Use of Insoluble Dietary Fiber and Probiotics for Bowel Preparation Before Colonoscopy: A Prospective Study

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Background: In screening colonoscopy, patients usually have to ingest large amounts of bowel-cleansing agents, including polyethylene glycol (PEG). This is difficult and has various side effects; thus, patients avoid undergoing a colonoscopy. We tested a novel bowel preparation method before colonoscopy using insoluble dietary fiber and probiotics (PB).

Methods: This was a prospective clinical study conducted between October 2018 and March 2019 at a general hospital. Forty participants were randomly assigned to low-volume PEG solution diet (MoviPrep), wheat bran fiber (WBF) and probiotic *Bifidobacterium animalis* subsp. *lactis* GCL2505 (PB GCL2505), or standard-volume regimen (1.0 to 1.5 L of MoviPrep) (control group). The patient compliance and the quality of bowel preparation were evaluated.

Results: Forty individuals aged 38 to 83 years were randomly assigned to the WBF with PB (n = 20) and control (n = 20) groups. All participants underwent bowel preparation before colonoscopy according to each protocol. The mean required volume of MoviPrep was significantly lower in the WBF with PB group than in the control group (582.5 vs. 1305 mL, $P < 0.0001$). Successful bowel-cleansing rates were not significantly different between the 2 groups; however, the ratio of the Harefield Cleansing Scale grades C and D was significantly lower in the WBF with PB group than in the control group ($P = 0.0471$).

Conclusions: The intake of WBF and GCL2505 before colonoscopy reduces the required PEG quantities while maintaining bowel-cleansing quality. This novel, minimally invasive pretreatment method makes colonoscopy more accessible contributing to the prevention and early treatment of colorectal cancer.

Key Words: colonoscopy, dietary fiber, probiotics, bowel preparation, cancer screening

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The authors declare no conflicts of interest.

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To ensure high-quality screening colonoscopy, adequate bowel-cleansing is essential. In recent years, the morbidity and mortality rates of colorectal cancer have been increasing globally.[1] Currently, colonoscopy is the most effective method in preventing the occurrence of colorectal cancer or detecting colorectal cancer at an early stage so that superficial cancers can be resected.[2] Nevertheless, participation rates for colonoscopy are unsatisfactory. For example, participation rates range from 20% to 39% in most countries.[3–6] One of the major reasons the patients avoid undergoing colonoscopy is the need to ingest large amounts of bowel-cleansing agents, including polyethylene glycol (PEG) for bowel preparation, which may cause various side effects, such as nausea and hypotension, dehydration, and intestinal obstruction. Furthermore, forced irrigation of the intestinal tract with a large amount of intestinal lavage may adversely affect the intestinal flora.

To resolve these challenges, we developed a novel method that reduces the dose of bowel-cleansing agents and promotes bowel movements by ingesting foods that promote natural defecation, instead of forced cleansing with intestinal flush, as in the conventional method. Briefly, we focused on 2 dietary factors, namely, insoluble dietary fiber [wheat bran fiber (WBF)] and probiotics (PB; *Bifidobacterium animalis* subsp. *lactis* GCL2505).[7–9] A recent study reported that the daily intake of > 20 g of wheat bran cereal significantly increased stool volume and its intake of 20 to 50 g/d would be effective in improving constipation. Ishizuka et al[7] reported an increase in the defecation frequency with GCL2505 administration than with placebo. Takii et al[8] reported that the defecation frequency and stool quantity increased significantly with consumption of GCL2505 fermented milk compared with that with placebo. These results suggested that GCL2505 improved constipation by increasing intestinal bifidobacteria.

On the basis of these studies, we hypothesized that WBF and GCL2505 would support bowel-cleansing while reducing adverse effects on the intestinal flora. Thus, this study aimed to investigate the safety and efficacy of ingesting wheat bran cereal and GCL2505 as a novel method for bowel preparation before screening colonoscopy.

METHODS

Study Participants

This prospective clinical study was conducted between October 2018 and March 2019 at a general hospital. The inclusion criteria were as follows: scheduled colonoscopy and provision of informed consent for examination, ability to achieve ordinary oral intake, full understanding of the study design and provision of informed consent, and age 20 years and above at the time of acquiring consent. In contrast, the exclusion criteria were as follows: obstruction of the gastrointestinal tract,

poor general conditions (performance status score ≥ 3), and judged by the investigators as inappropriate for this study. Written informed consent was obtained from all patients in accordance with the respective institutional regulations, and the study protocol was approved by the ethics committee of Fukuoka Medical and Dental College Hospital (registration number, 420; approval date, September 3, 2018).

The study participants were randomly categorized into 2 groups. Participants in 1 group received the novel regimen for bowel preparation using WBF and PB GCL2505 (WBF with PB group), and the remaining participants received the standard-volume regimen (1.0 to 1.5 L of PEG solution) (control group). The 40 eligible participants were randomly assigned in a 1:1 ratio to these groups, and data from participants in each group were analyzed.

Study Procedures

The degree of constipation in individuals in the WBF with PB group was assessed using the Bristol Stool Form Scale (BSFS)[10] and Constipation Scoring System (CSS).[11] Participants with a BSFS score ≤ 2 or CSS score ≥ 1 were classified into the constipation group, and the remaining participants with a BSFS score ≥ 3 and CSS score <1 were classified into the nonconstipation group. In the nonconstipation group, participants had regular meals until 2 days before the colonoscopy. On the day before the colonoscopy, only WBF and PB meals were allowed. As per the protocol, consuming at least 3 meals of 40 g of WBF (Kellogg All Bran)[12] and 125 g of PB (Glico BifiX yogurt) per meal was recommended. Participants in the constipation group had a meal of 40 g of WBF and 125 g of PB from 4 to 2 days before the colonoscopy, in addition to the regular meals. On the day before the colonoscopy, only WBF and PB were permitted as meals, as in the nonconstipation group. On the day of the colonoscopy, participants in the WBF with PB group were prepared with oral intake of 0.5 L of PEG solution (MoviPrep; PEG, sodium sulfate, sodium chloride, potassium chloride, sodium ascorbate, and ascorbic acid). In the control group, the standard-volume regimen (1.0 to 1.5 L of MoviPrep) was administered (Fig. 1). When the proper condition of stool was not satisfied, additional preparation was conducted by having patients ingest MoviPrep.

Patient compliance and the quality of bowel preparation were compared between the 2 groups. The quality of bowel preparation was evaluated using the Harefield Cleansing Scale.[12–14] Endoscopic findings identified as Harefield Cleansing Scale grade A [all segments scored 3 (clear liquid) or 4 (empty and clean)] or grade B [1 or more segments scored 2 (brown liquid/removable semisolid stools)] were regarded as successful bowel preparations (Fig. 2).

The primary outcome in the present study was a comparison of the quality of bowel preparation between the 2 groups, whereas the secondary outcome was a comparison of the actual required volume of MoviPrep between the 2 groups.

Statistical Analysis

Differences in characteristics between the groups were evaluated using Fisher exact tests or unpaired *t* tests. All *P* values were 2-sided, and a *P*-value of <0.05 was considered to reflect statistical significance. All analyses were performed with JMP PRO 13 software (SAS Institute Inc., Cary, NC).

RESULTS

Clinical Features

Forty individuals aged 38 to 83 years were randomly assigned to the WBF with PB group (n = 20) and control group (n = 20). Participants in each group underwent bowel preparation in accordance with each protocol, followed by colonoscopy. The baseline characteristics of the 2 groups are listed in Table 1. No differences were found in sex proportions, presence of constipation, smoking habits, and alcohol consumption between the groups. The mean age was significantly higher in the WBF with PB group than in the control group.

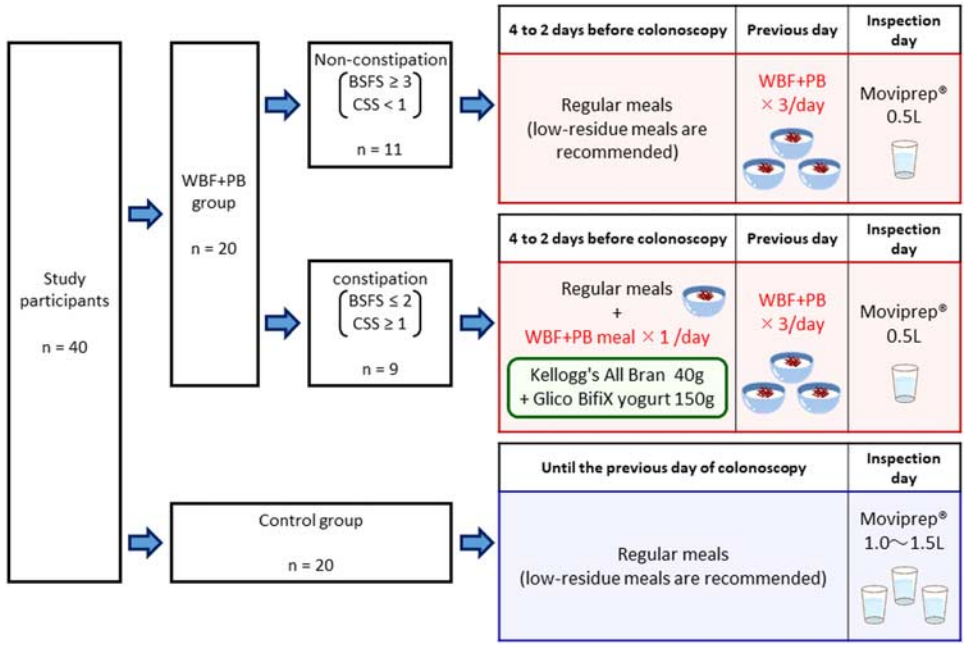

FIGURE 1. Study protocols of bowel preparation in the WBF with PB and control groups. BSFS indicates Bristol Stool Form Scale; CSS, Constipation Scoring System; PB, probiotics; WBF, wheat bran fiber.

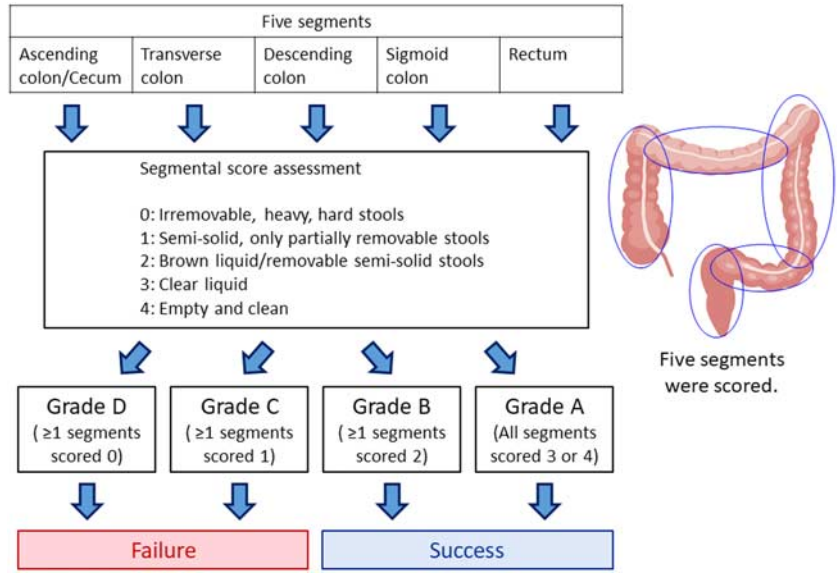

FIGURE 2. Details of the Harefield Cleansing Scale. Endoscopic findings identified as Harefield Cleansing Scale grade A [all segments scored 3 (clear liquid) or 4 (empty and clean)] or grade B [1 or more segments scored 2 (brown liquid/removable semisolid stools)] were regarded as successful bowel preparations.

Bowel Preparation

The mean required volume of MoviPrep was significantly lower in the WBF with PB group than in the control group (582.5 vs. 1305 mL, $P < 0.0001$) (Fig. 3). Patient compliance with WBF with PB and MoviPrep in each group is shown in Table 2. No adverse events related to the intake of WBF with PB or MoviPrep were recorded in either group.

The mean intervals between the time of taking MoviPrep and the start time of colonoscopy were 246 minutes (range: 120 to 420 min) in the WBF with PB group and 220 minutes (range: 115 to 305 min) in the control group. There were no significant between-group differences in the mean intervals ($P = 0.2810$). Alternatively, the mean time for the consumption of MoviPrep was 54 minutes (range: 15 to 220 min) in the WBF with PB group which was significantly shorter than the time for the control group (mean, 90 min; range: 25 to 155 min, $P = 0.0373$).

TABLE 1. Baseline Demographic and Clinical Features of the WBF+PB and Control Groups

Factors	WBF+PB Group (n = 20)	Control Group (n = 20)	*P*
Sex			
Male	8 (40.0)	8 (40.0)	1.0000
Female	12 (60.0)	12 (60.0)	
Age [mean (range)] (y)	71.8 ± 1.7 (50-82)	63.6 ± 3.3 (38-83)	0.0339
Constipation			
No	13 (65.0)	11 (55.0)	0.7475
Yes	7 (35.0)	9 (45.0)	
Use of laxatives			
No	16 (80.0)	14 (70.0)	0.7164
Yes	4 (20.0)	6 (30.0)	
Smoking			
No	19 (95.0)	20 (100.0)	1.0000
Yes	1 (5.0)	0 (0.0)	
Alcohol consumption			
No	15 (75.0)	14 (70.0)	1.0000
Yes	5 (25.0)	6 (30.0)	

Data are presented as the number (%) unless otherwise stated.
PB indicates probiotics; WBF, wheat bran fiber.

Colonoscopy Procedures and Quality of Bowel Preparation

The purpose of colonoscopy was screening for 38 of 40 participants and polypectomy for previously diagnosed polyps and a diagnosis for refractory abdominal pain for the remaining 2 patients. For all the participants in both groups, cecal intubation was accomplished, and screening of all segments was possible. The Harefield Cleansing Scale grades of participants in each group are summarized in Table 3. Successful bowel-cleansing rate was significantly higher in the WBF with PB group (100%) than in the control group (75%) ($P = 0.0471$) (Table 3). The colonoscopy findings from each group are shown in Figure 4. Only powdery residues were noted in the colonoscopy findings of some participants in the WBF with PB group and most of these were easily removable.

Outcomes of colonoscopy in each group are summarized in Table 4. There were no significant between-group differences in the number of detected lesions. Regarding the location of polyps, the proportion of polyps detected in the right side of colon (cecum, ascending colon, and transverse colon) in the WBF with PB group was significantly higher than that of the control group ($P = 0.0220$).

DISCUSSION

In the present study, we investigated the safety and efficacy of a novel method of bowel preparation by providing patients WBF and GCL2505 before their colonoscopy. We observed reduced requirement of bowel-cleansing agents in the WBF with PB group than in the control group. In addition, the success rates for bowel-cleansing were higher in the WBF with PB rendering this method safe and effective.

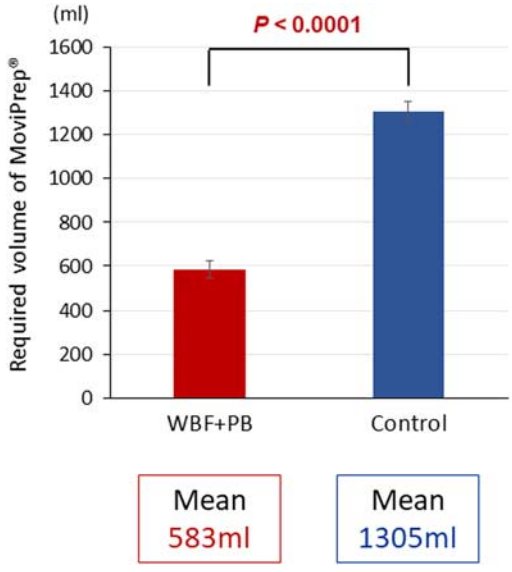

FIGURE 3. Comparison of the mean required volume of MoviPrep between the WBF with PB and control groups. The mean volume was significantly lower in the WBF with PB group than in the control group (582.5 ± 40.9 vs. 1305 ± 48.2 mL, $P < 0.0001$). PB indicates probiotics; WBF, wheat bran fiber.

We focused on the effect of WBF and GCL2505 on defecation. First, WBF contains large amounts of dietary fiber. The reported effects of dietary fiber include shortened transit time of food in the gastrointestinal tract, increased fecal volume, and reduced blood sugar and cholesterol levels. Dietary fiber is classified as water-soluble dietary fiber and insoluble dietary fiber. The former produces short-chain fatty acids by fermentation of the colon and promotes peristalsis of the intestinal tract,[15] whereas the latter has water-holding properties, softens stool, and increases stool volume by increasing the water content of stools.[15] Among various dietary fibers, cereal fiber is the most beneficial in improving defecation habits. WBF contains abundant insoluble dietary fibers and helps increase the stool volume and frequency, shorten the intestinal transit time, and ensure appropriate stool firmness.

Recommendations for dietary fiber intake in adults range from 20 to 35 g/d. Despite numerous fiber consumption recommendations, the normal intake of dietary fiber is lower than the recommended levels, averaging only 14 to 15 g/d. Generally, the recommended treatment for constipation is the intake of a concentrated source of insoluble fiber, whereas cholesterol levels can be reduced with soluble fiber.[16] In one study, male golden hamsters were fed diets supplemented with 5% cellulose or various amounts of water-insoluble fiber-rich fraction (WIFF; 2.5%, 5%, or 10%).[17] The activities of fecal bacterial enzymes, short-chain fatty acid concentrations, and microbial counts in the cecal content, as well as cecal and fecal biochemical indicators, were evaluated in all hamster groups. Supplementing the diet with WIFF at 2.5% level ($P < 0.05$) reduced the hamsters' daily fecal ammonia production and gastrointestinal transit times. It reduced the activity of β-D-glucosidase, β-D-glucuronidase, mucinase, and urease in feces. Moreover, it elevated the total amount of short-chain fatty acids in the cecal content and promoted the growth of gut microbiota including *Lactobacillus* and *Bifidobacterium*. These results suggested that WIFF improved hamster cecal ecosystem function by reducing toxic compounds excreted by the gut flora.[17]

Bifidobacteria have important functions such as suppressing the growth of harmful bacteria, maintaining intestinal flora, regulating the immune system, and suppressing allergies or carcinogenesis.[8] Such physiological effects on the host are brought about by increasing the amounts of bifidobacteria in the intestine. A study reported that continuous intake of a specific strain of bifidobacteria improves the balance of the intestinal flora and fecal properties.[8] Moreover, recent studies have demonstrated that *Bifidobacterium* GCL2505 increased the frequency and amount of defecations and relieved difficulties in defecating.[7–9] Increased levels of GCL2505 in the intestine produce short-chain fatty acids such as acetic acid or lactic acid that suppress the growth of harmful bacteria and the production of putrefaction. In addition, short-chain fatty acids regulate intestinal epithelial cells and activate peristaltic movement, and these mechanisms promote defecation.[8] Our method is novel in that it promotes defecation by increasing the amount of stool as a consequence of the effects of WBF and GCL2505 rather than just reducing residue before a colonoscopy. Compared with the conventional preparation method, it is expected that our novel method will have less influence on the environment of the intestinal flora. Furthermore, only powdery residues were observed in participants in the WBF with PB group according to the colonoscopy findings, and these residues were easily removable. These points may be strengths of our method; nevertheless, further investigation is necessary to confirm the validity and utility of this approach.

TABLE 2. Patient Compliance for Each Bowel Preparation

Factors	WBF+PB Group (n = 20)	Control Group (n = 20)	*P*
WBF+PB meals			
Good	8 (40.0)		
A little hard	6 (30.0)		
Hard	6 (30.0)		
Failure	0 (0.0)		
MoviPrep			
Good	15 (75.0)	11 (55.0)	0.3203
A little hard	4 (20.0)	6 (30.0)	
Hard	1 (5.0)	3 (15.0)	
Failure	0 (0.0)	0 (0.0)	

Data are presented as the number (%).
PB indicates probiotics; WBF, wheat bran fiber.

TABLE 3. Harefield Cleansing Scale Grades of Participants in the WBF With PB and Control Groups

Harefield Cleansing Scale Grade	WBF With PB Group (n = 20)	Control Group (n = 20)	*P*
A	12 (60.0)	12 (60.0)	
B	8 (40.0)	3 (15.0)	
C	0 (0.0)	5 (25.0)	
D	0 (0.0)	0 (0.0)	
Success (A-B)	20 (100.0)	15 (75.0)	0.0471
Failure (C-D)	0 (0.0)	5 (25.0)	

Data are presented as the number (%).
PB indicates probiotics; WBF, wheat bran fiber.

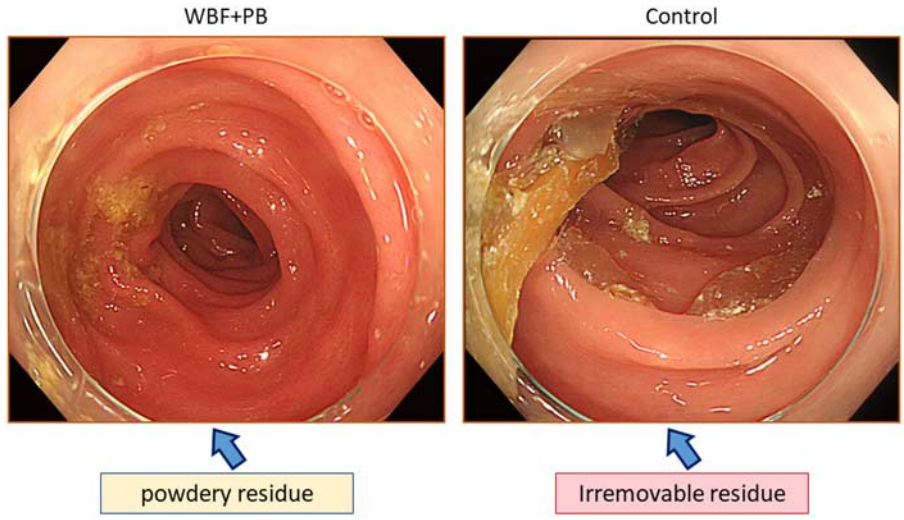

FIGURE 4. Examples of colonoscopy findings in the WBF with PB and control groups. PB indicates probiotics; WBF, wheat bran fiber.

A limitation of this study was that it had a small sample size and was a single-institution study.

We performed bowel-cleansing with WBF+PB experimentally before the formal design of this study, and the safety and efficacy of this method were empirically confirmed. Therefore, the actual number of cases collected was larger; however, when the study protocol was planned, the minimum number of cases required to prove efficacy was determined so as to allow for the earliest possible publication of our findings. Since the efficacy was proven with a sample of 20 participants, the present study was discontinued, and all subsequent cases in our hospital are currently receiving the WBF+PB protocol.

Although further accumulation of cases is desirable, we believe that the safety and efficacy of the new method have been demonstrated through this study.

In conclusion, the intake of WBF and GCL2505 before colonoscopy can reduce the required quantities of PEG while maintaining the bowel-cleansing quality. This minimally invasive pretreatment method makes colonoscopy more accessible and is expected to contribute to the prevention and early treatment of colorectal cancer.

TABLE 4. Outcomes of Colonoscopy in the WBF+PB and Control Groups

Findings	WBF+PB Group (n = 20)	Control Group (n = 20)	*P*
Polyp			
No	7 (35.0)	11 (55.0)	0.3406
Yes	13 (65.0)	9 (45.0)	
Location of polyps			
C	1 (4.0)	0 (0.0)	
A	11 (44.0)	3 (18.8)	
T	7 (28.0)	3 (18.8)	
D	2 (8.0)	2 (12.5)	
S	0 (0.0)	5 (31.3)	
R	4 (16.0)	3 (18.8)	
Location of polyps [right side (C-T) or left side (D-R)]			
Right	19 (76.0)	6 (37.5)	0.0220
Left	6 (24.0)	10 (62.5)	
No. polyps [mean (range)]	1.25 ± 0.35 (0-6)	0.80 ± 0.24 (0-3)	0.2904
Size of polyps [mean (range)] (mm)	6.16 ± 0.80 (3-20)	5.56 ± 0.58 (3-10)	0.5897
Diverticulum			
No	14 (70.0)	11 (55.0)	0.5145
Yes	6 (30.0)	9 (45.0)	
Colitis			
No	18 (90.0)	17 (85.0)	1.0000
Yes	2 (10.0)	3 (15.0)	
Advanced cancer			
No	20 (100.0)	19 (95.0)	1.0000
Yes	0 (0.0)	1 (5.0)	

Data are presented as the number (%) unless otherwise stated.

A indicates ascending colon; C, cecum; D, descending colon; PB, probiotics; R, rectum; S, sigmoid colon; T, transverse colon; WBF, wheat bran fiber.

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