REVIEW ARTICLE

Popular diets and nutritional assessment in the management of irritable bowel syndrome in inflammatory bowel disease: an overview of current evidence

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ABSTRACT

There is an increasing interest in using popular diets to manage inflammatory bowel diseases (IBDs), such as ulcerative colitis and Crohn disease. These conditions are often associated with nutritional deficiencies, protein-energy malnutrition, micronutrient malnutrition, altered body composition, and sarcopenia. While dietary interventions can be supportive in treating intestinal symptoms of adult IBD patients, it is important to note that current guidelines from major scientific societies do not recommend any specific dietary interventions in this field. This review aims to provide a summary of the current evidence on dietary-nutritional management for patients with IBD, specifically when the disease appears to be in remission, but the patient continues to experience irritable bowel syndrome (IBS) symptoms or functional gastrointestinal symptoms. We focus on vital aspects, such as malnutrition and sarcopenia definitions, screening, and nutritional assessment. We then discuss in detail the most popular diets used for IBD management over the years, characterizing each one in terms of effects on gut inflammation, IBS-like symptoms, and potential risk of malnutrition. These diets include a low-fermentable oligosaccharides, disaccharides, monosaccharides, and polyols diet, a gluten-free diet, a Mediterranean diet, and a plant-based diet. To date, current evidence does not conclusively establish the optimal diet for patients with IBS, suggesting that personalized dietary approaches may be the best strategy.

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Introduction Inflammatory bowel diseases (IBDs), such as Crohn disease (CD) and ulcerative colitis (UC), are inflammatory conditions affecting the gastrointestinal system. The exact causes of these diseases are not fully understood, but research suggests that they result from an abnormal immune response to gut microbes in genetically susceptible individuals, possibly triggered by environmental factors.[1] CD can affect any segment of the gastrointestinal tract with transmural involvement, whereas UC typically involves the mucosa and submucosa of the colon tract.[2]

Over the last few decades, the prevalence of IBD has been increasing in many regions around the world. In Poland, nationwide data from 2009 to 2020 confirm a significant rise in the disease burden.[3]

These conditions have been demonstrated to be associated with nutritional deficiencies and metabolic changes, mainly due to chronic inflammation. Malabsorption with increased intestinal protein loss and decreased dietary intake represent the main factors related to malnutrition in IBD patients.[4]

Malnutrition is a serious condition that can have adverse clinical outcomes.[5] The World Health

Organization defines malnutrition as a deficiency, excess, or imbalance in the intake of energy and/or nutrients, leading to altered body composition and cell mass.[6] Malnutrition can cause sarcopenia, which is a condition characterized by a decrease in skeletal muscle mass, strength, and function. Sarcopenia is associated with an increased risk of mortality and diminished well-being.[7] Malnutrition can express itself as caloric-protein and micronutrient malnutrition, and is associated with very poor quality of life, low response to therapy, and, therefore, clinical outcomes in IBD patients.[8]

It is important to note that some patients in remission may still experience gastrointestinal symptoms that are often attributed to irritable bowel syndrome (IBS) by their health care provider. According to a recent meta-analysis, this condition affects almost 40% of the IBD patients, which is significantly more than in healthy individuals, even when the patients are in remission.[9] Managing the symptoms and related malnutrition can be challenging, but understanding dietary habits of the patients can make a significant difference. By implementing a tailored dietary regimen, the patients can better manage their symptoms and improve their health. Therefore, it is crucial to consider specific dietary needs of each patient in order to provide them with comprehensive care.[10] Studies show that eating well is important for IBD patients. As many as 90.4% of them believe that a balanced diet is essential to control IBD, and 86.2% think that a more individualized diet could reduce their symptoms.[11] Another study shows that 86% of IBD patients strictly follow diets also in remission phase, which leads to malnutrition and micronutrient deficiency.[12]

The purpose of this review is to provide an overview of the dietary and nutritional management of IBD patients who appear to be in remission but continue to experience IBS-like or functional gastrointestinal symptoms. We will discuss important topics, such as definitions of malnutrition and sarcopenia, nutritional screening and assessment, and popular diets that have been attempted for IBD over the years. We will also characterize each diet, analyze their effects on gut inflammation and IBS-like symptoms, and determine which diets pose a risk in terms of malnutrition.

Determinants of malnutrition and characterization of sarcopenia in inflammatory bowel disease Malnutrition in IBD is characterized by protein-energy malnutrition (PEM), altered body composition, and micronutrient deficiency, and it can be determined by multiple factors[8] influenced by the nature and severity of the disease.

A decrease in oral food intake is one of the most important reasons for malnutrition in patients with IBD.[13] When there is chronic inflammation, proinflammatory cytokines are produced and that can result in anorexia.[4] Proinflammatory cytokines are also linked to an increase in the prevalence of chronic fatigue and breakdown of muscle proteins, causing muscle atrophy.[14] Moreover, circulating appetite regulators, such as gastric mediators (leptin and ghrelin) may regulate the anorexic process. Additionally, other symptoms and comorbidities, such as interleukin (IL)-6–induced depression,[15] may result in decreased nutrient intake, elevated resting energy expenditure, suppression of anabolic hormones (such as growth hormone, insulin-like growth factor 1, and testosterone), or even hormonal factor resistance.[16] This condition involves a reduction in appetite and therefore poor oral intake of nutrients.[13] Nausea, vomiting, abdominal pain, and diarrhea contribute to the loss of appetite.[8]

Malabsorption is the second determinant of malnutrition. It is especially common in patients with CD and small intestine involvement, as well as in those with UC. The same proinflammatory cytokines mentioned earlier, which are released by immune cells in the intestinal mucosa during active and remission phases, cause changes in the epithelium, such as altered ion transport and a loss of epithelial integrity. This results in electrolyte, water, and protein loss leading to nutrient malabsorption and, in the active phase of the disease, inflammatory diarrhea.[17] Additional causes of malabsorption include consequences of surgeries such as ileal, ileocecal, and colic resection. Bile acid malabsorption following ileal resection can lead to bile salt diarrhea.[18] Other conditions causing malabsorption include infections, for example, with *Clostridioides difficile* and bacterial overgrowth conditions.[19]

Other determinants of malnutrition include high energy expenditure in IBD patients with body weight below 90% of ideal body weight or prolonged use of drugs such as glucocorticoids, which can interfere with absorption and utilization of calcium, phosphorus, and zinc, and are associated with bone changes and osteoporosis.[16]

Sarcopenia can be defined as a muscle disease characterized by adverse muscle changes that accumulate over time. A diagnosis of sarcopenia is based on low levels of muscle strength and muscle quantity/quality.[20]

Thus, when malnutrition progresses into a generalized loss of muscle mass and function, a condition of sarcopenia is likely to develop. However, in IBD patients, sarcopenia may be also caused by some other etiopathogenetic mechanisms that are described below.

Up to 50% of IBD patients suffer from sarcopenia,[21] resulting in a decrease in muscle mass of up to 60%, as compared with healthy individuals.[22] Sarcopenia correlates with increased frequency of hospitalization, surgery, postoperative complications, and IBD severity, predicting adverse outcomes.[23]

There are several mechanisms of sarcopenia development, one of which is due to prolonged PEM leading to a gradual decline in muscle mass. In individuals with IBD, the incidence of PEM ranges from 36.7% to 65%, and its severity and type

depend on the geographic extent, activity, and duration of the disease.[22] Micronutrient malnutrition can also contribute to the development of sarcopenia, as in the case of vitamin D deficiency discussed in further sections of this review.

The muscle-gut axis is another mechanism that contributes to the development of sarcopenia. Gut microbiota plays a crucial role in controlling lean mass and can cause low-grade inflammation, which alters the immune response and host metabolism. This, in turn, upregulates several molecular pathways that are related to sarcopenia.[24,25] Expression of mitochondrial proteins that are involved in energy production and control of the inflammatory cascade activation is positively associated with short-chain fatty acids (SCFAs) produced by gut bacteria. IBD patients often have lower levels of bacteria that ferment fibers and generate SCFAs, which can lead to lower SCFA production and chronic subclinical inflammation. This inflammation can then strengthen the anabolic resistance of skeletal muscles.[22]

Sarcopenia also correlates with a degree of systemic inflammation and serum levels of tumor necrosis factor α (TNF-α). TNF-α stimulates synthesis of proteases, which can cause apoptosis of intestinal epithelial cells and increase degradation of muscle proteins.[26]

Nutritional screening and assessment Nutritional screening and nutritional assessment are 2 components of malnutrition and sarcopenia examination in IBD patients.[27]

Nutritional screening, using questionnaires and clinical history, is useful to evaluate the risk of malnutrition. The initial evaluation should include an analysis of symptoms (weight loss, anorexia, nausea, vomiting), IBD-related complications, such as strictures and fistulas, and micro- and macronutrient deficiency.[27] When used correctly and consistently, the nutritional screening tool identifies individuals at a risk of malnutrition. An ideal nutritional screening tool considers severity of the condition and adds dynamic indicators, such as recent weight loss, body mass index (BMI), and food intake. There are currently different questionnaires in use. The NRS--2002 is one of the nutritional risk screening tools that is most frequently used in hospitals around the world. The NRS-2002 is a validated instrument to perform prescreening in the form of 4 questions.[28] This screening evaluates nutritional status, static and dynamic parameters, disease severity, and other factors. Each parameter can receive a score between 0 and 3. In patients whose overall score is 3 or more, nutritional therapy is necessary, as they are either malnourished or at a risk of malnutrition. Additionally, Saskatchewan IBD-Nutrition Risk (SaskIBD-NR) and modified Malnutrition Universal Screening Tool (mMUST) have been developed and validated in IBD outpatients.[29]

Patient and dietary history, anthropometric measures, and biochemical information are all included in the nutritional assessment. The main aim of the nutritional assessment is to determine the severity of malnutrition and to develop an appropriate treatment.[30] In nutritional assessment, the results of functional measures are important. Therefore, knowledge of muscular strength and function is essential in the clinical setting. The handgrip test, which measures patient's strength, has been validated as a nutritional marker. It is a reliable indicator of both short- and long-term mortality and a quick and simple test which accurately recognizes the intensity of patient's strength in real time.[30] It is also important to know the patient's prescribed medications and to analyze their possible interactions with appetite, gastrointestinal function, or gastrointestinal symptoms. An analysis of dietary habits, including calorie and nutrient intake, consumption of certain foods or nutrients, frequency and composition of meals, and eating environment, is also essential.[11]

Anthropometric measurements and body analysis can provide important information about the nutritional status of a patient. Body weight and height are essential anthropometric measures used for calculating BMI. BMI below 18.5 kg/m^2 indicates underweight, between 18.5 and 24.9 kg/m^2 indicates normal weight, between 25 and 39.9 kg/m^2 overweight, and above 30 kg/m^2 obesity.[31]

When a patient is suspected of malnutrition or sarcopenia, it is crucial to conduct a body composition analysis. **TABLE 1** summarizes the main techniques used for such an analysis. Using these instruments along with strength assessment methods can help identify sarcopenia in clinical practice.

Magnetic resonance imaging (MRI) and computed tomography (CT) are considered the gold standards for noninvasive assessment of body composition and muscle quantity / mass.[32] However, these tools are not commonly used in health care due to high equipment costs and lack of portability.

Bioelectrical impedance analysis is a noninvasive technique that indirectly measures the body ability to a flow of current or impedance. It calculates the amount of water present in the tissues and indirectly measures the lean mass of the body. Parameters such as reactance, resistance, and phase angle are combined with anthropometric variables (weight and height), sex, and age[33] in order to analyze total body water, extracellular water, intracellular water, lean body mass, skeletal muscle mass, body cell mass, and fat free mass.

Dual energy X-ray absorptiometry is considered an excellent method for body composition analysis, and it is increasingly often used in clinical practice despite a risk of radiation exposure.[27] It can discern variations in density of bone mineral content, lean body mass, and fat mass. Adult osteopenia and osteoporosis are not diagnosed using whole-body densitometry bone mineral density data.[34]

TABLE 1 Main techniques used for body composition analysis

Techniques	Advantages	Disadvantages
Magnetic resonance imaging (MRI)	– No radiation exposure – Superior spatial resolution and differentiation of body mass composition	– More expensive than BIA and DXA – Longer image acquisition time – Contraindications to MRI may preclude some patients
Dual-energy X-ray absorptiometry (DXA)	– Low radiation exposure – More sensitive than BIA – Inexpensive	– Two-dimensional data – Inability to distinguish between subcutaneous and visceral adipose tissue – Low accuracy as compared with CT and MRI – Lack of portability
Computed tomography (CT)	– High accuracy and reproducible findings – Ability to define lean body mass, subcutaneous fat, and visceral fat	– More expensive than BIA and DXA – Radiation exposure
Bioelectrical impedance analysis (BIA)	– Shorter execution time and immediate results – Portable – Inexpensive – No exposure to radiation	– Lack of precision

Biochemical investigations contribute to the nutritional assessment of IBD patients. The evaluation of deficiencies is crucial, as they can impact the disease activity, quality of life, and even a risk of carcinogenesis.[35]

Micronutrient deficiency includes all vitamins, especially B_{12}, folate, and vitamin D. Micronutient deficiency involves low levels of trace elements, such as iron, zinc, and selenium.

Vitamin D is a key micronutrient and prohormone for homeostasis of the skeletal muscles and intestinal system. It is synthesized primarily in the skin and is available in 2 biologically inactive forms, cholecalciferol (vitamin D_3) and ergocalciferol (vitamin D_2). Vitamin D obtained from sun exposure, food, or supplementation is biologically inert and must undergo 2 steps of hydroxylation to become active as 1,25-dihydroxyvitamin D_3 (calcitriol). Active vitamin D, acting via an autocrine mechanism, is essential for proliferation and differentiation of skeletal muscle stem cells, as well as preservation of muscle function.[36] Moreover, vitamin D acts through an endocrine mechanism that involves increasing intestinal calcium absorption and osteoclastic activity, and thus is essential for bone growth, density, and remodeling.[37] A Polish study[38] clarifies how vitamin D may not be the only factor influencing bone mineral density in IBD patients, and suggests how these patients should supplement a higher dose of vitamin D than healthy adults.

Vitamin D deficiency is a common abnormality in IBD patients, due to various reasons, such as a lack of sun exposure caused by immunosuppressive treatments, dietary restrictions, and altered absorption.[39] Studies have shown that vitamin D plays an important role in maintaining the gut epithelial integrity, innate immune barrier function, development and function of T cells,[40] and gut microbiota eubiosis.[41] Vitamin D deficiency can worsen IBD symptoms, increase the risk of mucosal damage, and contribute to sarcopenia,[42] resulting in increased disease activity, worse quality-of-life scores, and future clinical relapse.[43]

Iron is critical for forming essential enzymes, red blood cells, and reversible oxygen binding. Iron deficiency is another common clinical problem in IBD and, as in healthy people, it has a very high estimated prevalence, between 36% and 90%.[16] The incidence of iron deficiency anemia in IBD patients is high and often associated with fatigue, with a prevalence of up to 76% of patients.[44] The causes include inadequate iron intake, malnutrition, chronic blood loss, or inflammation affecting iron absorption. Chronic inflammation is the biggest contributor to this disorder, which often recurs in IBD patients. Proinflammatory cytokines such as IL-6, IL-1, and TNF-α increase hepcidin levels, reduce iron bioavailability,[45] and lead to chronic anemia.

Causes of nonsideropenic anemia in IBD include deficiencies of vitamin B_{12} and folic acid. Folate and folic acid, synthetic analogues of vitamin B_9, are necessary for a variety of metabolic activities, including RNA and DNA formation, DNA repair, and DNA methylation, all of which are crucial for maintaining health of the body cells and genome. Patients with CD and UC have significantly decreased folate levels, and it is reported that 28.8% of CD patients and 8.8% of UC patients are folate-deficient.[46] There are many different causes of folate deficiency in IBD, including malabsorption, low intake, and drug-induced (eg, methotrexate) deficiency.[47]

Vitamin B_{12} is essential for metabolism of macronutrients, DNA synthesis, and nerve function. Its deficiency can lead to macrocytic anemia via impaired folate metabolism, neurologic damage, and hyperhomocysteinemia. Only some receptors found in the terminal ileum can absorb vitamin B_{12} after its binding with an intrinsic factor

produced in the stomach. This is the reason why this deficiency is common in CD, particularly in patients with resection of more than 20 cm of the distal ileum.[48]

Furthermore, poor oral intake and intrinsically malabsorptive nature of IBD may contribute to trace element insufficiency in IBD patients, especially of zinc, magnesium, and selenium.[49]

It is important to note that zinc is a crucial micronutrient that supports various bodily functions, such as cellular metabolism, enzyme activity, immune function, and intestinal barrier function.[50] A study has shown that patients with IBD may have decreased serum zinc concentrations, even when in clinical remission and without overt malabsorption.[51] This highlights the importance of systematic laboratory testing for anemia or micronutrient deficiency in IBD patients, even if they are in remission.[51]

Dietary intervention in the management of irritable bowel syndrome in inflammatory bowel disease: a role of popular diets In the world of IBD, a diet holds a lot of appeal for both patients and health care professionals. It offers patients an opportunity to take control of their disease and improve their quality of life. In fact, a survey of Dutch adults with IBD found that 59% of patients believed that nutrition was at least as important, if not more important, as medication in treating their disease. Additionally, 62% of patients reported success in controlling IBD symptoms through dietary modifications.[52]

Diet also appears to play a supportive function in biologic therapies, helping to reduce the inflammatory burden, as found for particular exclusion diets, including the anti-inflammatory diet[53] and a specific carbohydrate diet.[54] However, evidence is lacking to support the concept that any dietary model can replace conventional treatments in adult IBD patients. Nevertheless, CD exclusion diet has been described as a possible therapeutic alternative in the case of inability to receive medical therapy or a failure of biologic therapy.[55] However, recent guidelines for the management of CD and UC in adults do not recommend specific oral diets due to a lack of long-term benefits.[56]

Despite this, popular diets for IBD treatment have been on the rise. They typically include certain foods / nutrients and exclude other, or even entire food groups, claiming therapeutic benefits for general health or for the treatment of specific conditions. However, the evidence to support these claims is often only partial.[57] In clinical practice, it is well known that a diet plays a key role in symptom management in IBD patients and in preventing the risk of malnutrition and sarcopenia, due to the mechanisms described above.

IBD patients experience a range of gastrointestinal symptoms that often resemble those of IBS, a chronic condition with a very high prevalence in the general population (20%), characterized by abdominal pain or discomfort associated with a change in stool form or frequency.[58] According to a recent meta-analysis, nearly 40% of IBD patients suffer from IBS-like symptoms, with even those in remission being more likely to experience them than healthy controls.[59] As a result, patients often report symptoms without objective evidence of the disease activity, leaving both patient and physician in a quandary. Treating presumed insidious disease would involve potent immunomodulating agents with potential adverse effects and significant financial expense. In this context, the dietary-nutritional approach plays a crucial role in achieving effective symptom relief in this subgroup of patients and managing possible risks associated with malnutrition.

In this narrative review, we collected all original articles that described several popular diets used in IBD, particularly in terms of their effects on bowel symptoms, IBS-like symptoms, and potential risks of malnutrition.

The literature search was performed using the following electronic databases: PubMed, Scopus, and Embase for articles written in English. The last search was performed on August 31, 2023. The terms "gluten free diet," OR "mediterranean diet," OR "plant based diet," OR "low fodmap diet," OR "popular diets" were matched with the phrases "inflammatory bowel diseases" AND "irritable bowel syndrome." The terms "gluten free diet," OR "mediterranean diet," OR "plant based diet," OR "low fodmap diet," OR "popular diets" were also matched with the phrases "malnutrition" AND "inflammatory bowel diseases." All terms were searched both as key words and Medical Subject Headings. We hand-searched the bibliography lists of relevant articles (based on titles and abstracts) to provide additional references.

Low-fermentable oligosaccharides, disaccharides, monosaccharides, and polyols diet The low-fermentable oligosaccharides, disaccharides, monosaccharides, and polyols (FODMAP) diet (LFD) is a dietary approach that limits the intake of certain fermentable carbohydrates.[53] These include mono-, di-, and oligosaccharides and polyols. Foods high in FODMAPs include dairy products containing lactose, excess fructose, fructans / galactans found in wheat, onion, chickpea, and lentil, and polyols found in peaches and artificial sweeteners. Patients who follow this nutritional approach should start with a strict adherence to LFD for 4–6 weeks, followed by reintroduction of FODMAPs while monitoring their symptoms.[60]

Research has shown that LFD is particularly effective in managing IBS. FODMAP-rich foods pass through the intestine without being broken down and contribute to increased water absorption in the small intestine, while in the large intestine, they are fermented by intestinal bacteria and produce excess gas that leads to pain, discomfort, and bloating.[61] Studies have shown that limiting these easily fermentable and poorly absorbed carbohydrates can help alleviate symptoms

TABLE 2 Main studies investigating the effects of low-fermentable oligosaccharides, disaccharides, monosaccharides, and polyols diet on gastrointestinal symptoms in inflammatory bowel disease

Study	Disease	Design	Comparison	Size	Patients	Length	Outcomes
Cox et al[65] (2020)	IBD	Single-blind randomized controlled trial	LFD vs control diet	52 (25 control, 27 LFD)	Adults	4 weeks	LFD can improve persistent gut symptoms with no effects on inflammation.
Prince et al[63] (2016)	IBD	Retrospective analysis	N/A	88 (39 CD, 38 UC, 11 IBD-U)	Adults	6 weeks	LFD can improve IBS symptoms.
Gearry et al[64] (2009)	IBD	Retrospective case--control study	N/A	72 (52 CD, 20 UC)	Adults	N/A	LFD adherence improves IBS symptoms.
Halmos et al[68] (2016)	CD	Randomized controlled crossover trial	LFD vs typical Australian diet	9	Adults	9 weeks	Higher intake of FODMAPs significantly increased gastrointestinal symptoms without changing the disease activity.
Pedersen et al[62] (2017)	CD	Randomized controlled crossover trial	LFD vs control diet	89 (26 CD, 61 UC)	Adults	6 weeks	LFD reduced IBS symptoms and improved quality of life.
Maagaard et al[66] (2016)	IBD and IBS	Retrospective cross--sectional study	LFD	180 (131 IBS, 49 IBD)	Adults	16 months	LFD is an efficacious treatment solution in the management of IBS in IBD patients.
Peng et al[67] (2022)	IBD	Systematic review and meta-analysis	LFD vs controls	446 (351 LFD, 95 controls)	Adults	N/A	LFD provides benefits for functional gastrointestinal symptoms but does not improve stool consistency and mucosal inflammation in IBD.

Abbreviations: CD, Crohn disease; FODMAPs, fermentable oligosaccharides, disaccharides, monosaccharides, and polyols; IBD, inflammatory bowel disease; IBD-U, inflammatory bowel disease, unclassified; IBS, irritable bowel syndrome; LFD, low-FODMAP diet; N/A, not available; UC, ulcerative colitis

in patients with IBS, although the data on LFD's efficacy remain somewhat conflicting. Numerous studies have investigated the effectiveness of LFD in IBD patients, and significant decrease in IBS-like symptoms and overall symptom severity scores has been observed in comparison with a normal diet.[62-66] Many of these studies have been included in a recent updated review and meta-analysis[67] and are summarized in **TABLE 2**.

Research results indicate that LFD can help improve IBS symptoms in the patients suffering from IBD, without any significant differences in the subgroups categorized by the disease type.[68] However, the study did not yield any significant differences regarding LFD effectiveness in improving stool consistency and inflammation level in patients with IBD. It is worth mentioning that most of the participants included in the study remained in clinical remission. However, some evidence suggests that undertaking LFD may alter the gut microbiota, but the long-term effects of these changes remain unknown.[68]

Studies on the effect of LFD on micronutrients are limited and yield conflicting results. A 4-week randomized controlled trial (RCT) found lower calcium intake in patients with IBS than in controls following a usual diet,[69] but another RCT did not find a significant difference in calcium intake.[70] A study that used a food frequency questionnaire[71] concluded that the intake of various micronutrients was adequate 6 to 18 months after implementing the LFD. However, another small study[72] showed that fiber intake was below baseline at 3 months. Moreover, a recent systematic review[73] suggests that LFD may contribute to vitamin D deficiency. On the positive side, an RCT showed that after implementing LFD, there were no significant differences in the intake of energy or macronutrients in comparison with control diets, and there were indications that LFD might improve overall dietary intake. For example, intake of vitamin B_{12} was higher than in the habitual control diet, which could represent a greater intake of eggs or fish.[70]

Gluten-free diet A gluten-free diet (GFD) is a dietary plan that excludes foods containing gluten, a protein found in wheat, barley, rye, and triticale. It is conventionally used for individuals with celiac disease. Hidden sources of gluten may also include thickening or flavoring agents used to enhance the taste of food. Foods allowed in the gluten-free diet include gluten-free grains, such as rice and corn, fresh meat or poultry, fresh fruits and vegetables, and dairy products. This diet has been further extended to individuals with nonceliac gluten sensitivity (NCGS), a disorder characterized by an improvement in gastrointestinal symptoms similar to IBS with the elimination of gluten, despite a lack of a genetic and immunologic phenotype typical of celiac disease.[74]

The role of diet in celiac disease is well understood, but its utility in IBD is less clear. A recent systematic review and meta-analysis[75] highlighted a lack of prospective controlled studies on the effects of GFD on inflammation in IBD patients. Although many IBD patients report following a GFD, assuming its beneficial effects on the disease symptoms, the current evidence on whether the GFD can improve gastrointestinal functional

TABLE 3 Main studies investigating the effects of gluten-free diet on gastrointestinal symptoms in inflammatory bowel disease

Study	Disease	Design	Comparison	Size	Patients	Length	Outcomes
Herfarth et al[76] (2014)	IBD	Cross-sectional survey study	N/A	1647	Adults	N/A	20% of patients reported folowing a GFD, more than half of the patients reported improved intestinal symptoms.
Schreiner et al[77] (2019)	IBD	Prospective internet-based cohort study	GFD vs non-GFD	1254	Adults	9 years	4.7% of the study population followed a GFD and did not find any differences in the disease activity, complications, and hospitalization rate; worse psychological wellbeing in those who followed the GFD.
Limketkai et al[78] (2018)	IBD	Cross-sectional survey study	NCGS IBD vs non-NCGS IBD	102 (55 CD, 46 UC, 3 IBD-U)	Adults	N/A	No difference in gastrointestinal symptoms between patients with and without GS. GS was associated with a recent flare, stenotic disease in CD, and dermatologic manifestations.
Morton et al[79] (2020)	IBD	Retrospective observational study	GFD vs non-GFD	233	Adults	12 months	66% of the patients reported improvement of the symptoms and 38% reported reduced flare frequency and severity.

Abbreviations: GFD, gluten-free diet; GS, gluten sensitivity; NCGS, nonceliac gluten sensitivity; others, see **TABLE 2**

symptoms or influence IBD severity overall is contradictory (**TABLE 3**).

A survey conducted in a Western IBD population[76] revealed that 20% of 1647 enrolled patients reported following the GFD. More than half of these patients reported improvement in intestinal and extraintestinal symptoms, and 40% claimed reduction in IBD flares while on the GFD.

Another study[77] revealed that 4.7% of 1223 participants followed the GFD with no significant differences in the disease activity, hospitalization, or surgery rate between the patients following and not following the GFD. In a cross-sectional study,[78] no differences in symptom frequency were found between IBD patients with and without NCGS. Despite a high percentage of patients with NCGS IBD who were on the GFD, more participants reported recent flares or dermatologic complications. Morton et al,[79] who investigated 233 IBD patients, found that 66% showed symptom improvement and 38% a reduction in the frequency and severity of relapses after following the GFD.

There have been only a few studies evaluating the nutritional value of GFD, but they were conducted several decades ago and have limited relevance now. Since then, new gluten-free and grain alternatives have become available for patients following this diet. Recent studies conducted in several countries focusing on celiac patients have presented conflicting evidence regarding completeness of the GFD with respect to macronutrient and micronutrient intake.

A recent study[80] found that celiac patients consumed more energy in the form of fat and less in the form of carbohydrates. Mariani et al[81] attributed this to the fact that carbohydrate-based foods, such as bread and pasta, were replaced by natural and processed foods rich in protein and fat. Analysis of the diet of adult celiac patients revealed that only 46% of women consumed the recommended amount of dietary fiber due to reduced consumption of grain products.[82] However, recently developed gluten-free products made from alternative grains and pseudograins, such as quinoa, have an optimal fiber content and could improve the situation.[80] Another study[82] found that the GFD did not meet the recommended intake of thiamine, riboflavin, niacin, folic acid, and iron. This evidence is partly explained by low iron and micronutrient enrichment of starch- or cereal--based gluten-free products.

Plant-based diet It is widely known that a Western diet, which is rich in refined carbohydrates, saturated fatty acids, and ultraprocessed foods, is one of the major environmental factors contributing to the increasing incidence and prevalence of IBD due to its proinflammatory effects.[83] Plant--based diets (PBDs) aim to maximize consumption of plant-based food, such as vegetables and fruits, and increase fiber intake while minimizing consumption of animal and processed products. Depending on the level of animal product restriction, PBD can be vegan, lacto-ovovegetarian, semivegetarian, or pescatarian.[84] It has been demonstrated that high amounts of dietary fiber decrease the risk of developing CD,[85] mainly by increasing the production of SCFAs by gut microbiota. These substances, such as acetate, butyrate, and propionate, have anti-inflammatory and immunomodulatory properties that improve integrity of the intestinal barrier.

Current clinical studies show that PBD may have a role rather in preventing disease flares than managing IBS (**TABLE 4**).

In a clinical study[86] including 691 IBD patients, Western diets were compared with PBDs, and the researchers found out that the latter were linked to a decreased risk of active symptoms. Furthermore, in a prospective clinical trial on CD patients in remission,[87] the effectiveness of a semivegetarian diet in preventing CD relapse was investigated, with a remission rate

TABLE 4 Main studies investigating the effects of plant-based diets on gastrointestinal symptoms and prevention of disease relapse in inflammatory bowel disease

Study	Disease	Design	Comparison	Size	Patients	Length	Outcomes
Limketkai et al[86] (2022)	IBD	Retrospective study	PBD vs Western diet	691 (36% CD and 64% UC or IBD-U)	Adults	Usual diet, recalled from the last 3 months or when in clinical remission	Diets with increased intake of fruits and vegetables, reduction of processed meats and refined carbohydrates, and preference of water for hydration were associated with lower risk of active IBD symptoms.
Chiba et al[87] (2010)	CD	Prospective, single-center, clinical trial	SVD vs non-SVD (omnivorous diet group)	22	Adults	24 months	SVD was highly effective in preventing CD relapse.
Hanai et al[89] (2004)[a]	UC	Prospective, randomized clinical trial	GBF + conventional treatment vs conventional treatment alone	59	Adults in remission	12 months	GBF appeared to be effective and safe as a maintenance therapy to taper steroid dose and prolong remission in patients with UC.
Hallert et al[88] (1991)[a]	UC	Randomized controlled trial	Ispaghula husk vs placebo	29	Adults in remission	4 months	Ispaghula can be helpful in the management of gastrointestinal symptoms in quiescent UC.

a Studies investigating the effect of specific components enhanced in each diet

Abbreviations: GBF, germinated barley foodstuff; SVD, semivegetarian diet; others, see **TABLE 2**

TABLE 5 Main studies investigating the effects of the Mediterranean diet on gastrointestinal symptoms in inflammatory bowel disease

Study	Disease	Design	Comparison	Size	Patients	Length	Outcomes
Godny et al[99] (2020)	UC	Prospective observational study	N/A	153	Adults	3–8 years	MD decreases intestinal inflammation and potentially reduces symptoms.
Chicco et al[98] (2020)	IBD	Prospective clinical trial	N/A	142 (58 CD, 84 UC)	Adults	6 months	MD improves the disease activity and reduces malnutrition-related parameters.
Morvaridi et al[97] (2020)[a]	UC	Randomized crossover clinical trial	Extra virgin olive oil vs canola oil	40	Adults	3 weeks	Intake of extra virgin olive oil decreased inflammatory markers and improved gastrointestinal symptoms in UC patients.

a Studies investigating the effect of specific components enhanced in each diet

Abbreviations: MD, Mediterranean diet; others, see **TABLE 2**

around 100% after 1 year and 92% after 2 years. Moreover, several controlled studies revealed benefits of adding fiber to the diet of patients with UC.[88,89]

Despite biologic support for PBDs, additional high-quality evidence is required to fully comprehend their function in the management of IBS in IBD.

In terms of the risk of malnutrition, studies have shown that a PBD can effectively maintain adequate levels of micronutrients and macronutrients. A cross-sectional Epic Oxford Study[90] that included healthy patients evaluated nutritional adequacy of a PBD. At the end of the observational period, all micronutrient values were found to be in line with reference guidelines, except for vitamin D and calcium, which were deficient in both plant-based and omnivorous diets. The PBDs are well balanced and rich in whole grains, legumes, nuts, and seeds, thus providing an adequate intake of protein. It should be noted that patients were receiving vitamin B_{12} supplements, therefore in clinical practice this value needs to be kept under control given its presence in animal products. With the added benefit of a decrease in trans and saturated fats, refined carbohydrates, and a significant increase in fiber intake, no additional shortfall was shown.[91]

Mediterranean diet Mediterranean diet (MD) represents a dietary pattern based on large amounts of monounsaturated fatty acids, omega-3 polyunsaturated fatty acids, dietary fiber, and phytochemicals which combine to provide its favorable anti-inflammatory and antioxidant effects.[92] Its main components include legumes, vegetables, fruits, nuts, and seeds, with a low intake of processed food, red meat, and processed meat. A traditional MD includes a regular intake of olive oil, which has been associated with health-promoting effects.[93]

MD also plays a role in preventing IBD, including a modulation of the gut microbiota.[94] Several in vitro studies demonstrated anti-inflammatory effects of olive oil[95,96] and its ability to reduce the production of proinflammatory mediators (IL-1β, IL-6, IL-8, and TNF-α), improving intestinal integrity.

This evidence had prompted researchers to test MD, or dietary components that are particularly prominent in it, in patients with active disease in order to evaluate its effects on gut inflammation. However, we have no data regarding efficacy of this diet on managing IBS-like symptoms in IBD patients in remission (TABLE 5).

In a randomized crossover clinical trial,[97] consumption of 50 ml of extra virgin olive oil for 20 days reduced gastrointestinal symptoms such as bloating, constipation, fecal urgency, and incomplete defecation, and reduced the level of inflammatory markers in UC patients. In a prospective interventional study,[98] all IBD patients with moderate to severe illness achieved remission or had mild disease activity after 6 months on the MD. The improvement in the disease activity was further confirmed by a significantly higher number of patients in whom fecal calprotectin normalized after the dietary intervention. A recent prospective study involving patients with UC also reported that strict adherence to the MD is associated with a significant reduction in fecal calprotectin levels after pouch surgery.[99]

This dietary pattern is an excellent representation of beneficial nutritional quality; in addition to better dietary fat quality, anti-inflammatory effects, and higher consumption of antioxidants, we must also include increased nutritional adequacy, with an added advantage of a nonrestrictive diet. Higher adherence to MD has been correlated with an increased prevalence of individuals showing adequate micronutrient intake.[100]

Conclusions It is currently recognized that diet can play an additional role in the management of gastroenterologic and nutritional issues in patients with IBD. This is the first review that concentrates on the effects of popular diets on the symptoms of IBS in these patients.

The LFD was found effective in controlling IBS symptoms in IBD patients when maintained for a short period of time. However, there are concerns about its long-term sustainability and potential nutritional risks. On the other hand, there are no prospective studies on the GFD, MD, and PBD, but GFD may be a viable option for patients with NCGS, a condition that can often co-occur with IBS. Meanwhile, MD and PBD are thought to be beneficial in reducing inflammation and general intestinal symptoms.

However, the data collected from these studies are often marred by study design, risk of bias, confounding factors, lack of control or randomization as well as significant heterogeneity in definitions of efficacy. This, for example, may be caused by a difficulty physicians and researchers often encounter in distinguishing occult disease activity from true IBS. Therefore, the best dietary approach in this setting remains an individualized one, with the goal of improving the patient's symptoms and quality of life, while preventing the onset of malnutrition or correcting nutritional gaps and dietary imbalances.

ARTICLE INFORMATION

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