatment of chronic constipation ($p=0.017$); in addition, 61.5% preferred lactulose versus 35.9% that

preferred fiber⁵⁹. When comparing polyethylene glycol (PEG) 3350 plus electrolytes (PEG+E) for 2 weeks, PEG+E was more effective and more rapid in its onset of action than ispaghula⁶⁰.

Two studies in adults compared ispaghula to plums. As previously mentioned, Attaluri et al. found dried plums to be more effective than psyllium for the treatment of mild-to-moderate constipation, and a palatable option²⁵, while Erdogan et al. found no difference in effects between a plum-derived mixed fiber and psyllium²⁶. Three adult studies evaluated psyllium versus placebo. Cheskin et al. found fiber supplementation to improve colonic transit time and benefit constipated elderly patients⁶¹. Ashraf et al. found that psyllium increased stool frequency, weight, and consistency in idiopathic constipation⁶². In addition, Nouredin et al. found that psyllium supplementation decreased constipation symptoms in patients with Type 2 diabetes and chronic constipation⁶³. When comparing psyllium to docusate sodium for the treatment of chronic constipation in adults, bowel movement frequency was significantly greater with psyllium ($p=0.02$)⁶⁴.

In a recent study in children with IBS (mixed type, but included IBS-C), those receiving psyllium fiber treatment noted less hard stools (Bristol 1 or 2) from baseline, than those in the placebo group ($p<0.048$)⁶⁵. In a parallel-group study involving 100 children with chronic FC, a psyllium-containing fiber mixture was as effective as PEG+E ($p=0.79$) for treating constipation; 77.8% of children improved on the fiber mixture, versus 83% of children treated with PEG+E⁶⁶ (Table 9).

Polydextrose

Polydextrose is a non-digestible soluble fiber polymer that is synthesized from glucose and sorbitol. This polysaccharide is partially fermented in the colon⁴⁷. Two studies in adults (combined 127 enrolled subjects) have shown a beneficial effect of polydextrose in yogurt mixture for the treatment of constipation^{67,68}. Hengst et al. showed that the yogurt mixture shortened the orocecal transit time and improved stool consistency ($p>0.05$)⁶⁷. Similarly, Magro et al. demonstrated shorter transit times post-intervention compared to the control group ($p=0.01$)⁶⁸. These results reveal a possible use of polydextrose for the prevention of constipation.

In constipated adult Japanese dialysis patients, those who received 10 g of polydextrose daily for 8 weeks significantly improved their bowel habits. Stool frequency increased from 3 to 7.5 times weekly with no adverse GI effects ($p<0.01$)⁶⁹.

In contrast, a recently published 2018 study by Duncan et al. found no significant improvements in gut function in 128 adults with chronic constipation, after 2-week treatment with either 8 or 12 g of polydextrose daily⁷⁰. However, according to the Joint FAO/WHO Expert Committee on Food Additives (JECFA) and the European Commission Scientific Committee for Food, the laxative threshold for polydextrose is 90 g/day, or 50 g as a single dose⁷¹. Thus, longer-term trials with increased dosing are warranted.

In children, one Turkish study evaluated the effects of 4 weeks of a symbiotic/prebiotic mixture, including polydextrose, for the

TABLE 9. Clinical trials on psyllium for the treatment of functional constipation.

Author	Year published	Enrolled	Age (years)	Fiber type	Fiber dose	Comparator	Length of treatment	Findings
Rouse et al. ⁵⁸	1991	124	Adults	Ispaghula	One sachet of ispaghula BID	Lactulose	4 weeks	Both treatments were shown to be effective for the treatment of constipation
Dettmar and Sykes ⁵⁹	2008	394	Adults	Ispaghula	3.5 g of Ispaghula BID	Lactulose	4 weeks	Consumption of Ispaghula husk led to better stool consistency and less side effects compared with lactulose
Quah et al. ⁶⁰	2007	50	18-85	Ispaghula	3.5 g of ispaghula once daily	Lactulose	4 weeks	Lactulose resulted in significantly higher defecation frequency than fiber
Wang et al. ⁶¹	2004	126	18-75	Ispaghula	3.5 g of ispaghula husk BID	PEG + E	2 weeks	PEG + E was more effective and rapid in its onset of action than ispaghula
Cheskin et al. ⁶²	1995	10	Adults	Psyllium	24 g of psyllium daily	Placebo	1 month	Fiber supplementation decreased gut transit time, and there was a trend toward an increase in stool frequency
Ashraf et al. ⁶³	1995	22	35-70	Psyllium	5 g of psyllium BID	Placebo	8 weeks	Psyllium increased defecation frequency and weight, and improved stool consistency
Noureddin et al. ⁶⁴	2018	60	38-72	Psyllium	10 g of psyllium BID	Placebo	12 weeks	The consumption of psyllium by patients with chronic constipation and diabetes resulted in decreased constipation symptoms, body weight, glycemic, cholesterol, and increased HDLC levels
McRorie et al. ⁶⁵	1998	381	20-74	Psyllium hydrophilic mucilloid	5.1 g of psyllium BID	Docusate sodium	2 weeks	The consumption of psyllium was more effective than docusate sodium for softening stools and had a greater overall laxative effect
Shulman et al. ⁶⁶	2017	163	7-18	Psyllium	7-11 years: 6 g daily 12-18 years: 12 g daily	Placebo	6 weeks	Children in the placebo group had a significant reduction in the percentage of stools rated as constipation, but not the psyllium group
Quitadamo et al. ⁶⁷	2012	100	6.5±2.7	Acacia fiber + psyllium fiber + fructose	16.8 g daily	PEG + E	8 weeks	Both treatments were proved to be safe for constipation treatment

PEG+E: PEG 3350 plus electrolytes

TABLE 10. Clinical trials on polydextrose for the treatment of functional constipation.

Author	Year published	Enrolled	Age (years)	Fiber type	Fiber dose	Comparator	Length of treatment	Findings
Hengst et al. ⁶⁸	2009	56	19-66	Polydextrose	8 g daily	Placebo	8 weeks	The consumption of polydextrose shortened the gut transit time and to improved stool consistency
Magro et al. ⁶⁹	2014	71	18-45	Polydextrose	3.6 g daily	Control yogurt	2 weeks	The consumption of yogurt with polydextrose significantly shortened colonic transit time
Shimada et al. ⁷⁰	2015	50	51-79	Polydextrose	10 g daily	Control	4 weeks	The consumption of polydextrose led to significant improvements in defecation frequency
Duncan et al. ⁷¹	2018	128	18-75	Polydextrose	8 or 12 g daily	Placebo	4 weeks	The consumption of polydextrose did not significantly improve defecation frequency, consistency, or transit time
Baştürk et al. ⁷³	2017	155	4-18	Polydextrose, fructo-oligosaccharides, and galacto-oligosaccharides + synbiotic	1996.57 mg sachet once daily	Placebo	4 weeks	The consumption of the polydextrose mixture led to a significant improvements in defecation frequency, abdominal pain, and painful defecation

treatment of FC. Significant improvements in defecation frequency, abdominal pain, and pediatric Bristol Scale ($p \leq 0.001$) were noted, compared to the placebo group⁷² (Table 10).

Prebiotic fibers (oligosaccharides, inulin)

Prebiotic fibers including inulin-type fructans and galactooligosaccharides are non-digestible fibers intended to provide a health benefit to the host⁷³.

Four adult studies found beneficial effects on improvement in bowel symptoms with prebiotic fibers⁷⁴⁻⁷⁷. Marteau et al. demonstrated that

15 g of inulin supplementation improved constipation and quality of life in elderly people⁷⁴. Another study in the elderly population showed improvement in constipation in 9 out of 10 subjects on inulin consumption⁷⁵. Orafiti®, a granulated inulin powder, was studied in two of the trials^{76,77}. Micka et al. found Orafiti® significantly increased stool frequency compared to placebo ($p=0.038$)⁷⁶. Similarly, in another study, subjects with irregularity due to low dietary fiber intake had significant improvements in laxation at 10 g ($p=0.04$) and 15 g ($p=0.004$), daily⁷⁷.

In children, Orafiti® supplementation has been shown to improve stool consistency ($p=0.003$) in a group of 22 constipated, 2-5-year-old children⁷⁸. In another study of 20 constipated 4-16

years old, galactooligosaccharides ingestion increased bowel movement frequency ($p<0.0001$) compared to placebo. To note, straining during defecation was relieved ($p<0.0001$), and a decrease in stool consistency was also highlighted ($p=0.0014$)⁷⁹. Weber et al. evaluated fructooligosaccharides and inulin fiber mixture for the treatment of chronic constipation in children. Patients in the fiber group increased their daily bowel movements, ($p=0.014$) as well as improved stool consistency ($p=0.003$)⁸⁰.

In contrast, Kokke et al. did not find a transgalacto-oligosaccharides and inulin fiber mixture to be more effective than lactulose for the treatment of childhood constipation in regard to defecation frequency ($p=0.481$) or fecal incontinence frequency ($p=0.084$)⁸¹ (Table 11).

Cellulose

Cellulose is a structural component of the cell wall of plants. It is frequently added to foods to increase the fiber content without compromising flavor⁴⁷. Spent grain is an example of this, with the composition of cellulose and hemicellulose 65.6%. A 4-week pilot study had 19 patients with chronic constipation consume 20-25 g of fiber daily, through spent grain fiber-enriched biscuits and scones. Bowel movement frequency improved in 79% of participants, flatulence in 63%, abdominal pain in 53%, stool consistency in 42%, and laxative dependence in 74%⁸².

Hamilton et al. found a low dose of just 1 g methylcellulose to be an effective laxative. 59 chronically constipated adults were treated with daily doses of either 1, 2, or 4 g of methylcellulose or 3.4 g psyllium. All of these

doses resulted in statistically significant increases in defecation frequency and water content ($p<0.01$)⁸³. However, these results were not replicated in a Japanese study. In a group of constipated adults, the consumption of up to 8 g of cellulose did not result in any significant changes in stool weights, stool water content, defecation consistency, and defecation frequency⁸⁴.

In addition to efficacy, tolerability is important for adherence to treatment. Smith et al. tested a novel oral bulk-fiber laxative caplet, with a two caplet dose providing 1 g of methylcellulose for 2 weeks. 21 out of 24 patients (87.5%) who had had previously used fiber preferred the caplets over other products. Furthermore, the percentage of complete bowel movements, bowel movements having normal stool consistency and reduced straining significantly increased ($p<0.05$)⁸⁵.

Two pediatric studies with a total of 698 enrolled patients reported that methylcellulose is beneficial for the treatment of chronic and acute constipation. Vignec et al.⁸⁶ documented satisfactory results in 72.2% of cases, while Snape et al. found 61% of the participants to have less constipation⁸⁷ (Table 12).

Guar gum

Guar gum contains 90 g of fiber per 100 g⁸⁸. An early 1988 study, with 33 elderly hospitalized patients with chronic constipation, utilized a guar gum and wheat bran enriched yogurt for treatment. 2 weeks later, 50% of the patients were treated efficiently, versus 25% in the control group; fecal output increased 1.6 times from baseline,

TABLE 11. Clinical trials on prebiotic fibers for the treatment of functional constipation.

Author	Year published	Enrolled	Age (years)	Fiber type	Fiber Dose	Comparator	Length of treatment	Findings
Marteau et al. ⁷⁵	2010	100	50-70	Inulin	15 g daily	Placebo	28 days	Daily supplementation of inulin improved constipation and quality of life in an elderly population
Kleessen et al. ⁷⁶	1997	35	68-89	Inulin	20-40 g daily	Lactose	19 days	The consumption of inulin led to a better laxation than lactose
Micka et al. ⁷⁷	2016	54	≥20 and ≤75	Inulin	12 g daily	Placebo	4 weeks	Inulin was effective for chronic constipation and significantly improved bowel function
Buddington et al. ⁷⁸	2017	104	18-65	Inulin	5 g daily, then increased to 10 and 15 g daily	Placebo	12 weeks	The consumption of inulin led to a laxation effect, without adverse effects, in those with low dietary fiber intake
Closa-Monasterolo et al. ⁷⁹	2017	22	2-5	Inulin	4 g daily	Placebo	6 weeks	The consumption of inulin-type fructans improved stool consistency in children
Beleli et al. ⁸⁰	2015	22	4-16	Galactooligosaccharide	1.7 g daily	Placebo	4 weeks	The consumption of galactooligosaccharide resulted in an increase in bowel movement frequency, and relief of straining during defecation
Weber et al. ⁸¹	2014	60	4-12	Inulin + fructooligosaccharides + gum + resistant starch + soy polysaccharide + cellulose	3.8-7.6 g	Placebo	4 weeks	The consumption of the fiber mixture promoted an increased defecation frequency and an improvement in the stool consistency, but did not reduce transit time
Kokke et al. ⁸²	2008	135	1-13	Inulin + Trans-galacto-oligosaccharides + soy fiber + resistant starch	10-30 g daily	Lactulose	8 weeks	The consumption of lactulose and the fiber mixture was equally effective for improving defecation frequency and fecal incontinence, but lactulose led to softer stools

TABLE 12. Clinical trials on cellulose for the treatment of functional constipation.

Author	Year published	Enrolled	Age (years)	Fiber type	Fiber dose	Comparator	Length of treatment	Findings
Odes et al. ⁸³	1986	19	Adults	Spent grain (composed of cellulose and hemicellulose)	20-25 g daily	None	4 weeks	The consumption of spent grain led to an increase in defecation frequency in 79% of participants
Hamilton et al. ⁸⁴	1988	59	19-59	Methylcellulose	1, 2, or 4 g daily	Psyllium	2 weeks	Consumption of methylcellulose led to statistically significant increase in stool frequency, water content, and fecal solids
Danjo et al. ⁸⁵	2008	26	20-55	Cellulose	4-8 g of cellulose	Control	4 weeks	Cellulose supplementation did not significantly affect fecal water content, fecal weight, and fecal consistency
Smith et al. ⁸⁶	2003	52	18-82	Methylcellulose	2 caplets daily	None	2 weeks	21 of 24 patients preferred the caplets over prior fiber products, thus methylcellulose tablets may provide a useful alternative for improving compliance
Vignec and Mitty ⁸⁷	1952	115	1 month-10 + years	Methylcellulose	½-1 tsp, or 1-2 tablets TID	None	unknown	83 or 115 infants and children had excellent or good response to methylcellulose treatment
Snape ⁸⁸	1989	583	Adults	Methylcellulose	1-3 tablespoons daily	None	unknown	The consumption of spent grain led to improvements in defecation frequency and consistency, and 61% of the patients were judged to have less constipation

versus 1.2 in the control group ($p<0.05$)⁸⁹. Later, a study with IBS patients (including constipation-predominant) compared wheat bran (30 g daily) to partially hydrolyzed guar gum (PHGG) (5 g daily), with 60% finding success in the PHGG group versus 40% in the wheat bran group⁹⁰. In constipated women, both placebo and prebiotic inulin plus PHGG mixture resulted in increased weekly bowel movements, but with no significant differences⁹¹. When used in isolation for chronic constipation, PHGG use has shown to improve colonic transit time, from 57.28 ± 39.25 to 45.63 ± 37.27 h ($p=0.026$)⁹².

No study has evaluated PHGG versus placebo in children, although Üstünda et al. found PHGG and lactulose to be equally effective for stool frequency and consistency in a group of 61 constipated patient's ($p<0.05$)⁹³ (Table 13).

DISCUSSION

This review found that the role of fiber in the treatment of FC in children and adults is not well established. Previous data indicate that a lack of fiber may contribute to the etiology of chronic constipation in children⁹⁴.

TABLE 13. Clinical trials on guar gum for the treatment of functional constipation.

Author	Year published	Enrolled	Age (years)	Fiber type	Fiber dose	Comparator	Length of treatment	Findings
Rajala et al. ⁹⁰	1988	33	Elderly	Yogurt with lactitol, guar gum, or wheat bran	150 ml portion of yogurt twice daily	Control	2 weeks	50% of participants treated with fiber enriched yogurt experienced effective treatment, versus 25% in the control group
Parisi et al. ⁹¹	2002	188	Mean age was 40.3	Partially hydrolyzed guar gum	30 g of wheat bran, or 5 g of PHGG daily	Wheat bran	12 weeks	Both bran and PHGG consumption improved bowel habits
Waitzberg et al. ⁹²	2012	60	18-65	Inulin/PHGG mixture	15 g daily	Maltodextrin	3 weeks	Both groups experienced an increase in defecation frequency and patient satisfaction
Polymeros et al. ⁹³	2014	49	>18	Partially hydrolyzed guar gum	5 mg daily	No treatment	4 weeks	Partially hydrolyzed guar gum consumption increased defecation frequency, and accelerated colonic transit time
Üstünda et al. ⁹⁴	2010	68	4-16	Partially hydrolyzed guar gum	3-5 g daily	Lactulose	4 weeks	Partially hydrolyzed guar gum and lactulose were equally effective for relieving constipation-associated abdominal pain, and improving stool consistency

PHGG: partially hydrolyzed guar gum

Thus, it would appear that increasing fiber intake to the dietary recommended allowance could help prevent and treat FC, but a gap in data remains to definitively establish its benefit⁹⁵.

Kiwifruit seems to be the most extensively studied fruit for its dietary fiber content, though the clinical trials used both fresh fruit and the concentrated powders Zyactinase and Actazin. Although the majority of the trials found beneficial effects when compared with placebo, a trial comparing fresh kiwifruit to powder is warranted. Moreover, the most recent investigation by Weir et al.¹³ required a dosing regimen of six 360 mg capsules daily, which may not be realistic for children.

Adding the powder to other products, like applesauce, has not been explored in this setting.

Prunes, green banana, and papaya were shown to improve constipation symptoms with no adverse effects, but the limited amount of clinical trials makes it difficult to endorse these findings. In addition, mango appears to be a promising fruit given its richness in both fiber and polyphenols, which may decrease intestinal inflammation; however, only one study has shown it. Fig consumption may be beneficial for adults, but one study in children found red sugar to be equally effective. No studies explored the use of fiber-rich berries, such as blueberries, strawberries, blackberries, or raspberries. Finally, wheat bran appears to

be effective at low doses, although it increases stool bulk which can potentially cause adverse effects for children who are already prone to withholding.

This review also explored isolated fiber extracts or functional fibers. Glucomannan seems to be beneficial for FC treatment, although one negative study in children served as an outlier. In a double-blind, placebo-controlled, and randomized trial, Chmielewska et al. did not find that glucomannan is effective for the treatment of FC in children. Psyllium has been compared to other laxative agents, including lactulose, PEG, and docusate sodium, all with mixed findings. Given its mechanism of action, bulkier stools may not be desirable for the pediatric population. Polydextrose and cellulose are often added to cereals to enhance the fiber content, but it remains unknown if fiber additives have the same health benefits of natural fiber from whole grains. Orafit[®], a soluble prebiotic fiber, has been studied in adults and children. It appears to increase stool frequency, but perhaps no more than lactulose⁸¹. Guar gum may be the most promising fiber type, with the highest fiber content and ability to easily mix into juice or smoothies. However, guar gum is fermented to short chain fatty acids and can worsen GI symptoms, such as nausea, diarrhea, and flatulence.

There are several limitations to this review. Only clinical trials in English were searched; thus, many studies in other languages may have been excluded. Moreover, the degree of constipation is not uniform throughout the included studies, with varying definitions of constipation. Some of the studies used small doses, and it is not known if larger doses would have resulted in different outcomes.

Finally, outcome measures were not equivalent; some studies measured the frequency of defecation, while others measured discontinuation of laxatives.

General recommendations to “increase fiber intake through fruits, vegetables, and whole grain” are not sufficient. All of the fiber types influence the intestine differently. Although the evidence for the role of fiber in the treatment of FC in children and adults is not conclusive, physicians and dietitians should still encourage healthy eating habits. More research is needed to differentiate between the fibers and to personalize care to appropriately counsel both pediatric and adult patients.

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