Chapter

Dietary Fermented Rice Bran Is an Effective Modulator of Ulcerative Colitis in Experimental Animal

Afroza Sultana, Abul Fazal Mohammad Nazmus Sadat and Md. Alauddin

Abstract

Ulcerative colitis (UC) is an inflammatory disorder with colon and rectum, characterized by recurring bloody diarrhea due to microbial dysfunction and some autoimmune response. Scientists have linked microbial disruption in the gut to several chronic conditions such as UC and other types of inflammatory bowel disease (IBD). Surprisingly, our gastrointestinal tract contains more than 100 trillion microbial cells. Some microbes in the gut microbiome are friendly bacteria that can help to treat UC by influencing metabolism, nutrition, immune function, and more in the gut. The conventional medical treatment of UC relies on the use of amino-salicylates, corticosteroids, immunosuppressive drugs, glucocorticoids, and antibiotics. Multiple new mechanisms in the treatment of UC are being developed and many are showing promising results in ulcerative colitis. Still need scientific evidence to support the role of gut microbiota in the etiology of UC. The dietary fermented rice bran (DFRB) may include the active potential for the treatment of ulcerative colitis. The DFRB may attenuate intestinal inflammation by regulating gut permeability for cellular infiltration and maintenance of luminal safety with favorable efficacy in UC. In this chapter, we discussed and summarized the insight mechanism of DFRB's modulatory activities for the management or treatment of ulcerative colitis.

Keywords: ulcerative colitis, fermented rice bran, gut microbiome, intestinal homeostasis, and tight junction barrier integrity

1. Introduction

Chronic inflammatory disease, ulcerative colitis (UC) is recognized by the luminal abnormalities by the flourishing of cytokines at the large intestine that can cause irritable mucosal lining cells and disruption of tight junction protein [1]. UC is one form of inflammatory bowel disease (IBD) and the severity was first coined in the 18th century [2]. Another form of this (IBD) disease is known as Crohn disease (CD). Worldwide, both diseases are commonly termed IBD and the frequency of this disease is observed commonly not only in the first world countries but also

increasing this scenario in Asian countries due to their dietary habits. Surprisingly, the severity of this disease was found more common in Caucasians than other racial and colors people based on their lifestyle and food habits and as well as remarkably increased in Jewish [3]. The disease severity was found to be age dependent and the onset of the disease is 30–40 years old among the men and women equally [4]. The complexity of this disease makes a debilitating disorder by the discontinuous lacerations in the gut mucosal cell [5]. But the mechanism of inflammation in UC is typically confined in the mucosal cell lining that is the main cause of damage of the bowel wall and ultimately loss of mucosal tight barrier in the intestinal tract [6]. This mechanism has occurred recurrently in the mucosal cell lining leading to bloody diarrhea, which is the most common symptom of UC, although diagnosis is made from a combination of symptoms, endoscopy and histology [6]. The common symptom of UC is not only diarrhea with the blood but also some other symptoms sometimes less found with abdominal pain, body temperature, and weight loss [7]. The different types of UC can be recognized by the extent of the disease such as proctitis, this type of UC is limited to the end of the colon. Proctosigmoiditis is found in the rectum and sigmoid colon. The left-sided and extensive colitis is confined to and beyond splenic flexure [6, 8, 9]. The disease severity of UC is categorized as mild, moderate, severe, and fulminant with stool output category. If the stool output frequency is four per day with or without bloody is called mild, and more than four bloody stools per day is called moderate, more than six bloody stools per day is called severe and more than 10 bloody bowel movements with abdominal distention is called serious or fulminant colitis. UC disrupts not only the intestinal integrity but also predominantly affects the immunologic skin, joining part of the body, vision of eyes, and the most important organ liver [1, 6, 8, 9]. Similarly, different arthritis such as peripheral or axial and narrowing bile duct disease are also accompanying UC [1, 9]. The consequence of pathologic outcome for UC depends on dietary habits and environmental factors that can affect the host immunologic response, and ultimately change the microbiota symbiotic action in hereditarily vulnerable characters [10]. Dietary habits with lower fiber-based processed food and fewer intake of plant-based meals in lifestyle could be attributed to the augmented incidence of UC in the Asian population. A recent review article showed that the risk of UC is inversely associated with the herbal intake, they also found that the risk of UC is directly associated with total fat intake including Omega-6 fatty acids and meat [11].

In that connection food supplements are the important modulators of UC. The dietary habit with high fiber, multivitamins, free amino acids, bioactive compounds for antioxidants may be considered as the effective potential to encourage digestive health [12].

2. Etiology of ulcerative colitis

Even while its specific cause is still unknown, various contributing variables have been implicated such as an immunological response that is out of control, altered gut microbiota, genetic susceptibility, and environmental factors. The etiology of UC is primarily initiated by the invasion of inflammatory molecules to the intestinal tract changing the microbiota and ultimately loss of intestinal integrity causing bloody diarrhea [13]. The actual pathophysiologic pathway of UC remains elusive, but the number of studies postulated that overstimulation of immunologic function and insufficient

control of mucosal barrier integrity leads to cell infiltration and inflammation in the intestinal tract [3]. The gastrointestinal tract is the main part of the body for digestion, absorption metabolism, and control of immunity for normal health. Disruption of this pathway may affect the deregulation of microbiota and mucosal immunological function is the main cause of propagation of UC [14, 15]. Deregulation of normal microbiota may change the pro-inflammatory molecules such as tumor necrosis factor α (TNF-α), interleukin 1β (IL-1β), and IL-6, which are responsible for colonic tissue damage and gut bleeding leading to ulceration of the colon. The intestinal tract contains a lot of microorganisms called microbiota, primarily bacteria; some other organisms including viruses, archaea, and fungi are responsible for inhibiting the gastrointestinal tract [16]. For example, the proteobacteria phylum, among other bacterial species, have been demonstrated as microbial initials in inflammatory bowel disease (IBD) for gut microbiota in IBD patients [17]. The non-eligible function of proteobacteria has been found for the development of IBD. The proteobacteria such as *E. coli*, was found to be disproportionately proliferated leading to the development of IBD [18]. This bacterial proliferation may influence the infiltration of severe and continuing provocative cells in the intestinal lumen. This provocative infiltration predominantly increases the mucosal immunoglobulin G production, subsequently chemoattractant complement activation leading to aggregation, and ultimately enhancement of macrophages and T cells. This cascade of immunological activity is connected with the discharge of inflammatory cytokines, kinins, leukotrienes, platelet-activating factor (PAF), and reactive oxygen metabolites in the gastrointestinal tract for initiation of IBD. The mechanism of these mediators that amplify the immune and inflammatory response not only the main cause but also have deviating effects on epithelial cell function which may increase the permeability, this is the cause of ischemia The mediators may influence on repair mechanisms in the colon, thus increasing the biosynthesis of collagen leading to the fibrosis process in the intestine, one of the causes of the intestinal bleeding. In addition, the acute phase striking forces such as IL-1, IL-6, and TNF-α will activate a chronic response in the intestinal lumen and ultimately. The resulting storm can cause fever in the body with an increased level of serum acute-phase proteins [19–22]. The detailed mechanism of intestinal increased permeability due to the cytokines storm is not completely stated, but an association with increased permeability due to the bacterial translocation into the lamina propria that could exacerbate the loss of tight junction protein and loss of barrier function [20].

3. Summary of possible mechanisms of UC treatment pathway

As the detailed mechanism of UC disease is unclear, so that there are no known single preventive or curative interventions or safe colectomy therapy was found in most of the IBD patients for lifelong [21]. Up to date most of the therapeutic treatments are able to inhibit the beginning of immunological and inflammatory effectors, loss of integrity protein, regulation of inflammatory cytokines, and loss of intestinal barrier mechanisms. These therapeutic strategies may lead to an improvement in the patient's symptoms and decrease inflammatory activity [1]. Several functional compounds and their metabolites may inhibit the UC progression. **Table 1** and **Figure 1** describe the possible mechanisms of UC treatment pathways that are commonly observed in the dextran sulfate sodium (DSS)-induced UC animal model.

Sl. no	Target of the pathways	Functional compounds	Reference
1	By restoration of tight junction protein and maintenance of barrier function.	Omega-3 fatty acid	[20]
2	The activation of transcription factors (PPARγ), possibly inhibiting Nfκ-b transcriptional activity and iκ-b phosphorylation and ERK1/2 pathway.	Omega-3 fatty acid, naringin, fiber and polyphenols, evodiamine, magnolol, eupatilin, terpinen-4-ol and allyl isothiocynate.	[21–29]
3	Inhibition of AMP-activated protein kinase (AMPK)	Fiber and polyphenols of red raspberry Eupatilin (flavonoid) found in the leaves of Artemisia argyi	[24, 26]
4	Restoration of crypts losses	Magnolol from Magnolia officinalis Terpinen-4-ol from Zanthoxylum bungeanum.	[27, 28]
5	Suppression of oxidative stress enzyme such as NOs and COX-2.	Porcine β-defensine-2.	[30]
6	Inhibition of inflammatory cytokines IL-1,IL-1β, IL-6,TNF-α.	short-chain fatty acid such as propionate and antimicrobial peptide like Porcine βdefensine-2	[30–32]
7	Reduced the infiltration of neutrophil.	short-chain fatty acid such as propionate and antimicrobial peptide like Porcine βdefensine-2	[30–32]
8	Inhibition of paracellular migration.	short-chain fatty acid	[32]
9	Reduce epithelial hyper permeability by regulating occluding, ZO-1 ZO-2, claudin1 and E-cadherin junctional adhesion molecule-A (JAM-A), claudin-3, claudin-4, claudin-7, mucin.	short peptide such as Chromofungin, naringin, fiber and polyphenols.	[10, 23, 24, 30, 33–40]
10	Inhibited oxidative stress	Phloretin (a flavonoid available in apples and strawberries)	[34]
11	Ameliorate colitis by regulation of IL-8 and STAT3	Chromofungin	[35]
12	Reduce colon tissue damage	Neuropeptides.	[38]
13	Down regulation of IL-8 and STAT3	Catestin	[39, 40]
14	Inhibited the loss of goblet cells	Phloretin (a flavonoid available in apples and strawberries) Phellinus igniarius (medicinal mushroom) Terpinen-4-ol from zanthoxylum bungeanum Allyl isothiocynate from wasabia japonica	[27, 29, 34, 41]
15	Stabilized intercellular junctions by regulating IL-10	Oleanolic acid	[29, 32, 35]
16	Inhibition of the NLRP3 inflammasome	Phloretin (a flavonoid available in apples and strawberries) Formononetin is a natural isoflavone Evodiamine (an alkaloid obtained from Evodia rutaecarpa) Terpinen-4-ol from Zanthoxylum bungeanum	[25, 27, 34, 36]

Sl. no	Target of the pathways	Functional compounds	Reference
17	Inhibit histological damage	Salvianolic acid a (phenolic compound) found in salvia miltiorrhiza bunge (danshen)	[37]
18	Inhibit leukocyte infiltration	Salvianolic acid a (phenolic compound) found in salvia miltiorrhiza bunge (danshen) Magnolol from magnolia officinalis	[28, 37]
19	Protected against weight loss and colon shortening	Antrum mucosa peptide (amp-18)	[42]
20	Regulation of microbiota in UC patients.	Escherichia coli strain Nissle 1917.	[43]
21	Controlling inflammation by regulating innate and adaptive immune responses	Vitamin d and its receptor	[44]
22	Direct scavenging of reactive oxygen species	Curcumin, a polyphenolic antioxidant	[45]
23	Ameliorate colonic inflammatory responses by modulates mucosal permeability.	Aloe anthraquinones and chromone	[20, 46]
24	Regulation of phase-II-detoxifying enzymes.	Moringa isothiocyanates	[41]
25	Inhibition of bacterial translocation	Isoflavonoids from soybeans and barley	[47]
26	Inhibit edema in the mouse colon	Salvianolic acid a (phenolic compound) found in salvia miltiorrhiza bunge	[37, 48]

Table 1.
Prospective pathways and modulators for minimizing UC (revised from the experiment on dextran sulfate sodium (DSS) induced UC animal).

4. Dietary fermented rice bran (DFRB) as an alternative modulator for ulcerative colitis treatment

The by-product of the rice grain is called rice bran (RB) a valuable and low costing source of biologically active components that is currently available in most regions of the world. It has been possible to improve the quality or make RB edible for humans by using RB procedures such as bacterial fermentation. In contrast to typical raw bran, treated RB or nutritionally enriched dietary fermented rice bran (DFRB) include more basic nutrients such as proximate composition and bioactive compounds [49]. Rice bran is one of the most plentiful agricultural products in Asian countries and is a superb source of nutritional fiber, protein, and fat [50]. RB has been recently claimed for its nutraceutical properties; specific components of the lipid fraction of RB such as tocotrienols, a group of compounds with vitamin E [51]. The difficulty of its use is because of its excessive fiber content material, low protein, and antinutritional elements along with phytic acid [52]. Most of the dietary fiber content in RB belongs to the class of insoluble dietary fiber which may be beneficial for increasing fecal bulk and laxation [53].

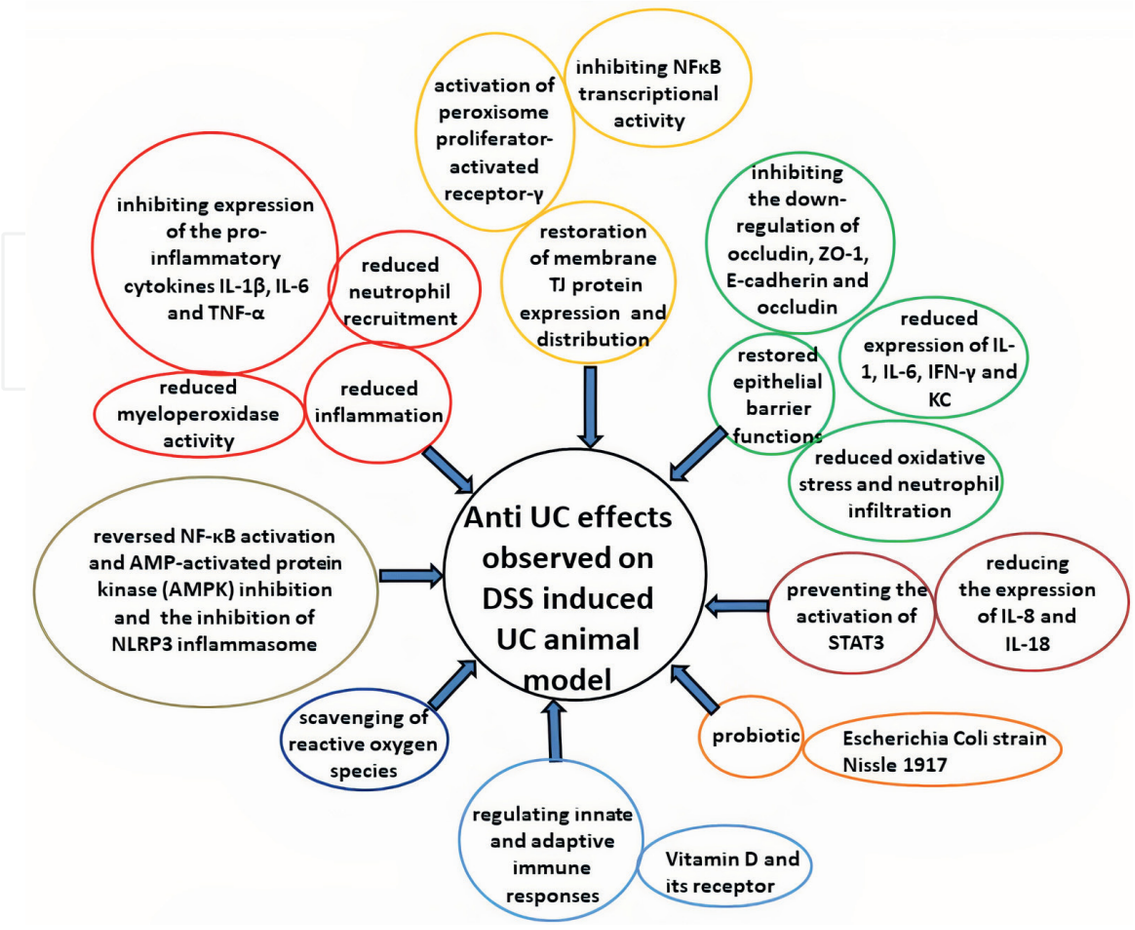

Figure 1.
Anti ulcerative effects observed in experimental animal.

4.1 Nutritionally enriched dietary fermented rice bran

Recent studies have suggested that fermentation can improve their biological activities. Fermenting is the process of naturally gathering wild cultures and yeasts from the air and combining them with an organic substance. During the fermentation process, sugars and starches contained in the feed ingredients are broken down into lactic acid bacteria (LAB). The lactic acid formed by the action of LAB from substrate sugars through pyruvate (a glycolysis end product) plays an important role in food fermentation. Fermentation technology produces not only lactic acid, but also other end products such as ethanol, acetic acid, and formic acid depending on bacterial species and conditions [54]. The lactic acid bacteria produced during fermentation promote the growth of beneficial microbes called probiotics. These improve the digestive system health and boost the immune system. Feed fermentation is a complex process that depends on the nutritional requirements and digestive physiology of animals, the nutritive value of feedstuffs, fermentation characteristics of the microorganisms added to the starter culture, and actual situations on individual farms [55]. Systematic use of bacteria may improve desired food ingredients in the diet.

Previous studies reported that *Bacillus amyloliquefaciens* may successfully produce various enzymes such as αamylase, α-acetolactate, decarboxylase, β-endoglucanase, hemicellulase, phytase, maltogenic amylase, and xylanase, which possess the

potential to degrade fiber [56]. Some lactic acid bacterial strains can produce Exopolysaccharides (EPS), which exert health-promoting effects as a function of prebiotics. The EPS may be responsible for the immunomodulator action [53]. Due to the significant increment of protein content in the fermented rice bran, the quality of this produced compound is the target of interest. Dietary fermented rice bran (DFRB) has been interested in particular for the treatment of unfavorable duodenal inflammation. DFRB supplementation would be able to alter intestinal inflammation caused by DSS-induced colitis. The evidence of DFRB was found to raise the amounts of striking modulators such as short-chain fatty acids and other microbial metabolites in the gastrointestinal tract. Tryptamine is one of them which comes from tryptophan metabolism in the intestine by beneficial microorganisms. The striking modulator metabolites may regulate the intestinal loss of tight junction barrier and ultimately intestinal microbiota homeostasis. The preventive action of DFRB may be partially due to the availability of bioactive compounds during fermentation of rice bran, such as polysaccharides, carbohydrate conjugated proteins, γ-oryzanol, plant sterols, and antioxidant vitamin E. DFRB is very important for the regulation of IBD patients because of fermentation technique make its bioactive compounds more accessible and easier to metabolize. Several studies have pointed out that fermentation technologies enhance the amount of the total phenolic content, short-chain fatty acids, amino acids, and other metabolites that can ameliorate intestinal inflammation. Consequently, it is prospective that DFRB can be used not only as a protective measure but also as a beneficial mediator against an ongoing intestinal inflammation like UC [49, 57–60].

4.2 DFRB as ulcerative colitis modulator

One of the enriched ingredients of DFRB is tryptamine, 5-hydroxytryptamine comes out as bacterial metabolites. These metabolites are considered an effective modulators for the candidate against UC [7, 14]. Tryptophan, one of the boosted constituents in DFRB, is recognized as an effective modulator for UC [7, 14]. Tryptamine and 5-hydroxytryptamine derived from tryptophan, can act as a ligand for the receptor of the aryl hydrocarbon, which modulates immunologic cytokines IL-22 gene production, controls autoimmune, and facilitates fast recovery from colitis in the large intestine. Some insoluble DFRB may also stimulate the microbial proliferation and production of short-chain fatty acids (SCFAs), particularly, acetic acid (AA), propionic acid (PA), butyric acid (BA), and lactic acid (LA), which are strappingly linked with the colonic health in DSS induced UC [15, 49].

A single modulator for the treatment of IBD seems difficult to pinpoint due to the intricate interplay of various variables. For individuals with IBD, the use of biologically effective significant functional compounds such as anti-tumor necrosis factor (TNF) drugs have lowered early surgery. Nevertheless, there are still many difficulties with current treatment intervention and new therapies are highly required. In various experimental murine colitis models, many single substances or combinations made from natural commodities based on traditional usage knowledge have shown promising anti-inflammatory qualities with minimal negative effects and have the potential to be next-generation therapeutics. Even now, clinical studies are being conducted on several plants' small components, including berberine, curcumin, epigallocatechin-3-gallate (EGCG), and triptolide. There is a new IBD treatment in the works, a recovered anti-mycobacterium drug (Oral capsule RHB-104, here, RHB-104 = Red hill biopharma, an investigational drug), now in phase III clinical trials. The current

therapy challenges associated with numerous side effects might be greatly improved by using a suitable and non-invasive IBD medication that targets specific receptors in the colon. Ethnopharmacology-guided drug discovery, with a particular emphasis on tiny molecules and peptides of medicinal plants, has the potential to generate safe and new therapies for IBD. Clinical and histological damage to the colon is both reduced by a cardiotrophin (CT)-1 injection before DSS induction. This effect seems to be done by inhibiting inflammation and apoptosis directly and activating the Stat-3 and nuclear factor kappa B (NF-kB) signaling pathways. Stat-3 and NF-kB CT-1 might potentially be expected to be a feasible, innovative method to prevent UC relapse. A fermented diet was included in the regular diet as a supplement. When given a Fermented diet (FD) with DSS for 7 days, mice did not lose weight or suffer from atrophy of the intestinal length. IL-6 and TNF-_ levels in the mice did not rise after FD treatment, indicating that inflammation was kept under control. People who ate an FPE-enriched diet for 3 months had an increased clostridiales order in their feces, which generates short-chain fatty acids to reduce inflammation. FPE supplementation has been shown to increase the proliferation of Clostridiales in the gut, as well as to reduce inflammation in colitis [61–63].

Another research found that the relative abundance of bacteroidetes species was adversely associated with UC activity and might serve as important microbiological biomarkers to monitor UC disease activity and exacerbation. A reliable and non-invasive method for monitoring UC and establishing personalized therapy might be made possible by identifying components of the microbiome that are associated with disease activity. In mice with inflamed intestines, FRB supplementation helped to heal the damage caused by DSS. DAI scores and the generation of intestinal pro-inflammatory cytokines were reduced by FRB administration. The anti-inflammatory cytokine Il-10, the tight junction component Clad4, and antimicrobial proteins were all considerably increased by FRB supplementation in the gut. This capacity to inhibit both canonical and non-canonical pathways of Tgf-b profibrogenic activity was also able to reduce the development of fibrosis in mice intestines after inflammation. Using FRB supplements to reduce inflammation is not the only way to repair the intestines in people with chronic colitis, according to the findings of this study. It has been postulated that FRB acts as a prebiotic in the gut, but even if intestinal dysbiosis has developed as a result of inflammation, it may still treat colitis. As a result, the role of FRB supplementation on gut microbiota populations and composition has to be studied further [63–65].

In **Figure 2,** three different conditions of intestinal luminal microbial flora. The movement of luminal microbiota and smoothie mucosal protection has been seen in stage 1, generally is regulated by pro-inflammatory cytokines such as IL-10,IL-1β, IL-4,IL-6,TNF-α, and membrane tight junction protein occludin, ZO-1 and E-cadherin etc. indicate normal expression of cell. In stage 2, the changed luminal microbial diversity (dysbiosis), impaired epithelial, and mucus layer barrier via disruption of tight junctions expressed the intestinal inflammation mediated by Dextran sodium sulfate (DSS). Usually, DSS induced inflammation prompts to disruption of the mucosal layer, with an increased loss of crypts, inflammatory cell infiltration, increased MPO activity, and pro-inflammatory cytokine transcript (Tnf- α, Il-1 β, Il-6, and Il-17) associated with excessive intestinal epithelial permeability via the tight junction of epithelial and by increasing luminal antigen uptaking. That's how Toll-like receptors recognize non-pathogenic bacteria (commensal microbiota) and activate antigen-presenting cell (e.g. TLRs) APC activated T-cells become Th-2 effector cells (which produce

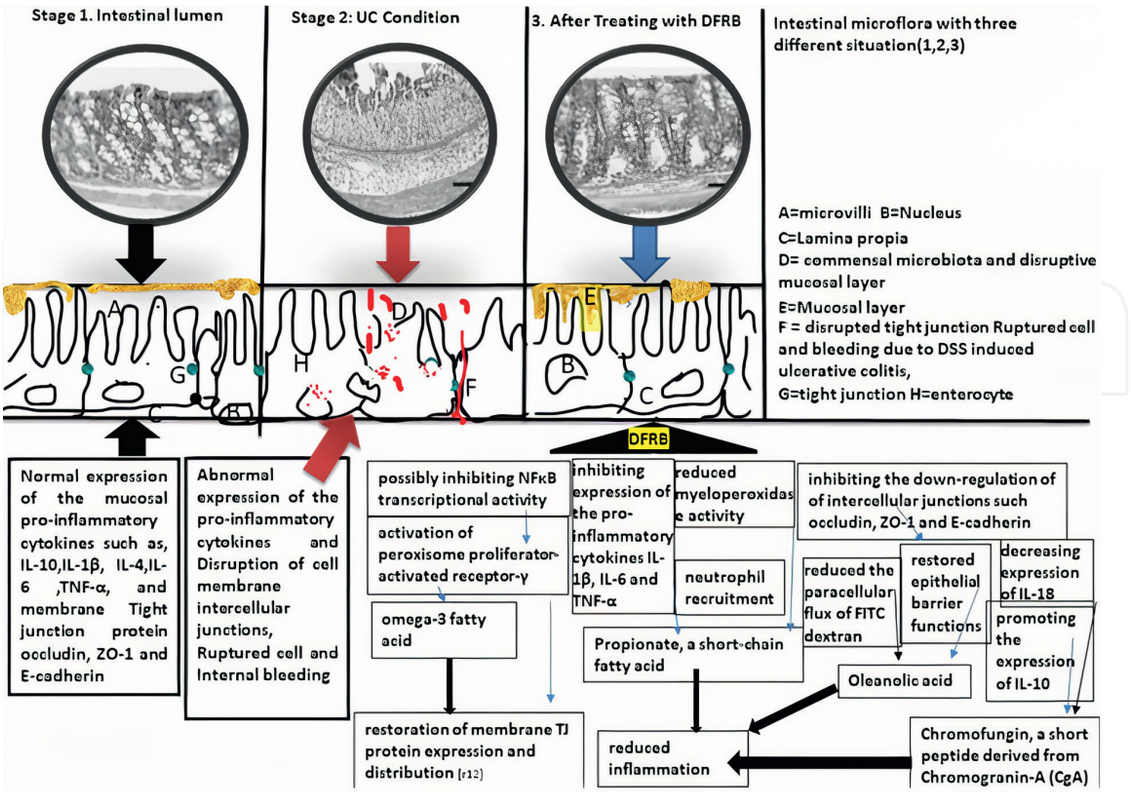

Figure 2.
A simple fictional image of enterocytes associated with normal behavior, inflammatory condition and after treatment with DFRB (review from [62, 67]).

pro-inflammatory cytokines like TNF-, IL-5, IL-6, and IL-13). TNF and IL-1 activate the NF-B pathway, promoting pro-inflammatory and cell survival genes.

The mucin generation and epithelium integrity appeared in the 3rd stage of this fictional image of intestinal lumen after treating with DFRB and it has been proved by Islam (2017) that, this incidence is facilitated by increased SCFA levels in the colon via inducing colonic regulatory T cells and reducing UC. Also, apoptosis can be induced in mutated epithelial cells through innate immune cell-driven inflammation. To maintain colonic homeostasis and intestinal barrier integrity, these activities are essential. Thus, the integrity of the intestinal barrier helps not only to maintain a healthy relationship between the intestinal microbes and the host but in addition to being a physical barrier, it also serves as a barrier to the entry of invading microorganisms pathogenic microorganisms or their toxins can be detected by an organism's immune system. Tight junctions (TJs) are made up of occludin and a variety of other proteins (OCLN) and claudin (CLDN), which are primarily responsible for determining the integrity of the intestinal barrier. TJs can be found here. At the ends of the epithelial cell's lateral membrane, the loss of TJ barrier integrity is linked to the onset and progression of UC.

The study has shown that transcription factor named by aryl hydrocarbon receptor (Ahr) regulates the expression of IL-22 genes, controls autoimmunity processes, and promotes rapid recovery from colitis by binding to tryptophan-metabolites in the microbiota. DFRB might boost up the microbial power generation of short-chain fatty acids (SCFAs), such as AA, PA, BA, LA, which are intimately connected to colonic health of us, might even be a result of DFRB [61, 66].

5. Future perspective

A number of fermentation studies on rice bran indicated that the process is capable of producing short-chain fatty acids such as acetic acid, propionic acid, butyric acid, lactic acid, enzymes such as protease amylase, phenolic compound, and antioxidant compound like vitamin E as well as secondary metabolites such as griseofulvin, etc. for treatment of UC [67–74]. Previous studies also indicated that it is possible to change the lipid and phospholipid composition and phenolic acid content and antioxidant activities of rice bran would be the effect modulators for the treatment of UC [75, 76]. In the future, the possibility of DFRB would be the natural source of modulators for the potential regulators of the disease burden. The single-component of DFRB such as short-chain fatty (like Propionate), omega-3 fatty acid (like eicosapentaenoic and docosahexaenoic acid), fibers (both soluble and insoluble), polyphenols (oleanolic acid and salvianolic acids), and even vitamins (C, D, E) may be responsible for specific modulators in the maintenance of gastrointestinal tract health. The detailed experimental data is still needed worldwide. These vibrant modulators could be produced by using suitable variants of bacteria and fungi for fermentation as well as by using recombinant technology to modify the bacteria and fungi for a specific purpose. However, variations in the conformation of duodenal microorganisms are generally responsible for the establishment of gut health in patients with UC. Furthermore, DFRB influences not only the attendance of gastric microbiota but also modulates their metabolites. The interchange of microbes and metabolites by the DFRB would be a good modulator to alter the intestinal defense mechanism against mucosal inflammation for the treatment of UC [23]. The DFRB also modulates impaired DNA integrity that occurs during oxidation after the intestinal inflammation [24]. Hence, the DFRB would be a good candidate for therapeutic treatment of UC rather than a preventive measure, but this scenario still requires many animal experiments. This is a significant peculiarity of DFRB to make a potential modulator, especially in the case of IBD. Whereas the treatments of IBD are generally aimed to prevent a flare-up of enduring inflammation and to hinder its development into an irreversible state such as stricture and altered colonic motility and permeability [66].

6. Conclusions

The availability of bioactive components in DFRB, such as dietary fiber, vitamins, free amino acids, and antioxidants, ensures the potential of DFRB to improve the health of the gastrointestinal tract (gastrointestinal health). By utilizing fermentation technology, it is possible to incorporate many more nutrients into rice bran, particularly potential UC modulators, than are currently available. The nutritional content of rice bran is typically determined by the fermented organism, the length of time the bran has been fermented, and the source or types of rice bran used. A high level of concentration is required to isolate the specific bacteria, fungi, or yeast that is capable of producing the desired fatty acids, fibers, vitamins, amino acids, anti-inflammatory, antioxidants, and other compounds in fermented rice bran. Using recombinant technology, it may be possible to produce the desired microorganisms for use in the fermentation process, which would then be used to introduce desired nutrition into the DFRB. This will also be beneficial in the treatment of other metabolic conditions in addition to UC colitis.

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Authors contribution

Md. Alauddin conceived the study design and manuscript preparation. AFM Nazmus Sadat carried out suggestions and data analysis. All the authors contributed to analysis and Afroza sultana contributed to manuscript writing. Md. Alauddin approved the final version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

Appendices and nomenclature

UC	Ulcerative colitis
IBD	Inflammatory bowel disease
DFRB	Dietary fermented rice bran
CD	Crohn disease
TNF-α	Tumor necrosis factor α
L-1β	Interleukin 1beta
IL-6	Interleukin 6
PAF	Platelet-activating factor
DSS	Dextran sulfate sodium
NF-kB	Nuclear factor kappa B
AMPK	AMP-activated protein kinase
FITC dextran	Fluorescein isothiocyanates–dextran
Zo	tight junction protein
JAM-A	E-cadherin junctional adhesion molecule-A
STAT3	Signal transducer and activator of transcription 3, transcription factor
LAB	Lactic acid bacteria
EPS	Exopolysaccharides
Ahr	Aryl hydrocarbon receptor
Profibrogenic cytokine e.g. TGF-β1.	
SMDs	Small-molecule medicines (such as tofacitinib and 5-ASA derivatives mesalamine)
Tj	Tight junction
AA	Acetic acid
PA	Propanoic acid
BA	Butyl acid

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