

# Clashing paradigms: low fibre or high fibre diets for non-infectious gut inflammation?

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## Abstract

### Introduction

Crohn's disease and ulcerative colitis, the two primary types of inflammatory bowel disease (IBD), are characterized by lengthy episodes of life-altering gastrointestinal symptoms that include incapacitating abdominal pain, diarrhoea, and bleeding. Progressively sophisticated microbiome research methods have inspired a fresh perspective among IBD researchers regarding the potential for dietary fibre to improve non-infectious gut inflammation outcomes. The purposes of this review are to (a) present some of the published rationale upon which IBD researchers justify their studies testing various dietary fibres of interest, (b) explain the reasons that low fibre recommendations continue to be generalized for persons diagnosed with IBD undergoing conventional care, and (c) encourage dissemination of updated dietary fibre/IBD information that is based upon present day science.

### Discussion

Rationale published in peer-reviewed journals to support the testing of dietary fibre for IBD is based upon mechanisms related to the beneficial effects of fibre on the microbiome, upon beneficial mechanisms not related to the microbiome, and upon epidemiological observations. Low fibre recommendations for IBD were introduced approximately a century ago based upon an assumption that the word 'indigestible' equates to 'irritating.' Emphasis on low dietary fibre recommendations persist,

perhaps because low fibre intake decreases diarrhoea. However, emerging research demonstrates that patients who have been carefully screened for contraindications to fibre can be safely taught to explore the gastrointestinal health-promoting effects of dietary fibre by consuming foods containing intact dietary fibre.

### Conclusion

Conclusive evidence is lacking for the effectiveness of either a low or a high fibre diet to improve outcomes in persons being treated for IBD. However, rationale for testing dietary fibre as a therapeutic agent in IBD is multifaceted, and 21<sup>st</sup> century mechanistic and clinical findings are encouraging. Additional mechanistic studies and rigorous clinical trials are needed to determine effectiveness and generalizability of previous findings.

### Introduction

Crohn's disease and ulcerative colitis, the two main types of inflammatory bowel disease (IBD), are characterized by lengthy episodes of life-altering symptoms, including incapacitating abdominal pain, diarrhoea, and bleeding. From the early 1900s, it has been assumed that dietary fibre, an environmental factor, contributes to poor outcomes in IBD<sup>1</sup>, yet the role that environmental factors play in these chronic inflammatory conditions today remains unclear.

Progressively sophisticated microbiome research methods have inspired a fresh perspective among IBD researchers regarding the potential for dietary fibre to improve non-infectious gut inflammation outcomes. These researchers' perspective on supplemental fibre for IBD contrasts sharply with the low dietary fibre information generally disseminated to individuals with IBD by both practitioners and the IBD

community itself. Although specific circumstances surrounding IBD in some instances may require adherence to a low fibre diet, the generalization of low fibre recommendations to the entire IBD population imposes dietary restrictions with the potential to eliminate the specific nutritional building blocks required for natural epithelial healing and restoration of healthy gastrointestinal function.

Highly-purified derivatives of fibre have recently generated research interest as potentially patentable supplements for those with IBD, compared to less emphasis on testing fibre-rich foods that are inexpensive and readily available on grocery store shelves. The aims of this review are to (a) present published rationale upon which IBD researchers justify studies testing various dietary fibres of interest, (b) explain the reasons that low fibre recommendations continue to be generalized for those with IBD undergoing conventional care, and (c) encourage dissemination of dietary fibre and IBD information that is based upon present day science.

### Discussion

The authors have referenced some of their own studies in this review. These referenced studies have been conducted in accordance with the Declaration of Helsinki (1964) and the protocols of these studies have been approved by the relevant ethics committees related to the institution in which they were performed. All human subjects, in these referenced studies, gave informed consent to participate in these studies.

### Published rationale for testing dietary fibre in IBD

In recent years, scientists in the United Kingdom, the United States, Sweden, Belgium, New Zealand, Iran, and Japan

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have conducted studies designed to test the idea that therapeutic use of dietary fibre may improve gut function for those with IBD<sup>2,3,4,5,6,7,8,9,10,11,12</sup>. Some of the more widely tested dietary fibres are purified fibre extracts such as fructo-oligosaccharides<sup>8</sup>, inulin<sup>10</sup>, and fructo-oligosaccharide-enriched inulin<sup>13</sup>, germinated barley foodstuff<sup>4,5,6</sup>, and docosahexaenoic acid<sup>3,11</sup>. Other less purified or more intact dietary fibres such as breads and cereals that include oat bran<sup>2</sup>, wheat bran<sup>12</sup>, psyllium<sup>14</sup>, and cellulose<sup>9</sup> have received less attention from researchers yet are more readily available to the public.

The relationship of dietary fibre to the gut microbial ecosystem provides some of the published, complex rationale to justify IBD-related investigations of purified fibre extracts and fibre-rich foods. Dietary fibre is the component of food not digested by human enzymes, thus allowing this fibre to arrive in the intestines undigested and available for use by the beneficial gut bacteria, specifically those bacteria using almost exclusive saccharolytic metabolism<sup>15</sup>. These beneficial bacteria feed on the fibre through the process of fermentation, thereby producing by-products of fermentation that nourish and promote the health of the gastrointestinal tissue. The effect of dietary fibre on the gut ecosystem and gut health is summarized in figure 1.

Dietary fibres are polysaccharides that preferentially promote the proliferation of beneficial bacteria because these bacteria generally use saccharolytic metabolism and are thus able to break down (ferment) complex carbohydrates<sup>15</sup>. Finding effective ways to correct the altered intestinal microbial balance associated with IBD (dysbiosis) has been identified as a cutting edge area of IBD research<sup>16</sup>. Healthy colonies of beneficial bacteria are thought to decrease the growth of pathogenic bacteria through colonization resistance—a group of mechanisms described elsewhere<sup>17</sup>.

Using fibre-rich foods to promote the beneficial bacteria already resident in the gut of an individual with IBD may be a simple first step towards a natural correction of dysbiosis.

Butyrate and other short-chain fatty acids, which are produced by fermentation of dietary fibre by colonic bacteria, further promote gastrointestinal health through mechanisms relevant to the disrupted pathophysiology of IBD. Although space limits a discussion of the beneficial mechanisms of butyrate here, information shown in table 1 summarizes some of the mechanisms that undergird the published rationale for fibre and IBD testing. For example, butyrate decreases proinflammatory cytokine tumour necrosis factor by inhibiting nuclear factor kappa beta activation, two recognized targets of IBD therapy<sup>18</sup>. This mechanistic pathway and others are summarized together here showing that butyrate and other short-chain fatty acids ‘modulate inflammatory and regulatory mediators.’

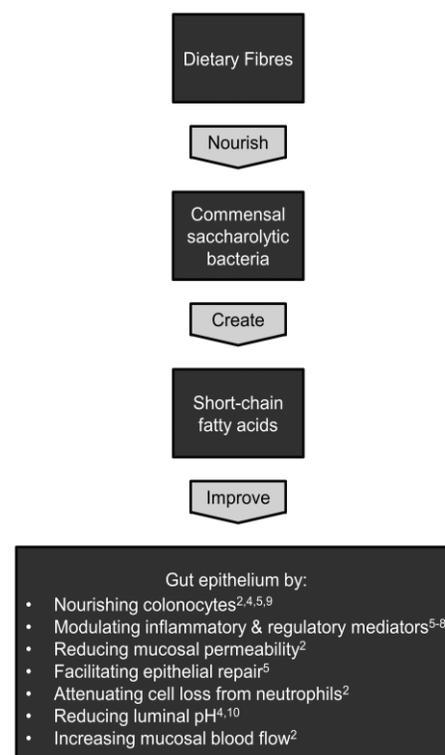
One recognized challenge to delivering the IBD-relevant benefits of butyrate to the distal gastrointestinal tract is that orally consumed butyrate does not remain intact, that is, survive, after passage through the upper gastrointestinal tract, and butyrate enemas only reach the most distal intestinal tissue. However, orally ingested intact dietary fibre is capable of delivering butyrate and its benefits to relatively inaccessible segments of the bowel because this fibre resists digestion in the upper digestive system<sup>2</sup>. In fact, French researchers have reported that “The targeted stimulation of native butyrate-promoting bacteria by dietary prebiotics [dietary fibre] provides an obvious approach for delivering butyrate to its site of utilization at the colonic mucosa<sup>19</sup>.”

Information shown in table 2 summarizes some of the published non-microbiome-related rationale for testing dietary fibre in IBD. The high water-holding capacity of fibre<sup>5</sup> has

functional benefits because the water-holding capacity of the luminal contents helps to determine the presence or absence of diarrhea<sup>20</sup>, a prominent IBD symptom. Additionally, the water-holding capacity of fibre adds bulk to the stool, diluting the concentration of any antigens present in the gut luminal contents. Additional observations include epidemiologic evidence<sup>9</sup>, evidence of human tolerability of some dietary fibres<sup>2,12,21</sup>, and that some patients credit dietary fibre as an aid in maintaining healthy gastrointestinal function<sup>12</sup>.

### Generalized low fibre recommendations—a logical beginning?

Early 20<sup>th</sup> century low fibre recommendations for treating chronic bowel inflammation were linked to the untested assumption that indigestible dietary fibre is irritating to the digestive tissue<sup>1,22,23</sup>.



**Figure 1:** Gut bacteria that are beneficial to the health of the human host are generally saccharolytic and thus able to metabolize polysaccharide dietary fibres through fermentation. Short-chain fatty acids are by-products of the fermentation process that promote the health of the gut epithelial lining through multiple mechanisms.

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**Table 1: Microbiome-related mechanisms cited in peer-reviewed journals to support the testing of dietary fibre in IBD**

A. Butyrate and other short-chain fatty acids:	nourish colonocytes <sup>2,4,5,9</sup>
	modulate inflammatory and regulatory mediators <sup>5,6,7,8</sup>
	reduce mucosal permeability <sup>2</sup>
	facilitate epithelial repair <sup>5</sup>
	attenuate cell destruction by neutrophils <sup>2</sup>
	reduce luminal pH <sup>4,10</sup>
	increase mucosal blood flow <sup>2</sup>
B. Enemas containing butyrate and other short-chain fatty acids have effectively treated distal colonic inflammation <sup>2,3</sup>	
C. Fermentable fibre taken orally delivers butyrate to sites of inflammation not accessible to enemas <sup>3</sup>	
D. Dietary fibre has been shown to promote the growth of beneficial bacteria <sup>3,7,8,9,10,11</sup>	

The complex gastrointestinal benefits of bacterial fermentation of fibre were unknown at the time. The first author of this review examined medical, nursing, and dietetics textbooks published between 1918 and 1985 and found no cited research to support the idea that the word 'indigestible' equates to 'irritating.' Indigestible simply means that dietary fibre is left intact by human enzymes in the upper digestive system, thereby leaving the dietary fibre available for fermentation by beneficial bacteria in the lower digestive system.

However, once low fibre recommendations were introduced, the recommendations produced the appearance of helping individuals with chronic bowel inflammation. When less fibre is consumed, less faecal matter reaches the distal intestines. In an inflamed intestinal tract where all ingested matter passes through as diarrhoea, low fibre intake does result in reduced diarrhoea. However, to our knowledge, evidence is lacking to demonstrate that less faecal matter passing through the intestinal tract decreases intestinal inflammation.

### Universal low fibre recommendations for IBD—unsubstantiated?

By the 1980s, researchers had linked low fibre diets to various gastrointestinal diseases and challenged the effectiveness of universal low fibre recommendations for IBD<sup>21,24,25,26</sup>. Research during this period led to the conclusion that neither low fibre nor high fibre diets improved outcomes in IBD<sup>21,24,25</sup>. However, a study by Ritchie and colleagues<sup>24</sup> deserves special attention because researchers often quote it as authoritative and definitive evidence that fibre is an ineffective agent for improving IBD outcomes.

The study has been cited 85 times from 1988 through 2013, with six of these citations having occurred in 2013. Authors characterize the study

as having tested a high fibre diet for IBD in which the fibre did not demonstrate any benefit. At the 2010 Advances in Inflammatory Bowel Diseases research conference<sup>27</sup>, a presenter cited the Ritchie and colleagues study<sup>24</sup> singularly as the evidence that dietary fibre has been shown to be of no help for IBD patients. However, the study participants in the so-labelled 'high fibre' group consumed only 27.8 grams of fibre per day, whereas recommended fibre intake for men under age 50 is 38 grams per day<sup>28</sup>. Fibre intake that does not meet the recommended daily consumption cannot accurately assess the effectiveness of a 'high fibre' diet. This weakness and other shortcomings of this study raise questions about the foundation upon which 21<sup>st</sup> century IBD experts discount the benefits of fibre while emphasizing a low fibre diet to individuals looking for helpful dietary information.

The emphasis on teaching IBD patients to eat a diet low in fibre is evidenced by information provided on credible IBD-related Web sites. To illustrate, the Crohn's and Colitis Foundation of America Web site currently describes a low fibre diet, refers to fibre as 'scrapy,' and does not present a clear description of IBD-relevant benefits of fibre<sup>29</sup>. The Mayo Clinic Web site strongly cautions readers against fibre and includes a link for information about a low fibre diet, with no information about IBD-relevant benefits of fibre<sup>30</sup>.

The Crohn's and Colitis UK Web site presents the topic of fibre and IBD in a

**Table 2: Non-microbiome-related rationale cited in peer-reviewed journals to support testing dietary fibre in IBD**

A. Functional benefit:	The high water-holding capacity of dietary fibre has been shown to modulate stool water content <sup>5</sup>
B. Suggestive observations:	Some dietary fibres have been found to be well tolerated in IBD <sup>2,12,13</sup> (in contrast to the common assumption that all dietary fibres are potential irritants in IBD)
	Epidemiological evidence suggests an association between rising incidence of IBD and decreased consumption of dietary fibre <sup>9</sup>
	Some patients credit high dietary fibre consumption for remission maintenance <sup>12</sup>

more comprehensive and balanced approach than the sites previously mentioned; however, instructions for a low fibre diet still are not balanced with equivalent information aimed at helping individuals with IBD adopt a healthy high fibre diet<sup>31</sup>.

### Fibre testing—research findings

It is beyond the scope of this review to report fully on findings from all recent IBD and fibre investigations. Challenges to reporting a concise analysis of the findings across the studies include the variety of fibre tested, differences between participant samples, and the multiple variables measured. In general, a range of mechanistic and clinical benefits of fibre have been demonstrated<sup>2,3,4,5,6,7,8,9,10,11,12,32</sup>, although some fibre was shown to be poorly tolerated by some participants during active disease. For example, in studies investigating ducosahexaenoic acid and fructo-oligosaccharides in participants with active IBD, intolerance to the intervention diet accounted for some attrition<sup>3,8,11</sup>.

However, oat bran and inulin were well tolerated during remission<sup>2,10</sup>, and wheat bran and germinated barley foodstuff were well tolerated even during mild to moderate disease activity<sup>5,12,32</sup>. No data were found through this review to suggest that fibre would be detrimental to patients who have been screened carefully for clinically significant stricturing, fistula, or other contraindications to fibre consumption. In fact, in an early 1979 study, Heaton and colleagues<sup>26</sup> followed 32 high fibre-treated patients for a mean follow-up of 52 months and found favourable outcome results compared to matched controls, despite the fact that the high fibre diet-treated patients included many who had had intestinal strictures.

**Table 3: Tips for teaching patients with IBD about high fibre diets**

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Qualitative considerations	Too many raw fruits or vegetables cause loose stools, but high fibre cereals such as oatmeal and bran cereals soak up and hold water, creating large, soft, comfortably-passed stools
	A poorly chewed raw fruit or vegetable can lodge in a stricture and cause an obstruction, but a well-hydrated cereal fibre stool is soft and malleable and able to squeeze through narrowed segments of bowel
	Introducing a new complex carbohydrate can cause a temporary increase in gas, but consistent use can result in less gas than before the new carbohydrate was introduced <sup>34</sup>
Quantitative considerations	Inulin is a fibre sometimes added to packaged foods to increase the fibre content, but relatively few bacterial strains can ferment inulin, and individuals without these strains will not be able to tolerate inulin, even with consistent use <sup>33</sup>
	Many people count mainly fruits and vegetables when judging the quantity of fibre in a diet, but bran-centric food products and legumes are the easiest way to consume a truly high-fibre diet (see Table 4)
	Words printed in large print on food packaging front labels are designed to appear high in fibre, but ingredients listed in the fine print must be examined to compare fibre content of competing products based on equal serving sizes

### Teaching individuals with IBD to safely consume a healthy high fibre diet

In the absence of contraindications such as recent abdominal surgery, short bowel syndrome, and obstructive strictures or fistulae, carefully screened patients with IBD can safely and comfortably adopt a high fibre diet<sup>12</sup>. Those who temporarily require a low fibre diet need encouragement from health care providers to recognize when and how to conclude the low fibre diet and return to a healthy high fibre diet<sup>31</sup>. Information about consuming a high fibre diet must emphasize the necessity of drinking a sufficient quantity of fluids because the beneficial bowel action associated with fibre consumption depends upon adequate hydration and dry fibre in the gut may contribute to developing an obstruction.

Qualitative differences among types of dietary fibres are important for

persons with IBD to understand. For example, patients with stricturing Crohn's disease need to understand the difference in malleability between a poorly chewed raw carrot and a bowl of oatmeal. Dietary fibre, an umbrella term, covers a heterogenous group of foods high in fibre such as wholemeal breads, wholegrain (unrefined) cereals, fruits, and vegetables, not the homogenous entity usually presented in IBD and fibre information. It is useful to teach patients that different types of fibre have different effects. For example, it is common knowledge that excess fruit can produce loose stools regardless of IBD status; thus, fruit fibre should be avoided during a flare characterized by diarrhea. Information provided to patients should emphasize that consistent fibre use helps to resolve bloating and gas, with inulin being one notable exception for people lacking the specific bacteria needed to ferment this fibre<sup>33,34</sup>. Table 3 presents sample tips for teaching patients with IBD about high fibre diets.

**Table 4: Examples of fibre content information accessible to the informed patient**

Food	Portion	Fibre (grams)
Wheat bran cereal	1 cup	39.0
Black beans	1 cup	12.0
Raw apple	1 med	4.0
Lettuce (Boston, leaf, iceberg)	1 cup (shredded)	0.8

Quantitative differences between fibre-containing foods are important, too. Individuals who want to judge for themselves the effect of a high fibre diet on their personal IBD symptoms need detailed information about the quantity of fibre in the foods they consume.

Teaching patients to assess food labels accurately is necessary, but patients also need help to assess accurately unlabelled produce for fibre content. Using the Internet, it is easy to direct patients to credible fibre information that can help them to correct common overestimates of the fibre content in fruits and vegetables. For example, the Mount Sinai Health System (New York City)<sup>35</sup> has posted an online table reporting the fibre content of many foods. Data shown in table 4 illustrate the type of food fibre comparisons that can be made by patients who have been taught to seek this information on food packaging labels and from credible online sources.

### Wheat bran effects—informal track record over 3 decades and proof of concept data

Wheat bran has been labelled the 'gold standard' for faecal bulking, which is conducive to healthy bowel action<sup>36</sup>. In her role as a gastroenterology nurse for more than a decade, the first author of this review had the opportunity to empower countless persons with IBD by teaching a wheat bran-inclusive, high fibre pattern of eating and letting the individuals judge the effects for themselves. In addition, a 2012 proof of concept study<sup>32</sup> using a randomized, controlled study design to test the Hill model<sup>37</sup> in a sample of individuals with Crohn's disease yielded clinically significant improvement in gastrointestinal function and health-related quality of life in the intervention group.

### Conclusion

Conclusive evidence is lacking for the effectiveness of either a low or a high fibre diet to improve patient outcomes in IBD. Nonetheless, rationale for

testing dietary fibre as a therapeutic agent in IBD is multifaceted, and 21<sup>st</sup> century mechanistic and clinical findings have been encouraging. While low fibre diets may be a necessity for some patients at defined points in time during a lifetime of living with IBD, intentional provision of up-to-date fibre information may prevent unnecessary fibre avoidance by those individuals with IBD who might benefit from the physiologic benefits of intact fibre in the gut. Additional mechanistic studies and sufficiently powered clinical trials are needed to determine effectiveness and generalizability of previous findings.

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