ETHICAL NUTRIENTS
PROFESSIONAL NATURAL MEDICINES

Low FODMAP Diet for Irritable Bowel Syndrome

WHAT ARE FODMAPS?

"FODMAP" is the acronym for Fermentable Oligosaccharides, Disaccharides, Monosaccharides and Polyols, a group of short-chain carbohydrates and sugar alcohols (polyols).[1] These nutrients are ubiquitous in the diet. The key FODMAPs are:

- Oligosaccharides, such as fructans/fructo-oligosaccharides (found in grains and vegetables) and galactans/galacto-oligosaccharides (found in legumes)
- Disaccharides, such as lactose (found in milk)
- Monosaccharides, such as fructose (found in fruit)
- Polyols, such as sorbitol (found in sweetened products)

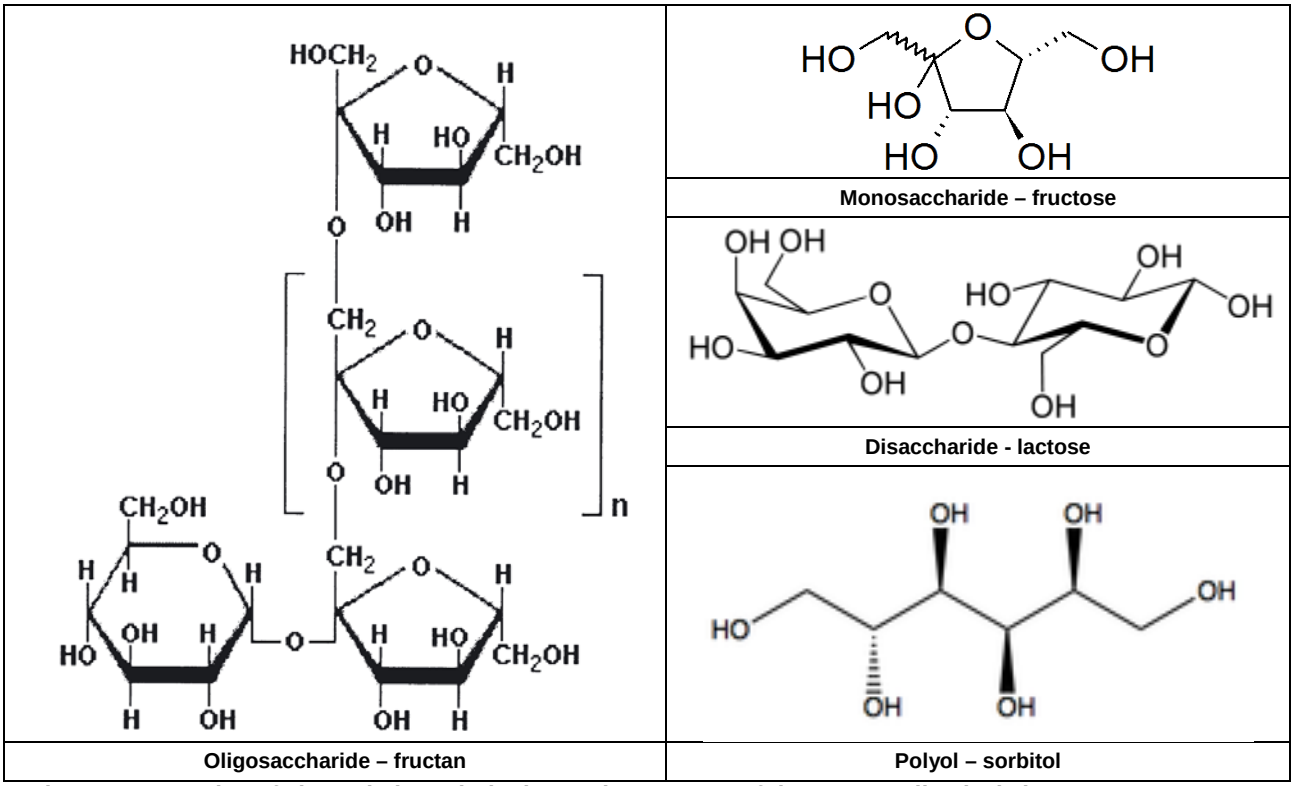

Figure 1. Examples of short-chain carbohydrates that are part of the group collectively known as FODMAPs.

Over the past three decades evidence has emerged that FODMAPs can play a role in the promotion of irritable bowel syndrome (IBS) symptoms.[2] The restriction of dietary FODMAPs has been shown to be beneficial in reducing the symptoms of IBS and there are emerging benefits of a low FODMAP diet to other functional gastrointestinal disorders and even neurological conditions.

WHAT EFFECT DO FODMAPS HAVE IN THE DIGESTIVE SYSTEM?

Although a seemingly diverse group of carbohydrates, FODMAPs share three common functional properties. These properties contribute to their benefits for health, such as their prebiotic effects, but can also render them problematic in *some* individuals.

- FODMAPs are poorly absorbed in the small intestine: Dietary carbohydrates that are in the form of two or more sugar moieties need to be broken down into their individual monosaccharides for absorption across the epithelium. Unlike other forms of carbohydrates (such as glucose), all the FODMAP molecules are generally poorly absorbed in humans. For example, fructose is only absorbed via a slow, low capacity transport mechanism (via GLUT5 receptors), whilst polyol molecules are too large for simple diffusion. Lactose is poorly cleaved into its two monosaccharides (galactose and glucose) as the hydrolase enzyme required for this reaction in the brush border of the small intestine exhibits a low activity. Oligosaccharides such as fructans and galactans are also difficult to cleave, as humans have low levels of the hydrolases for these particular carbohydrates. The normal gastrointestinal handling of

these carbohydrates means that they remain in the distal small and proximal large intestine for longer periods. In susceptible individuals, this can result in gastrointestinal symptoms.

- FODMAPs are osmotically-active molecules: The malabsorbed FODMAPs remaining in the intestine can draw water into the lumen via osmosis. This may promote altered bowel movements (such as diarrhoea), luminal distension (bloating) and subsequent gastrointestinal pain.
- FODMAPs are rapidly fermented by bacteria: Short chain carbohydrates, such as mono-, di- and oligosaccharides, are rapidly fermented by both commensal and dysbiotic bacteria residing in the intestine. Excessive fermentation can increase the production of gases such as hydrogen, carbon dioxide and methane, resulting in flatulence and bloating.[3]

Figure 2 illustrates the effects of FODMAP molecules and how they may contribute to the pathophysiology and symptomatology of IBS symptoms.

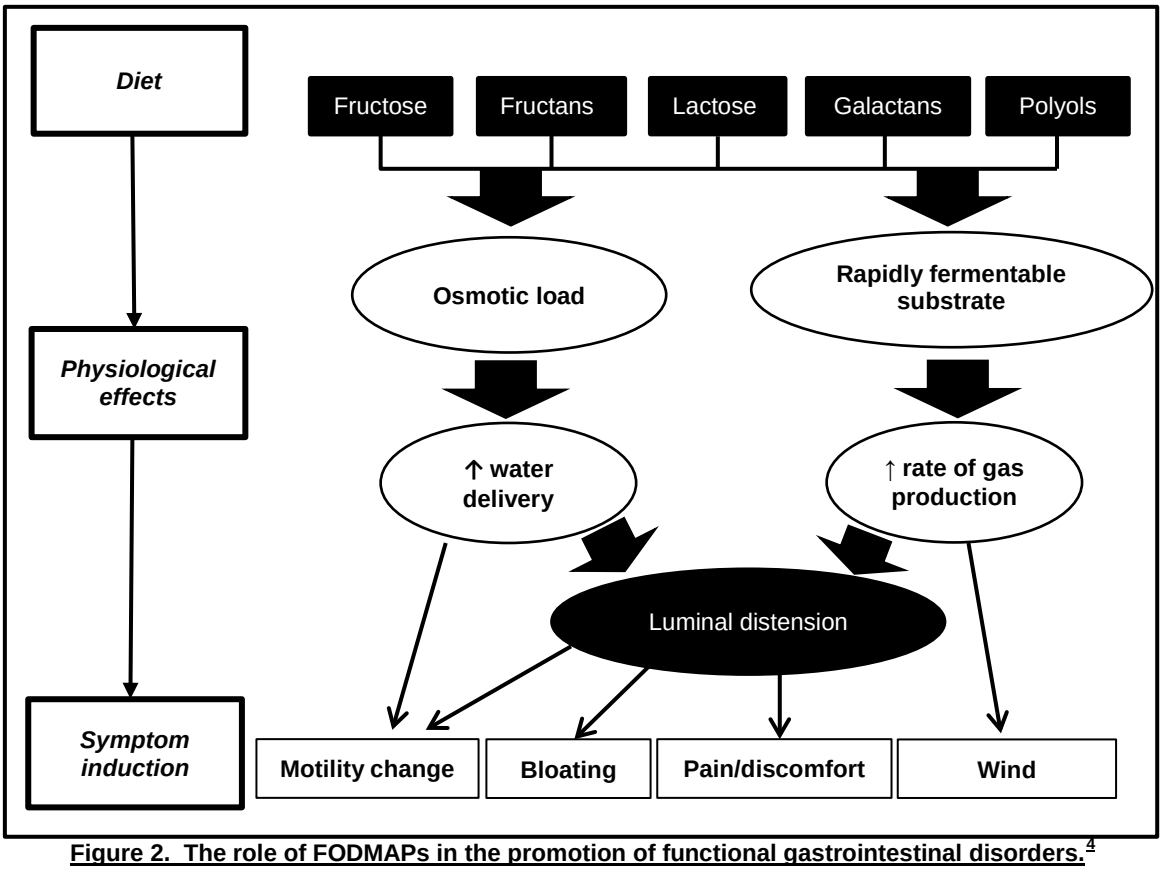

Figure 2. The role of FODMAPs in the promotion of functional gastrointestinal disorders.[4]

It is important to note that FODMAP-containing foods are a normal part of the diet, and do not cause symptoms in most individuals.[5] However, in individuals with functional gastrointestinal disorders, such as IBS, there may be a heightened activation of the enteric nervous system as a response to luminal distension. This can also be combined with altered resident microbiota (dysbiosis) and existing motility dysfunction, which can also be worsened by the presence of FODMAPs in the intestine.
For IBS sufferers, a low FODMAP diet may be more effective if it is combined with an appropriate probiotic supplement with proven clinical efficacy for the management of IBS symptoms, such as *Lactobacillus plantarum* 299V.[6,7]

NON-GIT CONDITIONS THAT MAY BENEFIT FROM A LOW FODMAP DIET

In addition to assisting in the management of functional gut disorders, preliminary evidence suggests that a low FODMAP diet may have a role to play in mood and neurological disorders.

Fructose and lactose malabsorption have both been associated with mild depression, and preliminary research has demonstrated the improvement of affective symptoms in depressed patients using a low fructose diet.[8,9] Another study found that subjects with fructose malabsorption showed significantly lower plasma tryptophan concentrations and higher depression scores compared to those with normal fructose

absorption. It is suggested that high intestinal fructose concentrations may promote the formation of fructose-L-tryptophan complexes in the gut, reducing tryptophan absorption. As tryptophan is the precursor of serotonin, biosynthesis of the "feel good" neurotransmitter serotonin could be impaired in this situation.[10]

Some clinicians are also trialling a low FODMAP diet in children with autistic spectrum disorder (ASD), as many of these patients have marked gastrointestinal symptoms and pathology.[11] Recently, a study found that compared to healthy children, children with ASD have deficiencies in the enzymes for disaccharide digestion and do not adequately break down and absorb disaccharides.[12] Additionally, ASD subjects have repeatedly been found to have a higher degree of intestinal dysbiosis, such as overgrowth of *Clostridia* spp and *Candida albicans.*[13] It is suggested that in ASD, undigested carbohydrates (i.e. FODMAPs) are rapidly fermented by dysbiotic organisms, producing proprionic acid (a short chain fatty acid) as a metabolite. Proprionic acid itself acts as a neurotoxin and induces autistic-like behaviour when administered in animals, highlighting its potential role in the promotion of autistic symptoms.[14]

HOW TO EAT A LOW FODMAP DIET

Professor Peter Gibson of the Monash University Department of Medicine, who coined the term FODMAPs and developed the diet, stresses the importance of reducing all types of FODMAPs simultaneously to determine the potential benefits of the diet for each individual.[15] The general principles to adhere to when following a low FODMAP diet are elimination or drastic reduction of all:

- High lactose foods (e.g. milk, yoghurt)
- High oligosaccharide foods (e.g. chickpeas, lentils)
- High fructose foods (e.g. certain fruits and honey)
- High fructan foods (e.g. wheat, onion)
- High polyol and polyol-sweetened foods (e.g. certain fruits and confectionery)

Table 1 gives a more detailed breakdown of foods in each FODMAP category that should be avoided. Where quantities are given, these foods should be avoided only above the given dose. It is recommended to strictly follow the low FODMAP diet for six weeks and then begin a reintroduction phase (described below).

Table 1: Foods to avoid for a low FODMAP diet[16, 17]

Fructose	• *Fruits:* apples, boysenberries, cherries (>3), figs, pears, nashi pears, peaches, mango, watermelon, tamarillo, tinned fruit, dried fruit, large serves of fruit • *Vegetables:* asparagus, artichokes, sugar snap peas • *Sweeteners:* honey, fructose (>5g daily*), high fructose corn syrup • *Drinks:* fruit juice, soft drinks sweetened with fructose, sparkling wine, dessert wine, ciders, rum *up to 5g daily of fructose may be consumed if taken with meals[18]
Fructans	• *Fruits:* custard apples, nectarines, peaches, persimmon, rambutan, tamarillo, watermelon • *Vegetables:* artichokes, asparagus (>3), beetroot (>4 slices), Brussel sprouts (>½ cup), broccoli (>½ cup), cabbage - savoy (>1 cup), chicory root, corn (>½ cob), fennel (>½ cup), garlic, leeks, okra, onions, peas (>1/3 cup), radicchio lettuce, snow peas (>10), spring onion (white part) • *Cereals:* wheat, rye, barley products (bread, pasta, couscous, crackers, biscuits) • *Nuts:* cashews, pistachios • *Fruits:* watermelon, custard apple, peaches, persimmon, pomegranates
Galactans	• *Legumes*: all (chickpeas, lentils, dried/canned beans, baked beans, soy beans) • *Drinks*: soy milk
Lactose	• *Milk:* cow, goat and sheep • *Cheese:* fresh (cottage, ricotta, cream cheese, mascarpone) • *Other dairy products:* yoghurt, ice cream, custard
Polyols	• *Fruits:* apples, apricots, avocado (>¼), blackberries, cherries (>3), longan (>10), lychees (>5), nashi pears, nectarines, pears, peaches, plums, prunes, watermelon • *Vegetables:* cauliflower, celery (>1 stick), mushrooms, snow peas, sweet potato (>½ cup) • *Sweeteners:* sorbitol (420), mannitol (421), xylitol (967), maltitol (965), isomalt (953)

Many alternative foods can be consumed whilst following a low FODMAP diet. Table 2 provides a list of suitable foods which can be enjoyed.

Table 2. Suggested alternative foods that can be consumed on a low FODMAP diet[19, 20.]

Fruit	Banana, blueberries, grapefruit, grapes, honeydew melon, kiwifruit, lemons, limes, mandarins, oranges, passionfruit, pawpaw, pineapple, raspberries, rock melon, tomatoes
Vegetables	Alfalfa, bamboo shoots, bean sprouts, bok choy, carrot, cabbage (common), capsicum, choko, choy sum, eggplant, green beans, lettuce, chives, parsnip, potato, pumpkin, radish, silver beet, spring onion (green only), squash, zucchini
Cereals	Gluten-free products, spelt, corn, oats, polenta, quinoa, rice
Nuts	(<1 handful daily) macadamias, peanuts, pecans, pine nuts, pumpkin seeds, sesame seeds, sunflower seeds, walnuts
Milk products	*Milk:* lactose-free cows' milk, rice milk *Cheese:* most, e.g., brie, camembert, cheddar, fetta *Other dairy products:* butter, yoghurt (lactose-free), dairy free gelati, sorbet
Sweeteners	Sugar (sucrose), glucose, maple syrup, golden syrup, stevia, sucralose
Meat and protein	Meat, poultry, eggs, tofu, tempeh

REINTRODUCING FODMAP-CONTAINING FOODS

It is not generally recommended that people follow a low FODMAP diet for life; restricting dietary intake of a wide array of foods should generally be avoided if possible to reduce the risk of nutrient deficiencies. As discussed, FODMAPs are a normal part of the diet and have benefits for health, such as providing fibre and prebiotics for gastrointestinal health.

A low FODMAP diet can be used in a similar fashion to other food elimination/rechallenge programs. That is, strict adherence to the diet for a period of time should be followed by systematic reintroduction of food groups one-by-one, to identify which foods can be tolerated in modest amounts. A suggested protocol is as follows.

Elimination phase

In the elimination phase, a person should follow the low FODMAP diet with strict elimination of all high-FODMAP foods for at least 6 weeks. Relevant symptoms should be monitored and recorded on a daily basis, to track any benefits from the dietary program. IBS sufferers should also take 20 billion CFU/day of *Lactobacillus plantarum 299v*. A significant reduction in IBS symptoms would usually be expected within 1-6 weeks.

Note: If there are no improvements in symptoms after the complete avoidance of all FODMAPs for 6 weeks, it is suggested that the person seeks advice from a health care practitioner to investigate other causes of their symptoms.

Reintroduction phase

The reintroduction phase may be commenced after at least six weeks or more in the elimination phase, when some resolution of symptoms has been achieved. The goal is to systematically reintroduce each FODMAP to determine the level of individual FODMAP consumption that a person can comfortably tolerate. Researchers and dieticians working in the field of FODMAPs agree that the reintroduction phase is an important component of the program to develop an eating plan that maximises variety and health.[21, 22]

A five week program for the reintroduction phase is outlined in Table 3. Each week a carbohydrate type is trialled, which includes three doses of the FODMAP-containing food, separated by a symptom monitoring day between each dose. FODMAP reactivity is dose dependent, and due to individual variability in tolerance, some people may be able to tolerate all three doses, while others may react after only the first dose.[23] For some individuals with particularly low or high tolerances, the serving sizes below can be adjusted to better define tolerance levels.

If symptoms are experienced following a challenge, these should be allowed to resolve before the next challenge is commenced. It is recommended to continue to avoid all FODMAPs (with the exception of the food being tested) for the duration of the five week reintroduction phase, even if a particular FODMAP appears to be well tolerated. This is to ensure that there are no residual additive effects of any other FODMAP class on the one being tested.

Table 3. The reintroduction phase of the low FODMAP diet[24]

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 1. Mannitol and sorbitol (polyols)	½ cup of mushrooms, 4 dried apricots and monitor symptoms	Monitor symptoms	½ cup of mushrooms, 4 dried apricots and monitor symptoms	Monitor symptoms	½ cup of mushrooms, 4 dried apricots and monitor symptoms	Monitor symptoms	Monitor symptoms
Week 2. Lactose (disaccharide)	250mL of milk or 200g of yogurt and monitor symptoms	Monitor symptoms	250mL of milk or 200g of yogurt and monitor symptoms	Monitor symptoms	250mL of milk or 200g of yogurt and monitor symptoms	Monitor symptoms	Monitor symptoms
Week 3. Fructose (monosaccharide)	2 tsp of honey and monitor symptoms	Monitor symptoms	2 tsp of honey and monitor symptoms	Monitor symptoms	2 tsp of honey and monitor symptoms	Monitor symptoms	Monitor symptoms
Week 4. Fructans (oligosaccharide)	2 slices of wholemeal wheat bread and monitor symptoms	Monitor symptoms	2 slices of wholemeal wheat bread and monitor symptoms	Monitor symptoms	2 slices of wholemeal wheat bread and monitor symptoms	Monitor symptoms	Monitor symptoms
Week 5. Galactans (oligosaccharide)	½ cup of lentils or legumes and monitor symptoms	Monitor symptoms	½ cup of lentils or legumes and monitor symptoms	Monitor symptoms	½ cup of lentils or legumes and monitor symptoms	Monitor symptoms	Monitor symptoms

Trial diet phase

After the five week trial, it is recommended to consume all the well-tolerated FODMAP classes at intended dietary levels for one week to determine the tolerance of the FODMAP combination. Symptoms should continue to be monitored closely during this trial week. If there is a return of symptoms then it is recommended to eliminate these FODMAP groups again until symptoms resolve. The combination of FODMAPs should then be reintroduced at a lower dose.

Maintenance phase

If specific FODMAP intolerances are identified during the re-introduction phase, it is recommended to continue to avoid or significantly restrict the problematic FODMAPs in the general diet. Table 1 provides a list of the foods grouped by FODMAP type to be used as a reference for continued avoidance.

Otherwise, once the six week reintroduction phase is complete, the person can integrate back into their diet the FODMAP groups deemed to be well tolerated, at the relevant dose. If symptoms remain controlled, the individual may wish to consider testing their tolerance at higher doses or frequencies of consumption.

RESEARCH AND SCIENTIFIC EVIDENCE

In 2006, Gibson and Shepherd published the first research trial of a low FODMAP diet for patients with IBS. 62 IBS sufferers demonstrating fructose malabsorption with hydrogen breath testing were provided with dietary guidance to avoid fructose and fructans. The IBS symptoms of each participant were recorded via telephone interview 2 to 40 months later (median duration 14 months) and response was measured by subjective self-assessment using a scale of -10 to +10; where 0 = pre-treatment symptoms, 10 = complete improvement and -10 = complete worsening. An improvement in symptoms by five points was classified as a response. The results found that 74% of all patients improved in all abdominal symptoms and further analysis found those who adhered most completely (77% of participants) had a significantly greater responses than those who were less compliant (see Figure 3).[25]

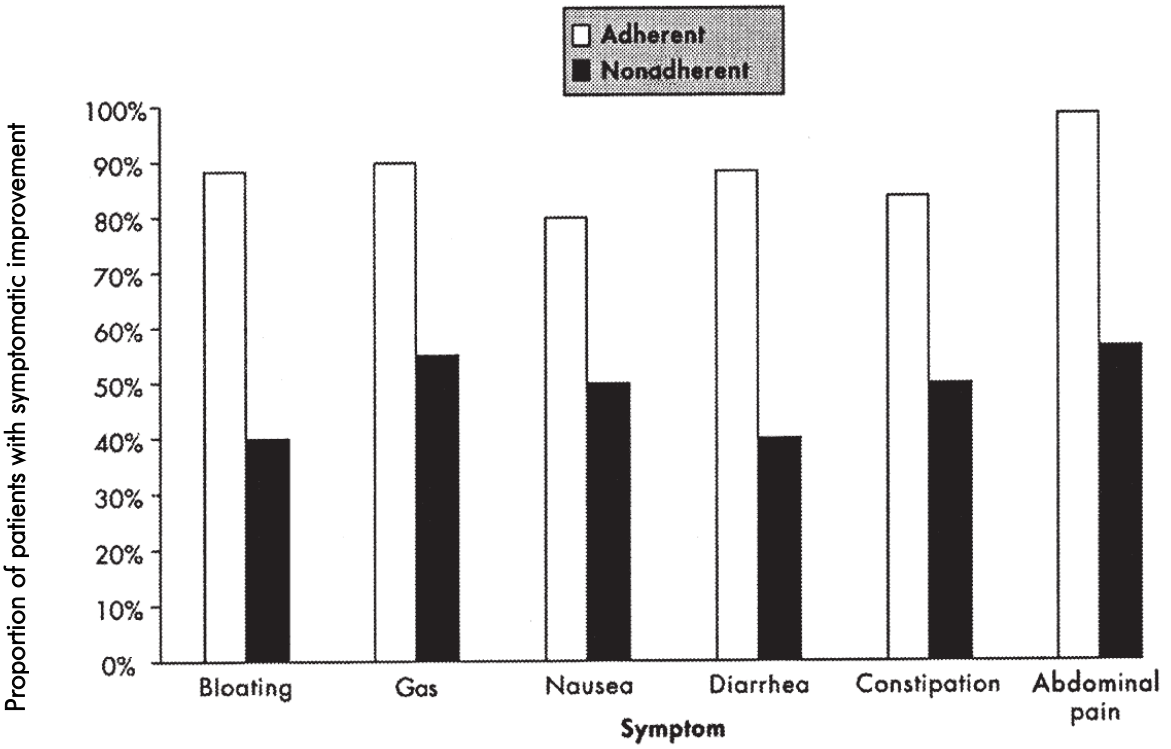

Figure 3. Proportion of IBS patients who achieved marked improvement in symptoms according to their compliance with a low fructose and fructan diet[26]

In 2008 Shepherd, Gibson and colleagues performed another dietary intervention study on IBS patients to show a causal relationship between FODMAP ingestion and IBS symptom exacerbation. 26 IBS patients followed a low FODMAP diet for at least three months with all but one participant achieving improvement in IBS symptoms. The 25 responders were then randomly challenged in a cross-over manner with various doses of fructose, fructans, a combination of both, or glucose with a washout period of 10 days between administration of the test drinks. Gastrointestinal symptoms were recorded daily via a symptom diary. The result found that either alone or in combination with each other, fructose and fructan administration elicited marked symptoms compared to glucose administration (Figure 4). The symptoms were experienced in a dose-dependent manner and mimicked the patients' previous IBS symptoms. These results demonstrated that a low FODMAP diet was effective in reducing symptoms in IBS patients, and that the reintroduction of FODMAP carbohydrates can induce IBS-like symptoms.[27]

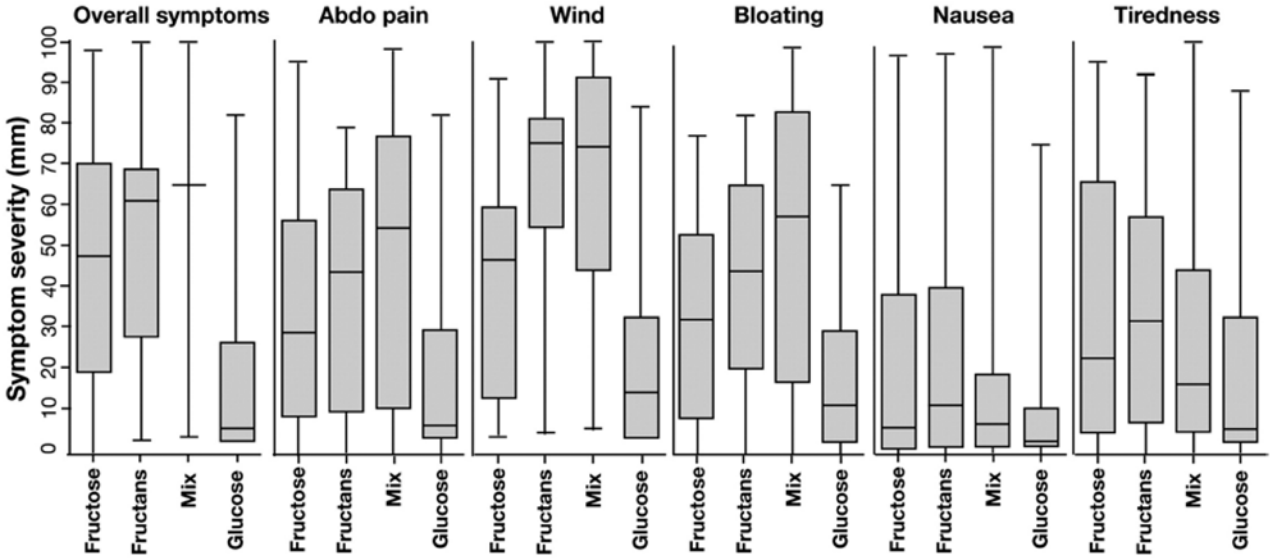

Figure 4. Severity of symptoms in IBS patients following a low FODMAP diet when rechallenged with fructose, fructans, a mix of fructose and fructans, or glucose[28]

A recent study in UK residents with IBS also demonstrated a low FODMAP diet is beneficial in the management of the symptoms of IBS. In this trial, 82 IBS subjects were randomly allocated to follow a low FODMAP diet (i.e. restriction of all FODMAPs) or the standard dietary advice for IBS based on the UK National Institute for Health and Clinical Excellence (NICE) guidelines. At the end of the nine month trial period, those who were given the low FODMAP diet exhibited significantly greater improvement in overall symptoms compared to those given the standard diet ($p<0.001$). Particular symptoms which were significantly improved were bloating, pain, wind and nausea compared to the control group (Figure 5).[29]

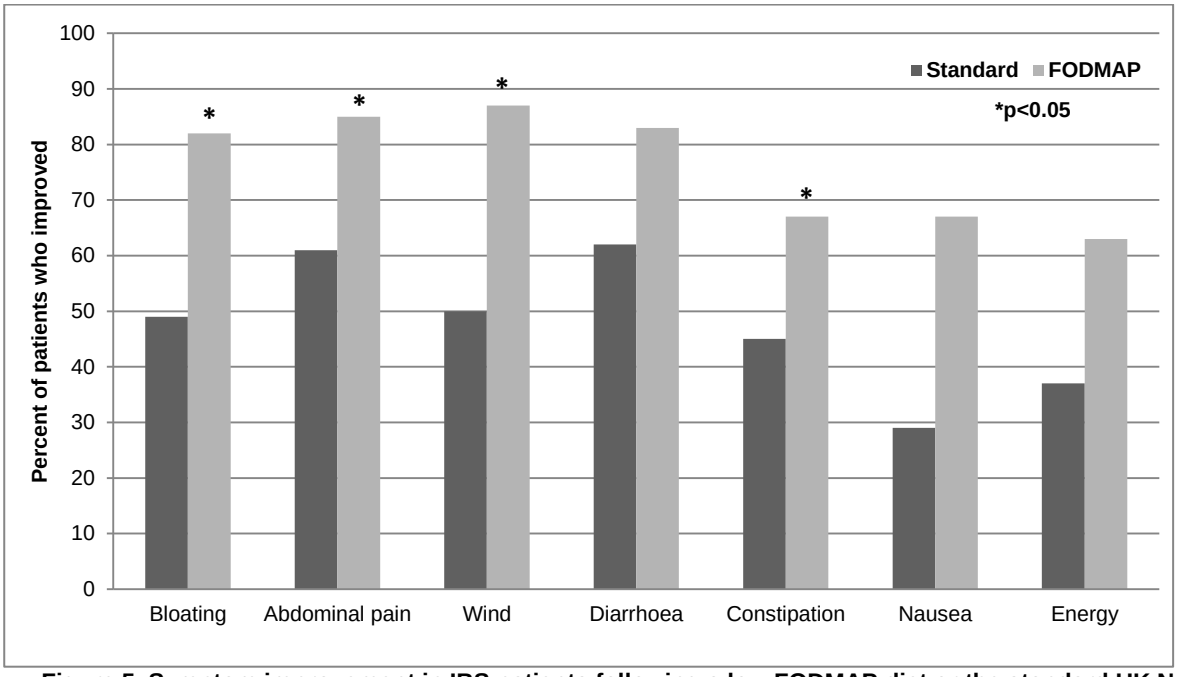

Figure 5. Symptom improvement in IBS patients following a low FODMAP diet or the standard UK National Institute for Health and Clinical Excellence dietary guidelines for IBS[30]

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