Effects of Germinated Barley Foodstuff on Microflora and Short Chain Fatty Acid Production in Dextran Sulfate Sodium-induced Colitis in Rats.

Yoshio ARAKI,1 Akira ANDOH,2 Shigeki KOYAMA,2 Yoshihide FUJIYAMA,2 Osamu KANAUCHI,3 and Tadao BAMBA2

1Department of Internal Medicine, Nagahama Red Cross Hospital, 14-7 Miyamae-chou, Nagahama, Shiga 526-8585, Japan
2Department of Internal Medicine, Shiga University of Medical Science, Seta Tukinowa, Otsu, Shiga 520-2100, Japan
3Applied Bioresearch Center, Corporate Research and Development Division, Kirin Brewery Co. Ltd., 3 Miyaharacho, Takasaki, Gunma 370-12, Japan

Received September 28, 1999; Accepted May 17, 2000

Germinated barley foodstuff (GBF) administration has been previously reported to suppress dextran sulfate sodium (DSS)-induced experimental colitis. In this study, we investigated the roles of the intestinal microflora and short chain fatty acids (SCFAs) following administration of GBF in DSS-induced rat colitis. Sprague-Dawley rats were fed 3% (w/w of diet) DSS in GBF-diets for 5 days. The control rats were fed 3% DSS in cellulose-diets for 5 days. The administration of GBF effectively prevented bloody diarrhea and mucosal damage as compared to control rats. GBF significantly elevated fecal acetic acid and n-butyric acid levels. GBF tended to increase the number of eubacteria and that of bifidobacteria as compared to control rats. In addition, the number of enterobacteriaceae, the total number of aerobes and bacteroides, were significantly lower in rats fed GBF than in the control group. It is suggested that the therapeutic effects of GBF for DSS-induced colitis depend mainly on increased SCFAs, which are accompanied by changes of composition of intestinal bacteria.

Key words: germinated barley foodstuff; microflora; dextran sulfate sodium-induced colitis; short chain fatty acids; eubacteria

Short chain fatty acids (SCFAs), such as acetic acid, propionic acid, and butyric acid are produced from carbohydrates (including dietary fiber, resistant starch, and mucus) that reach the colon. They exert a variety of effects, including the fueling of colonocytes1) and the maintenance of electrolytes and water balance, in addition to antineoplastic effects.2)

Previous studies have reported that a certain type of dietary fiber, germinated barley foodstuff (GBF) derived from the aleurone and scutellum fraction of germinated barley, ameliorated dextran sulfate sodium (DSS)-induced experimental colitis in rats,3) which is similar to human ulcerative colitis.4) In addition, GBF feeding increased the fecal SCFA levels in healthy humans and in ulcerative colitis (UC) patients5) without the adverse effects which are observed with other kinds of dietary fibers.6,7) However, the mechanisms of this amelioration and the alteration of microflora in the colon are still under investigation.

The aim of this study was to further investigate the therapeutic mechanisms of GBF on DSS-induced colitis in rats. Accordingly, alterations in fecal SCFA concentration and intestinal microflora were observed in this experimental model.

Materials and Methods

Germinated Barley Foodstuff. GBF (KRD-7181, Kirin Brewery Co., Gunma, Japan) was fractionated from beer spent grain by milling and sieving.8,9) GBF is composed of the aleurone layer, germ, and scutellum of germinated barley, and contains both glutamine-rich proteins and dietary fibers, mainly hemicellulose. The chemical composition of GBF is shown in Table 1.

Animals. Male Sprague-Dawley rats, 8 weeks old, were purchased from Nippon Clea Inc. (Tokyo, Japan). They were housed in a room with controlled temperature (20-22℃), humidity (50 ~ 60%), and a preset light-dark cycle (12 h: 12 h). The experimental protocol was approved by the Animal Care and Use Committee at the Shiga University of Medical Science, Shiga, Japan.

Rat DSS colitis. The rats were divided into two...
groups, each group consisting of five rats. The two groups were fed either cellulose (CE) as the control diet or the GBF diet for 7 days during the acclimatization period. After acclimatization, 3% (w/w of diet) DSS (molecular weight 5000, total sulfur 15.0 – 20.0%); Wako Pure Chemical, Osaka, Japan) was then administered to each group for another 5 days. The rats were allowed free access to food and drinking water. The compositions of the respective diets are summarized in Table 2. The total volume of protein and dietary fiber was adjusted to the same levels in both groups (protein, 14.6% and dietary fiber, 3.0% in the diet). During the experimental period, food intake and body weight were measured every day.

**Wet weight of the colon, the area of mucosal damage, and the damage score.** On the final day of the experiment, the rats were anesthetized with an intraperitoneal injection of pentobarbital sodium (40 mg/kg). After the rats had been killed by decapitation, body weight was measured and a laparotomy was done. The large intestine from the anus to the cecocolonic junction was resected, irrigated with chilled saline, and then cut along the anti-mesenteric border. After the wet colonic weight was measured, the mucosa was photographed and the area of mucosal damage (as evidenced by a color change to purple and red, structural changes with irregular folds, edema, and erosion) was measured using an image analysis apparatus (NIH image version 4.0/Macintosh) for the macroscopic evaluation.

To evaluate microscopic changes, a tissue specimen (10 × 10 mm) was removed 1 cm from the anal margin, fixed in Carnoy’s fixative, and embedded in paraffin. Histological samples were then cut into 5-μm sections, and stained with hematoxylin and eosin after de-paraffinization. The mucosal damage was evaluated by a previously described method. Briefly, the following three parameters were used: surface epithelium loss, crypt destruction, and inflammatory cell infiltration of the mucosa. A score of 0–4 was assigned to each of three parameters according to the extent and severity of change, such as 0 = no change, 1 = localized and mild, 2 = localized and moderate, 3 = extensive and moderate and 4 = extensive and severe. The sum of the scores of the three parameters represented the mucosal damage score in each animal.

In addition, toluidine blue staining (pH 2.5) was also done to evaluate sulfated polysaccharides in the mucosa.

**Table 1. Chemical Composition of GBF**

<table>
<thead>
<tr>
<th>Composition</th>
<th>% weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>7.8</td>
</tr>
<tr>
<td>Protein</td>
<td>46.0</td>
</tr>
<tr>
<td>Lipids</td>
<td>10.2</td>
</tr>
<tr>
<td>Ash</td>
<td>2.0</td>
</tr>
<tr>
<td>Dietary fiber</td>
<td>34.0</td>
</tr>
<tr>
<td>Nitrogen-free extracts</td>
<td>0.0</td>
</tr>
<tr>
<td>Composition of dietary fiber</td>
<td></td>
</tr>
<tr>
<td>Cellulose</td>
<td>26.0*</td>
</tr>
<tr>
<td>Hemicellulose</td>
<td>54.1*</td>
</tr>
<tr>
<td>Lignin</td>
<td>19.9*</td>
</tr>
</tbody>
</table>

GBF: Germinated barley foodstuff.

* As neutral detergent fiber.

**Table 2. Composition of Experimental Diets (g/kg diet)**

<table>
<thead>
<tr>
<th>CE</th>
<th>GBF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casein</td>
<td>146.0</td>
</tr>
<tr>
<td>Vitamin mixture</td>
<td>10.0</td>
</tr>
<tr>
<td>Mineral mixture</td>
<td>35.0</td>
</tr>
<tr>
<td>Choline chloride</td>
<td>2.0</td>
</tr>
<tr>
<td>Cellulose</td>
<td>30.0</td>
</tr>
<tr>
<td>GBF</td>
<td>100.0</td>
</tr>
<tr>
<td>DSS</td>
<td>30.0</td>
</tr>
<tr>
<td>Corn oil</td>
<td>50.0</td>
</tr>
<tr>
<td>Corn starch</td>
<td>727.0 (697.0)</td>
</tr>
</tbody>
</table>

**CE, GBF:** Basic diets containing cellulose, germinated barley foodstuff respectively.

DSS: dextran sulfate sodium.

* Vitamin and mineral mixtures were prepared according to the American Institute of Nutrition 93 formula (35).

**SCFAs concentration in the cecal contents.** Cecal contents were removed immediately after the laparotomy was done. SCFAs and organic anions (lactic acid and succinic acid) in the cecal contents were measured using HPLC with a minor modification of previously published methods. Briefly, after the addition of crotonic acid as an internal standard, 2 ml of distilled water was added to 400 mg of the sample. After mechanical shaking and centrifugation at 10000 rpm for 10 minutes, the supernatant was filtered through a membrane filter (pore size 0.45 μm). SCFAs in these samples were then separated with an ion-exclusion column (Shodex Rspak KC-811, 8 mm ID × 30 cm long, Showa Denko. Co., Ltd., Tokyo, Japan), and were detected using the pH indicator bromothymol blue as the postcolumn reagent. The column temperature was 60°C, and the mobile phase was a 0.75 mM aqueous sulfuric acid solution (flow rate: 0.8 ml/min.). The postcolumn reagent was an aqueous solution of 0.2 mM bromothymol blue-15 mM disodium hydrogen phosphate adjusted to pH 8.6 (flow rate: 0.8 ml/min.). UV absorption at 450 nm was used for detection.

**Bacteriological studies in the cecal contents.** The
cecal contents were collected and the aerobic and anaerobic type strains of the microflora were investigated using a slight modification of previous methods. Briefly, samples were serially diluted with dilution solution in a CO₂ environment. Each diluted sample was plated on differential media. In particular, anaerobes were enumerated on CDC anaerobic blood agar (Nissui Pharmaceutical Co., Ltd., Tokyo, Japan) and Brucella Hk agar (Nissui Pharmaceutical Co., Ltd.). Bifdobacteria were enumerated on BL agar (Nissui Pharmaceutical Co., Ltd.), lactobacilli on LBS agar (Nippon Becton Dickinson Co., Ltd., Tokyo, Japan), Clostridium perfringens on agar CW (Nissui Pharmaceutical Co., Ltd.), and Bacteroides fragilis group on BBE agar (Nippon Becton Dickinson Co., Ltd.). Plated media were incubated in an anaerobic environment (AnaeroPack, Mitsubishi Gas Chemical Co., Tokyo, Japan) at 37°C for 72 hours.

Differentiation of the microflora was done by 1) investigation of colony formation, microscopic finding under Gram staining and count of colony forming units per gram of wet sample, 2) investigation of growth under aerobic conditions, 3) analysis of acid production using HPLC (in the same manner as described in SCFAs concentration in the cecal contents) and 4) analysis of biochemical reaction using commercial kits (API 20A and rapid ID 32A, Bio Merieux Co., Tokyo, Japan).

Statistics. All data were expressed as means ± SEM. Data were compared using Student’s t-test for unpaired data (two-tailed). In all statistical analyses, a p value of <0.05 was considered to be statistically significant.

Results

Wet weight of the colon, the area of mucosal damage, and the damage score

In the CE-group of rats, diarrhea occurred on days 2–3 and macroscopic bloody stools appeared on days 4–5. In the GBF-group of rats, however, diarrhea did not occur until day 5 and macroscopic bloody stools did not appear. None of the rats died during the experimental period. The dietary intake of each group was comparable (30.3 ± 6.5 g/day and 28.0 ± 5.9 g/day in the CE- and GBF-group, respectively). No significant differences in body weight gain or wet weight of the colon were observed between the two groups during the experimental period (21.3 ± 5.2 g and 23.6 ± 4.2 g in body weight gain, 2.4 ± 0.7 g and 2.1 ± 0.6 g in wet weight of the colon, in the CE- and GBF-group, respectively). No significant differences in the weight of cecal contents were observed between the two groups (0.9 ± 0.3 g and 1.1 ± 0.4 g in the CE- and GBF-group, respectively).

Macroscopic examination of the colon revealed formation of hyperemia, erosion, and occasional tiny blood coagula, which were observed mainly in the rectum, in any group of rats. However, this evidence of mucosal damage was significantly reduced in the GBF-group of rats, as compared to the CE-group of rats (Fig. 1).

Histological findings

HE staining revealed conspicuous evidence of inflammatory cell infiltration into the mucosa and submucosa in both groups of rats (Fig. 2). Crypt loss and surface epithelial loss were also evident. Mucosal damage was measured using a scoring system, as shown in Fig. 1. Mucosal damage scores in the GBF-group of rats were significantly lower than those of the control rats.

On the other hand, toluideine blue staining revealed some mast cells and many macrophages containing DSS particles with metachromasia in the submucosa of both groups of rats to the same extent, indicating that DSS entered the mucosa and submucosa in both groups to the same extent. (Fig. 3).

SCFAs concentration in the cecal contents

The concentrations of SCFAs at the end of the experiment are shown in Table 3. The concentrations of both acetic acid and n-butyric acid were significantly increased in the GBF-group of rats as compared to the CE-group of rats. There were no significant differences in formic acid, propionic acid, iso-butyric acid, n-valeric acid or iso-valeric acid concentration between the CE-group of rats and the GBF-group of rats. Similarly, there were no significant differences in lactic acid or succinic acid concentration between the
Effects of Germinated Barley Foodstuff on Microflora and Short Chain Fatty Acids.

Fig. 2. Histological Findings.
Tissue specimens were removed 1 cm from the anal margin and fixed in Carnoy’s fixative. The histological samples were then stained with HE. (A) A cellulose (CE)-group rat. (B) A germinated barley foodstuff (GBF)-group rat. (× 100 magnification).

Table 3. Short Chain Fatty Acid Concentration in the Cecal Contents

<table>
<thead>
<tr>
<th>SCFAs</th>
<th>CE</th>
<th>GBF</th>
</tr>
</thead>
<tbody>
<tr>
<td>lactic acid</td>
<td>3.61 ± 1.93</td>
<td>0.49 ± 0.18</td>
</tr>
<tr>
<td>succinic acid</td>
<td>0.21 ± 0.07</td>
<td>0.07 ± 0.03</td>
</tr>
<tr>
<td>formic acid</td>
<td>0.14 ± 0.08</td>
<td>0.09 ± 0.06</td>
</tr>
<tr>
<td>acetic acid</td>
<td>9.22 ± 1.35</td>
<td>21.75 ± 2.46**</td>
</tr>
<tr>
<td>propionic acid</td>
<td>4.24 ± 1.27</td>
<td>4.01 ± 1.08</td>
</tr>
<tr>
<td>iso-butyric acid</td>
<td>0.31 ± 0.13</td>
<td>N.D.</td>
</tr>
<tr>
<td>n-butyric acid</td>
<td>1.44 ± 0.29</td>
<td>5.02 ± 1.47*</td>
</tr>
<tr>
<td>iso-valeric acid</td>
<td>0.26 ± 0.10</td>
<td>0.28 ± 0.18</td>
</tr>
<tr>
<td>n-valeric acid</td>
<td>0.38 ± 0.26</td>
<td>0.13 ± 0.10</td>
</tr>
</tbody>
</table>

After feeding of each diet for 5 days, the individual fecal short chain fatty acid (SCFA) concentration (× 10−6 mol/g cecal contents) in cellulose (CE)-group of and germinated barley foodstuff (GBF)-group of rats was measured by HPT.C. Values are expressed as mean ± SEM. N.D.: not detectable.

*p<0.05 vs CE-group of rats, **p<0.01 vs CE-group of rats by Student’s t-test for unpaired data (two-tailed).

timate the contribution of SCFAs to the amelioration of DSS-induced colitis. Only the sum of the acetic acid, propionic acid, and n-butyric acid concentration had a strong correlation with the damaged area (R = 0.69, p < 0.05).

Not only in the concentration, but also in the volume mass calculated with the weight of the cecal contents (total volume of individual SCFA in the cecal lumen), these findings were adapted.

Bacteriological studies in the cecal contents
Table 4 summarized the aerobic and anaerobic microbes respectively, in the cecal contents at the end of the experiment. With regard to anaerobes, GBF administration tended to increased eubacteria and bifidobacteria as compared to levels of the CE-group of rats. In contrast, GBF administration significantly decreased bacteroidesae as compared to the CE-group of rats. With regard to aerobes, GBF administration significantly decreased enterobacteriaceae and total aerobes, as compared to the CE-group of rats.

Not only in the CFU counts per g cecal contents, but also in the total counts calculated with the weight of the cecal contents (total counts in the cecal lumen), these findings were adapted.
Table 4. Bacteriological Study of the Cecal Contents

<table>
<thead>
<tr>
<th></th>
<th>CE</th>
<th>GFB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterobacteriaceae</td>
<td>9.22 ± 0.12 (5/5)</td>
<td>8.68 ± 0.13 (5/5)</td>
</tr>
<tr>
<td>Streptococci</td>
<td>9.70 ± 0.05 (5/5)</td>
<td>9.26 ± 0.24 (5/5)</td>
</tr>
<tr>
<td>Total aerobes</td>
<td>9.84 ± 0.05</td>
<td>9.40 ± 0.17</td>
</tr>
<tr>
<td>Bacteroidaceae</td>
<td>9.40 ± 0.07 (5/5)</td>
<td>8.96 ± 0.13 (5/5)</td>
</tr>
<tr>
<td>Bifidobacterium</td>
<td>8.44 ± 0.09 (5/5)</td>
<td>8.70 ± 0.24 (5/5)</td>
</tr>
<tr>
<td>Eubacteria</td>
<td>7.90 ± 0.21 (4/5)</td>
<td>8.34 ± 0.15 (5/5)</td>
</tr>
<tr>
<td>Lactobacilli</td>
<td>9.14 ± 0.08 (5/5)</td>
<td>9.20 ± 0.17 (5/5)</td>
</tr>
<tr>
<td>Total anaerobes</td>
<td>9.64 ± 0.05</td>
<td>9.64 ± 0.11</td>
</tr>
</tbody>
</table>

Colony forming units (CFU) of aerobic (upper) and anaerobic (lower) microflora.
CE indicates cellulose-group of rats and GFB germinated barley foodstuff-group of rats.
Data are expressed logarithmically (CFU/g cecal contents).
Values are expressed as mean ± SEM.
Parentheses indicates the ratio of detectable samples per total samples.

Discussion

Increased interest in fermentable fiber has occurred in recent years due to its apparently beneficial effects on the human gastrointestinal tract. Dietary fiber is well known to have beneficial effects in humans, for example improvement of constipation, reduction in serum cholesterol, and excretion of carcinogenic compounds into feces.\(^6,7\) It is widely accepted that the beneficial effects of these described effects of dietary fiber are mainly caused by its binding or bulking character.\(^7\)

Researchers, however, have also focused on the effects of fiber on colonic mucosal integrity and the products of colonic fermentation, SCFAs. SCFAs are produced from carbohydrates and exert a variety of effects in the gut lumen.

In addition, the relative efficacy of the SCFAs products has been reported to differ between various types of fiber, such as wheat bran, oat bran, pectin and cellulose.\(^8\)

GFB is fractionated from beer spent grain by milling and sieving.\(^9,10\) GFB is composed of the aleurone layer, germ, and scutellum of germinated barley. In addition, GFB contains both glutamine-rich proteins and dietary fiber, most notably low-lignified hemicellulose,\(^11,12\) which is fermented by microflora in the gut lumen, producing SCFAs, especially butyric acid.\(^13\)

We previously reported that GFB was efficiently fermented by microflora, especially by *Bifidobacterium breve* JCM 1192, *Bifidobacterium longum* JCM 1217, *Lactobacillus acidophilus* JCM 1132, and *Clostridium butyricum* JCM 1391 in an *in vitro* experiment.\(^14\) In contrast, cellulose is more difficult to ferment and produces fewer SCFAs.\(^15\) Previous studies have also revealed the therapeutic effects of GFB on DSS-induced colitis in rats\(^5\) and the capability of GFB to increase the fecal SCFA concentration in healthy humans.\(^20\) Recently, a pilot study revealed that 30 g per day of GFB significantly reduced the clinical activity index scores, and the endoscopic index scores of UC patients.\(^5\) The authors suggested strongly that the therapeutic effects depend on the colonic SCFA levels. Although it is certain that oral GFB administration elevates the fecal SCFA levels and exerts some therapeutic effects on the inflamed and intact mucosa, the role of microflora, which produces the luminal SCFAs, in this process is not well understood.

The aim of this study is to investigate alterations in the microflora and SCFA levels in the gut lumen following the administration of GFB and to evaluate the therapeutic effects in DSS-induced colitis in rats after the administration of GFB.

DSS is a certain type of sulfated polysaccharide. DSS was administered via solid diets, as described in a previous study,\(^13\) in this study. In this model, the development of colitis is dependent on the molecular weight and sulfation of the DSS, in addition to the dosage and duration of DSS administration.\(^22\) As pathogenic factors in the development of DSS colitis, previous reports have postulated the importance of various factors; e.g., local immunological disturbance,\(^23\) activation of mucosal macrophages,\(^23\) effects related to the strong negative charge of DSS,\(^24\) obliteration of the crypt lumina,\(^25\) and changes in the intestinal microflora.\(^20\) However, the precise etiology of this model is unclear. In the our study, colitis was induced only in the distal parts of the colon in a fashion similar to human ulcerative colitis in accordance with the previous report.\(^31\) Therefore, we evaluated the inflammation at the most severe lesions, in the rectum.

Result revealed that GFB administration significantly reduced DSS-induced colitis and significantly increased fecal acetic acid and n-butyric acid production. In general, bacterial fermentation of dietary fiber in the colon does not necessarily change fecal SCFA concentration because absorption may be greater than the rate of formation of SCFAs.\(^27\) Therefore, the degree of increase in acetic acid and n-butyric acid concentration noted in this study is marked.

Because of the heterogeneous nature of GFB, the
mechanisms of its preventive action are not fully understood. In this study, the sum of the acetic acid, propionic acid, and n-butyric acid concentrations was strongly correlated with the area of colonic damage. Therefore, it is possible that the protective effects were largely, if not entirely, attributable to the predominant SCFAs, acetic acid and n-butyric acid, derived from GBF.

Our previous in vivo study showed that GBF administration significantly increased bifidobacteria and eubacteria in the feces of healthy volunteers. In addition, our previous in vitro study showed that bifidobacteria produced lactic acid and acetic acid in peptone-yeast (PY) containing GBF as a sole source of carbon. Eubacteria produced n-butyric acid, acetic acid, and lactic acid in the same medium. Bifidobacteria coexisted with eubacteria produced effectively more acetic acid and n-butyric acid in the same medium. In this in vivo study, it is possible that these increased bifidobacteria and eubacteria induced by GBF strongly contribute to production of SCFAs and amelioration of DSS-induced colitis in rats although it is difficult to examine the complicated relationships among intestinal bacteria. In addition, a previous study reported that the SCFAs produced regulated the bacterial population in the colon. SCFAs, especially acetic acid, propionic acid, and butyric acid, increased the growth of bifidobacteria and inhibited the growth of some Gram-negative facultative and obligatory microorganisms. Actually, GBF administration significantly reduced the bacteroidaceae and total aerobes. Therefore, it is possible that these interactions between the intestinal microflora, GBF and SCFAs contribute to the amelioration of DSS-induced colitis. In addition, a previous researcher suggested that DSS increases potentially bacteroidaceae, resulting in production of colonic inflammation. According to their finding, GBF administration may maintain the suitable environment for colonic mucosa.

However, we could not evaluate clearly how SCFAs contributed to the amelioration of DSS-induced colitis.

In a preliminary study, the binding capacity of GBF for DSS was evaluated by measuring the alteration of electric conductivity of DSS solution. GBF did not adsorb DSS to any detectable level (under contribution data). In addition, histological examination using toluidine blue staining showed that macrophages containing DSS in their cytoplasm were found in both groups of rats to the same extent. These results strongly suggest that the amelioration of colitis was not due to the elimination of DSS by GBF.

It remains possible that other mechanisms excluding SCFAs contributed to the amelioration of colitis. GBF contains protein abundant in L-glutamine (Gln), which is tightly complexed to the dietary fiber. Barley synthesizes Gln and Gln-rich proteins, and uses Gln as a major energy source during germination and later growth. Gln has many physiological functions in the intestine, including its role as a major energy source for intestinal epithelial cells, and its stimulatory effects on intestinal epithelial cell proliferation. In general, Gln is very easily broken down if present in the free form. Gln in GBF may exist in a very stable form protected by coexisting dietary fibers, and may resist being broken down by gastric acid, thus it may act on the mucosa more effectively than native Gln. Previous study has reported that GBF elevates mucosal protein, DNA and RNA as well as mucosal sucrase activity in normal rat small intestine, maybe through its Gln derived from GBF, although how the bulky effect of GBF and colonic SCFAs derived from GBF contributed to the trophic effects on the small intestine remains unclear. It is impossible to rule out the possibility of Gln derived from GBF exerted the present beneficial effects on DSS-induced colitis.

In this study, the possibility of GBF as a novel tool for treatment and prevention of inflammatory bowel disease (IBD), the etiology of which may involve impaired SCFA metabolism in the colonic mucosa, was suggested. In addition, it may be possible that GBF exerts the therapeutic effects as an anti-neoplastic agent, in some colonic diseases such as colon cancer and familial polyposis and so on, through its effects on SCFA production. GFB is a very safe foodstuff. The conventional source of GBF is brewer’s spent grain and GFB has long been fed to cattle and sold to humans as a source of dietary fiber in some countries.

References

6) Pattee, P. L., and Thompson, W. G., Drug treatment

Effects of Germinated Barley Foodstuff on Microflora and Short Chain Fatty Acids. 1799
12) TOSOH Separation Report, No. 076 and No. 080.