

# A FODMAP Diet Update: Craze or Credible?



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**FODMAP is an acronym for Fermentable Oligosaccharides, Disaccharides, Monosaccharides, and Polyols. The term was first made popular in the early 2000's when Dr. Peter Gibson and Dr. Sue Shepherd created the FODMAP diet, an elimination diet which attempts to improve symptoms in functional gastrointestinal disorders. FODMAPs are osmotically active and ferment rapidly, thereby causing gastrointestinal symptoms in some individuals. Currently there are no official published guidelines recommending specific dietary treatment of functional gastrointestinal disorders, but multiple studies have looked into this topic and there is increasing evidence suggesting that this diet benefits certain patients. The purpose of this article is to help understand the FODMAP diet, its underlying concept, review some of the latest evidence behind the diet, and explain how this diet might be used.**

## INTRODUCTION

The FODMAP diet has been around since 2001, but only now does it have the evidence it needs to become more widespread in clinical practice. The diet is based on the idea that fermentable carbohydrates worsen symptoms of functional gastrointestinal disorders (FGID), most noticeably Irritable Bowel Syndrome (IBS). FGID affect about 15% of the world's population and are a difficult group of conditions to treat.<sup>1</sup> As the name implies, the cause of symptoms is related to altered function of the gut and the enteric nervous system rather than an anatomical abnormality. The American College of Gastroenterology has published guidelines regarding treatments of these disorders, but there is

little evidence supporting specific diet therapy of these conditions. Initially it was thought that food intolerance was responsible for most symptoms in patients with IBS, but there are now 3 main proposed mechanisms by which FODMAPS worsen symptoms in FGID.<sup>2</sup> Certain foods may induce functional gut symptoms via immune-mediated/mast cell pathways (food hypersensitivity), via direct action of bioactive molecules, and/or via luminal distension.<sup>3</sup> In order to understand the concept behind the FODMAP diet, one must first understand the process of carbohydrate absorption in the gastrointestinal (GI) tract and what makes up the FODMAP components.

## Carbohydrate Absorption

Carbohydrate absorption takes place in the small intestine. Here the carbohydrates undergo hydrolysis by luminal and brush border hydrolyses to monosaccharides: glucose, galactose, and fructose.<sup>4</sup> These molecules are

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then transported across the epithelium. There are 3 main transporters involved in this process (see Figure 1):

1. SGLT1 is the sodium/glucose-galactose co-transporter that is present in the apical membrane of the small intestinal epithelium.<sup>6</sup> When luminal concentrations of glucose are low, SGLT1 can transport glucose and galactose against a concentration gradient.
2. GLUT5 is a facultative transporter that is specific to fructose.<sup>7</sup> This transporter is found in the apical membrane along the length of the small intestine.
3. GLUT2 is a low affinity facultative transporter that will carry glucose, fructose, and galactose.<sup>8</sup> Unlike GLUT5, GLUT2 is present on the basolateral membrane and it transports hexoses down a concentration gradient out of the cell. This transporter is inserted into the apical membrane when SGLT1 transports glucose. It allows for a high capacity, low affinity pathway for absorption of glucose, galactose, and fructose. The glucose uptake with this transporter activates a system that can efficiently take up all hexoses. This is a diffusional pathway that explains why fructose uptake is increased by glucose and sucrose. This mechanism appears to be highly adaptive to wide variations of luminal glucose concentrations and ensures maximal nutrient utilization proximally in order to protect distal regions of the intestine from the presence of hexoses.<sup>9</sup>

Symptoms of FGID can result from the malabsorption of fructose and sucrose that occurs when the activity of one of these transporters is altered. As stated above, fructose absorption is highly dependent on GLUT 5 activity, and GLUT 5 expression appears to be influenced by dietary fructose and sucrose load.<sup>10</sup> GLUT 2 expression can be inhibited by stress, glucocorticosteroids, or a diet with a low glycemic index. When the small intestine is unable to absorb fructose, it is transported into the large intestine where it is fermented by colonic flora. During fermentation, hydrogen, carbon dioxide, short-chain fatty acids, and other trace gases are produced, which are thought to lead to symptoms of bloating. The delivery of fructose to the distal small bowel and colon also exerts an osmotic

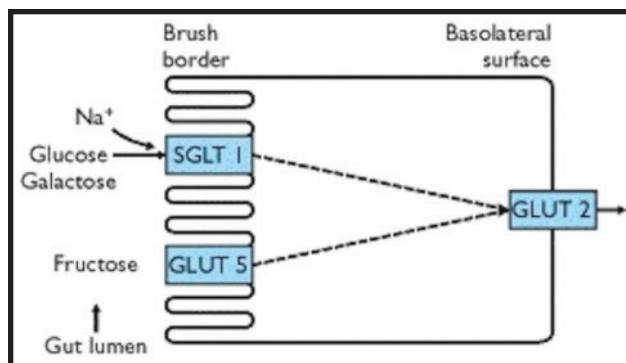


Figure 1. Monosaccharide Absorption<sup>5</sup>

effect causing an increased resorption of water from the gut mucosa into the lumen. This increased water accelerates gut motility, and can cause the symptom of diarrhea.

## Oligosaccharides

An oligosaccharide is simply a carbohydrate whose molecules are composed of a relatively small number of monosaccharide units. For example, chains of fructose with one glucose molecule on the end are oligosaccharides known as fructans. The small intestine lacks hydrolase capable of breaking fructose-fructose bonds; therefore, fructans are not transported across the epithelium or absorbed at all. Studies have shown that 50-90% of ingested fructans can be recovered from stool output of patients with an ileostomy.<sup>11</sup> Wheat is a major source of fructans in the diet, which means most breads, pasta, and pastries contain large amounts of fructans (see Table 1). Other sources are vegetables such as onions, garlic, and artichokes. Galactans are chains of galactose with one fructose molecule on the end and act similarly to fructans. Foods rich in galactans are legumes (soy, beans, chickpeas, lentils), cabbage, and brussels sprouts.<sup>12</sup>

## Disaccharides and Monosaccharides

Fructose exists as a monosaccharide (free fructose) or a disaccharide (sucrose). Fructose is absorbed directly from the small intestine. When ingested as sucrose the molecule is cleaved to one glucose unit and one fructose unit by sucrase, which is then absorbed into the bloodstream. The capacity at which fructose is absorbed ranges from about 15-50g per day with greatest absorption occurring when glucose and fructose are administered in equal quantities.<sup>13</sup> This is because fructose exists with glucose in a 1:1 ratio. The

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Table 1: Food Sources of FODMAPS<sup>12</sup>

| FODMAP                     | Oligosaccharides  | Disaccharides (lactose)   | Monosaccharides (fructose)  | Polyols   |
|----------------------------|---|---|---|---|
| <b>High FODMAP Content</b> | <ul style="list-style-type: none"> <li>• Artichokes</li> <li>• Asparagus</li> <li>• Broccoli</li> <li>• Cabbage</li> <li>• Onions</li> <li>• Peas</li> <li>• Wheat &amp; rye</li> <li>• Chickpeas</li> <li>• Watermelon</li> <li>• White peaches</li> </ul> | <ul style="list-style-type: none"> <li>• Cow, sheep, and goat milk</li> <li>• Ricotta and Cottage cheese</li> <li>• Yogurt</li> <li>• Ice Cream</li> </ul>        | <ul style="list-style-type: none"> <li>• Apples</li> <li>• Pears</li> <li>• Mango</li> <li>• Peaches</li> <li>• Honey</li> <li>• High fructose corn syrup</li> </ul>  | <ul style="list-style-type: none"> <li>• Cherries</li> <li>• Plums</li> <li>• Prunes</li> <li>• Avocado</li> <li>• Mushrooms</li> <li>• Cauliflower</li> <li>• Sorbitol</li> </ul>              |
| <b>Low FODMAP Content</b>  | <ul style="list-style-type: none"> <li>• Carrot</li> <li>• Celery</li> <li>• Eggplant</li> <li>• Green beans</li> <li>• Lettuce</li> <li>• Tomato</li> <li>• Gluten free cereals/breads</li> </ul>  | <ul style="list-style-type: none"> <li>• Lactose free and rice milk</li> <li>• Brie cheese</li> <li>• Lactose free yogurt</li> <li>• Sorbet and gelato</li> </ul> | <ul style="list-style-type: none"> <li>• Banana</li> <li>• Blueberry</li> <li>• Grapefruit</li> <li>• Grape</li> <li>• Honeydew melon</li> <li>• Orange</li> <li>• Strawberry</li> <li>• Maple syrup</li> </ul> | <ul style="list-style-type: none"> <li>• Lemon</li> <li>• Lime</li> <li>• Orange</li> <li>• Raspberry</li> <li>• Sugar</li> <li>• Glucose</li> <li>• sucralose, saccharin, aspartame</li> </ul> |

facultative transporter GLUT5 is present throughout the small intestine and takes up free fructose. When present with glucose, fructose is taken up more efficiently due to the insertion of GLUT-2 into the apical membrane of the enterocyte. Therefore malabsorption of fructose occurs when fructose is present in excess of glucose. Some foods rich in fructose are honey, prunes, dates, apples, pears, and papaya (see Table 1). It is also often added to commercial foods and drinks as high fructose corn syrup. Disaccharides such as lactose are found in dairy products, but may also be found in most beers or prepared soups and sauces.<sup>12</sup>

**Polyols**

Sorbitol is the most common polyol in the diet. Unlike some others in the FODMAP group, the absorption of polyols are not accelerated by co-ingestion with glucose. A few studies have found that sorbitol and fructose ingested together cause worsening IBS symptoms.<sup>14</sup> Most artificial sweeteners contain polyols such as mannitol, xylitol, or sorbitol (see Table 1). Interestingly, symptoms from polyols not only come

from foods, but also other ingested substances such as toothpastes, mints, sugar-free chewing gum, and many liquid cough/cold and pain relief preparations. Patients with small bowel bacterial overgrowth appear to be even more sensitive to polyol containing foods.<sup>14</sup>

**Evidence Behind the Diet**

Before examining the evidence, it is important to understand that high level, large study evidence in support of therapeutic dietary intervention is hard to come by because of the complexity of the diet and the difficulty in making changes to ones dietary routine. Dietary studies cannot be compared with the same objectives used in analyzing pharmacologic therapy. In the last few years there have been more studies supporting the ideas behind the FODMAP diet, as well as evaluating carbohydrate malabsorption and its clinical role in the symptoms of FGID.

Early studies of dietary therapy in FGID seemed to focus mainly on fructose restriction or lactose restriction rather than global FODMAP restriction. A

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pilot study then showed a low FODMAP diet led to sustained improvement in all gut symptoms in 77% of 62 patients with IBS and fructose malabsorption.<sup>15</sup> There were no placebo-controlled trials evaluating this subject until 2008. At that time Shepherd et al studied 25 patients with IBS in a double-blinded, randomized, quadruple arm, placebo-controlled rechallenge trial.<sup>16</sup> The aim of this study was to determine whether dietary restriction was the likely mechanism for symptomatic benefit as well as to define whether the efficacy resided in the restriction of free fructose specifically, or whether it reflected a restriction of poorly absorbed, short-chain carbohydrates in general. The study used test substances (fructose, fructans, glucose) in different phases on patients who were already on a diet low in FODMAPS. Seventy-seven percent of patients who received fructose and fructans and 79% receiving a mixture of fructose, fructans, and glucose reported their symptoms were not adequately controlled; however, only 14% of patients who received just glucose reported that symptoms were not controlled ( $p < 0.002$ ).<sup>16</sup> This study served as the first high-level evidence that dietary FODMAPS are triggers for symptoms in patients with IBS and that dietary avoidance of FODMAPS can lead to symptomatic improvement.

In 2010, Barrett and colleagues published the first randomized controlled trial which demonstrated that global FODMAP ingestion leads to increased water and substrate delivery using the ileostomy model, a well-established technique used to study digestion and absorption of carbohydrates.<sup>17</sup> Ileostomates were studied under controlled dietary intake to define the effect of FODMAPs on the nature and volume of ileal effluent and to document the perceived changes in the quality and quantity of the output. The study was a randomized, single blinded, crossover intervention study of 12 subjects involving diets that differed greatly in FODMAP content. High FODMAP content increased effluent collection weight by a mean of 22%, water content by 20%, and dry weight by 24% when compared to the low FODMAP diet arm.<sup>17</sup> Output increased by 95mL and subjects perceived effluent consistency was thicker with the low FODMAP diet than with the high FODMAP diet. Although the number of study subjects was small, the results were significant and support the theory of FODMAPs increasing delivery of water and fermentable substrates to the proximal colon.

Also in 2010, Ong et al evaluated the FODMAP

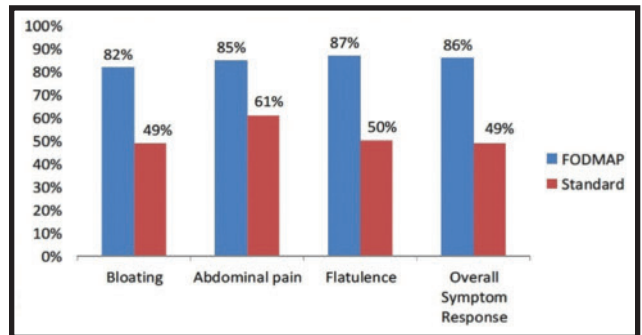


Figure 2. Low FODMAP Diet vs. Standard<sup>19</sup>

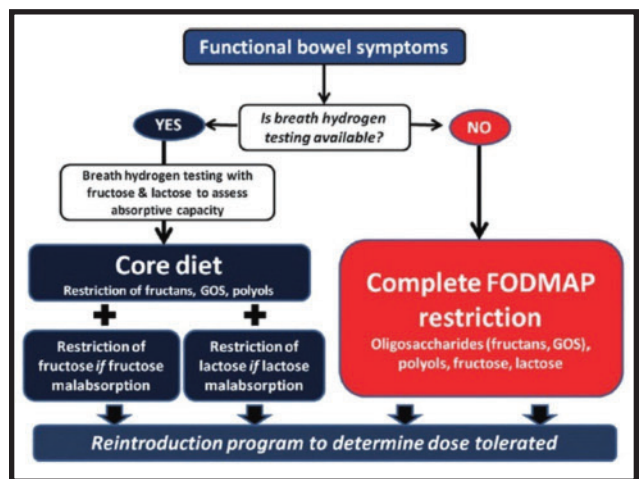


Figure 3. Diet Implementation<sup>25</sup>

diet and gas production in the intestine.<sup>18</sup> The aim of this study was to examine the effects of diets that varied in their FODMAP content on the production of hydrogen and methane in terms of amount and time course of production along with the relation to the induction of functional GI symptoms. Two groups of 15 patients were studied in this randomized, single-blinded, crossover intervention trial. Hydrogen breath testing was done every hour for 14 hours and subjects were asked to complete a GI symptom questionnaire every evening of the study. Higher levels of breath hydrogen were produced over the entire day with the high FODMAP diet for both healthy volunteers as well as patients with IBS. GI symptoms and lethargy were significantly induced by the high FODMAP diet in patients with IBS while healthy volunteers reported only increased flatus production. This study confirmed the previous hypothesis regarding GI symptoms due to luminal distension caused by increased gas production and offered mechanisms underlying the efficacy of the

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*(continued from page 42)***Table 2: Enteral Formula and FODMAP Content<sup>23</sup>**

| Formula                 | Estimated Content: Suspected | Estimated Content: Status | Measured Content: (g/day) | Measured Content: Present | Measured Content: Status |
|-------------------------|------------------------------|---------------------------|---------------------------|---------------------------|--------------------------|
| Nutrison 1.0            | -----                        | Low                       | 49.1                      | Fructan                   | High                     |
| Nutrison Multifibre 1.0 | Fructan                      | High                      | 59.6                      | Fructan                   | High                     |
| Peptamen OS 1.5 vanilla | -----                        | Low                       | 46.4                      | Fructan                   | High                     |
| Resource Protein coffee | -----                        | Low                       | 23.4                      | Fructan                   | High                     |

low FODMAP diet in patients with IBS.

Most recently, Staudacher and colleagues evaluated 82 patients who attended a follow up dietetic outpatient visit for IBS symptoms.<sup>19</sup> They found that more patients in the low FODMAP group reported satisfaction with their symptom response to the diet compared to the standard group. Statistically significant symptomatic improvement was seen with respect to bloating, abdominal pain, and flatulence (see Figure 2).

### Patient Populations Benefitting from a Low FODMAP Diet

The low FODMAP diet will benefit most patients with FGID. One study showed improvement of symptoms in 75% of patients.<sup>16</sup> The majority of patients with functional GI disorders complain that certain foods make their symptoms worse. A combined approach is likely to yield the greatest treatment success and improvement in symptoms. This article has focused on the use of the FODMAP diet in treating patients with FGID but there is also evidence that a low FODMAP diet may help symptoms in patients with IBD.<sup>20, 21, 22</sup> Other studies have been done using the FODMAP diet on patients with an ileostomy or ileal pouch to decrease high output.<sup>17</sup> Initial research is promising but more studies are needed in both of these areas before the diet will be routinely recommended for those conditions. Recent research has also linked enteral nutrition–associated diarrhea to the FODMAP content of the enteral formula; therefore, some patients may benefit

from low FODMAP enteral nutrition. Researchers at Monash University found that the liquid nutritional supplements are 3-7 times more concentrated in FODMAPs than an average Australian diet and this cannot be predicted by ingredient lists (see Table 2). Also reviewing enteral nutrition, an earlier study from the same institution retrospectively studied 160 patients to determine the source of developing diarrhea in hospitalized patients. The patient's length of stay and enteral nutrition duration were found to be independent predictors of developing diarrhea. Interestingly, starting an enteral nutrition formula with the lowest FODMAP content seemed to decrease the likelihood of diarrhea and this was statistically significant.<sup>24</sup>

### How Should the FODMAP Diet be Used?

The short answer to this question is easy, with a dietician's assistance. It is the physician's responsibility to accurately diagnose the patient with a FGID, order breath tests if available, and investigate any alarm symptoms that may be present. It is essential for primary care physicians and gastroenterologists to understand the science behind FODMAPS, carbohydrate digestion, and the role of the FODMAP diet; however, in clinical practice today, especially in the primary care setting, most physicians are unable to dedicate 20 to 30 minutes to educate patients regarding their nutrition needs. Teaming up with a local nutritionist is the key to treating these patients. Physicians must start the process, but

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specific education will be done in detail at the nutritionist visit. In general, the following approach, suggested by Dr. Gibson, can be implemented in initiating this diet (see Figure 3):

1. Hydrogen breath testing if readily available as this could potentially limit what foods need to be restricted.
2. Referral to a dietitian who is comfortable with the low FODMAP approach for examination of the patient's current diet to determine potential triggers, education regarding malabsorption, and education regarding portion control of fructose containing foods.
3. Complete FODMAP restriction for 6 weeks. This is an important concept behind the diet, understanding that an initial global restriction is indicated rather than avoiding only fructose or lactose containing foods.
4. A slow controlled reintroduction of FODMAPs to determine the level that will be tolerated.

## CONCLUSION

The above evidence indicates that the FODMAP diet provides an effective approach to managing patients with FGID. Drug therapy is often necessary as well, but long-term success is likely to take place only after the addition of dietary changes. More research is needed to determine the FODMAP content of all foods and to determine the legitimacy of applying a low FODMAP diet to patients with IBD. Many gastroenterologist and dietitians are now starting to apply this diet in clinical practice. The FODMAP diet may have once been a craze, but now with an increasing body of evidence behind it, is definitely a credible and valuable tool in the management of patients with FGID. ■

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