Introduction

Dietary fiber is a very important component of human nutrition. In recent years, the beneficial effects of water soluble dietary fibers have received much attention. The guar plant, *Cyamoposis tetragonolobus* L., has been grown in India and Pakistan since ancient times and is used in both human foods and animal feed. Since the 1950s, the seeds of the guar plant have been processed into guar gum in ever increasing amounts to meet the demand of the modern food industry. However, the high viscosity of guar gum limits its applications in many foods. Partially hydrolyzed guar gum (PHGG) is manufactured by the partial hydrolysis of guar gum by β-D-endomannanase. PHGG has a low viscosity and can easily be incorporated into food and beverages.

Sunfiber® is the trade name of Taiyo Kagaku’s enzymatically produced Partially Hydrolyzed Guar Gum (PHGG).

Sunfiber® has many physiological benefits in the body and functional applications for food products.

References:

Physiochemical Properties

Galactomannan is a polysaccharide found in guar gum that results from the milling of the endosperm of guar seed. Galactomannans consist of a linear backbone-chain of β-D-(1-4)-manno-pyranose units, to which α-D-galactopyranose units are attached in various proportions. Partially hydrolyzed guar gum (Sunfiber®) is produced from the enzymatic hydrolysis of galactomannans by endo-β-D-mannanase extracted from Aspergillum niger. The ratio of mannose and galactose in guar gum and PHGG is approximately 2 to 1.

Sunfiber® has the average molecular weight of about 20,000 Daltons, and makes a low-viscosity clear solution. Sunfiber® is a natural, water soluble dietary fiber.

Description of Sunfiber®

1) Trade Name
2) Generic Name
3) Major Polysaccharide
4) Structural Formula

(see diagram below)

Sunfiber®

Partially Hydrolyzed Guar Gum
Galactomannan
β-D-(1-4)-linked manno-pyranose units - mannose:galactose ratio = ~ 38:62

Structure of PHGG (Sunfiber®)
5) Guar Gum

The guar plant (*Cyamopsis tetragonolobus*) and guar seed are cultivated in India and Pakistan.

6) Manufacturing Process

*Sunfiber®* (PHGG) is produced from plant seeds (guar beans) by enzymatic hydrolysis and purification.
9) Comparison of Guar Gum and PHGG (Sunfiber®)

<table>
<thead>
<tr>
<th>Guar Gum</th>
<th>PHGG (Sunfiber®)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>&lt;Molecular Weight&gt;</strong></td>
<td></td>
</tr>
<tr>
<td>About 300 000</td>
<td>About 20 000</td>
</tr>
<tr>
<td><strong>&lt;Viscosity&gt;</strong></td>
<td></td>
</tr>
<tr>
<td>More than 2 000 mPa.s</td>
<td>5mPa.s</td>
</tr>
<tr>
<td>(1% solution)</td>
<td>5% solution @ 5°C</td>
</tr>
</tbody>
</table>

Enzymatic hydrolysis

10) Characteristic Properties
(for more details see section 12, Specifications)

1) White Powder
2) Soluble in water
3) Moisture – less than 70%
4) Protein – less than 1.0%
5) Ash – less than 2.0%
6) pH (5% solution) – 6.0-7.0%

11) Fiber Content

1) More than 76% AOAC Method

References:

Safety

The safety of guar gum was assessed by the Joint Expert Committee on Food Additives (JECFA) in 1975 and by the EC Scientific Committee for Foods (SCF) in 1978. In the USA, guar gum has been considered Generally Recognized As Safe (GRAS) since 1974 in numerous food applications. Guar gum has been established as a safe food additive; therefore, partially hydrolyzed guar gum (Sunfiber®) may also be considered safe. Partial hydrolysis of guar gum by β-D-endomannanase mimics a predigestion step occurring in normal digestion. Studies indicate that PHGG has similar physiological effects to guar gum. A history of safe use has been established in Japan as it has been used as a dietary fiber in various foods since 1987.

Animal Studies:

Acute Toxicity:

The acute toxicity of Sunfiber® was tested in Sprague-Dawley rats at dose levels of 0, 0.5, and 2.5g/kg body weight/day. The results of the 28 day administration of Sunfiber® demonstrated that supplementation was well tolerated, and food consumption and body weight gain were not influenced by the treatment. No differences were observed in hematology, urinalyses, ophthalmology and histopathological parameters.

Mutagenicity Assay:

Sunfiber® was dissolved in distilled water at concentrations of 0.05, 0.1, 0.5, 1.0, and 5.0 mg/plate. The mutagenicity was examined in a microbial reverse mutation assay with Salmonella typhimurium TA100 and TA98 strains, and concentrations up to 5mg/plate did not have any effect on reverse mutations.
Human Studies:

No effects on haematologic, renal and hepatic parameters were observed in association with PHGG intake in 10 healthy male volunteers. The subjects consumed a liquid diet, with or without 21g/L PHGG. There were positive effects on stool softening but no other gastrointestinal changes were observed. An oral glucose tolerance test was performed by administration of 75g glucose in 200ml water. The value of blood glucose levels after the oral glucose tolerance test showed no differences between the liquid diet and its fiber-rich counterpart. Basal serum insulin levels and levels after the oral glucose load did not show any difference between the 2 diets. Blood arginine levels were taken as an estimation of amino acid absorption. There were no significant differences between the 2 diets. Stool fat and fat estimation according to the $^{13}$C Hiolein breath test were not different between the 2 diet groups. The results demonstrate that PHGG does not interfere with the normal absorption of glucose, amino acid and fat, and does not affect normal blood safety parameters, and therefore is a safe source of soluble fiber.

### Safety Study in Human Volunteers

#### Plasma Arginine Concentration

<table>
<thead>
<tr>
<th>Time</th>
<th>Without fiber</th>
<th>With fiber</th>
<th>P - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal</td>
<td>259 ± 89</td>
<td>266 ± 65</td>
<td>NS</td>
</tr>
<tr>
<td>2 hours</td>
<td>415 ± 105</td>
<td>403 ± 90</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS = not significant

The results from this study are supported by other research. Twelve men consumed a liquid diet, alone, or with 21g/L Sunfiber®. This amount was well tolerated and showed no side effects. Obese women (n= 25) taking 20g/day of PHGG for one week had no differences in fasting values of glucose and insulin. There was also no significant effect on 2 hour postprandial responses of glucose or insulin. Administration of Sunfiber® (36g/day) for 4 weeks to adult men resulted in no side effects and no effects on mineral excretion.

### Conclusion:

On the basis of all of the experimental data and published scientific evidence, Sunfiber® is considered safe and appropriate to use as an ingredient in nutritional products and liquid oral supplement products for the purpose of providing dietary fiber.
References:


- SCF: Reports of the Scientific Committee for Food. 1978. 7th series: 5-10 and 18-20 (guar gum E 412).


- Favier ML, Bost PE, Guittard C, Demigne C, Remesy C. The cholesterol lowering effect of guar gum is not the result of simple diversion of bile acids toward fecal excretion. Lipids. 1997;32:953-959.


Physiological Effects

A diet rich in fiber has a preventive effect against many adverse conditions, such as constipation, colon diverticulosis, carcinoma of the large bowel and stomach, type 2-diabetes, metabolic syndrome and cardiovascular disease.¹ There are hundreds of papers published on the physiological effects of guar gum. Guar gum, however, is highly viscous and not easily incorporated into beverages or foods. Partially hydrolyzed guar gum has a very low viscosity and has the same fermentation characteristics in the large bowel. PHGG is marketed under the name of Sunfiber® and it is manufactured by a partial hydrolysis of guar gum by β-D-endomannanase extracted from Aspergillum niger. This hydrolysis imitates the digestion in the bowel. This fermentation serves as the basis for the physiological benefits of PHGG (Sunfiber®).²

Indications:

• Treatment of Constipation
• Reduction of Laxative Agents
• Reduction of Diarrhea
• Improvement of Terminal Ileum Villi Atrophy
• Improvement of Intestinal Microflora Balance
• Irritable Bowel Syndrome
• Improvement of Glycemic Response
• Improvement of Lipid Profile
• Enhancement of Mineral Absorption
• Improvement of Skin Conditions
• Weight control
Treatment of Constipation

Constipation has symptoms of hard feces causing difficulty in output and delayed transit time.\(^3\) Constipation varies by definition but essentially occurs when there is no fecal output for 3-4 days. Other symptoms may be difficulty or painful defecation, hard or dry stool, abnormally small stool, or a feeling of incomplete rectal evacuation. Dietary fiber has been considered effective in regulating fecal transit time by reducing both constipation and diarrhea. It may improve defecation by fecal bulking, changing fecal consistency, and increasing intestinal motility.\(^4\) Increased bulk, softness or pliability of colonic contents may indicate a protective effect against the development of constipation.

There is a significant amount of research regarding increased fiber intake and improvement of constipation. Sunfiber\(^\circledR\) (36g/day) was given to 8 healthy men for 8 weeks and resulted in increased frequency and fecal weight. This dose did not affect mineral absorption of calcium, iron or zinc.\(^5\) Another study looking at liquid formula diets and supplementation of PHGG (21g/L for 7 days) to 10 healthy male volunteers showed an improvement in the consistency of hard stool with fiber supplementation.\(^6\)

The influence of Sunfiber\(^\circledR\) on constipation was investigated in 15 women who commonly experienced discomfort before movements, had abdominal pain, and had fecal output occurring an average of 2.8 times/week. The women took 11g of Sunfiber\(^\circledR\)/day for 3 weeks with 2 control periods, 3 weeks before and 3 weeks after. Defecating frequency, pH, weight, moisture and bacterial flora of the feces were investigated and compared with the control periods.\(^7\) The pH decreased and defecation frequency and moisture content increased significantly after the 2\(^{nd}\) week of supplementation, but these effects did not continue after supplementation discontinued.
Sunfiber®
Physiological Effects

Effect of Sunfiber® (PHGG) on Females Suffering from Constipation

Measurements taken at the end of each 3 week period

(p < 0.05) a:b = significant difference, a:ab = no significant difference)

Beneficial Effect of Sunfiber® (PHGG) on the Weight and Moisture of Human Feces

Reduction of Laxative Agents

As well as reducing constipation, PHGG supplementation appears to reduce the amount of laxatives used in an elderly population. Fiber is an important constituent of the diet in the elderly but certain problems, such as poor dentition and food preferences, can limit the amount consumed. PHGG (Sunfiber®) can easily be incorporated into food and beverages. Sixteen elderly patients who regularly consume laxatives were given 4g PHGG beginning at week 4 and laxative intake was decreased by 50%. The fiber dose was gradually increased to 12g by the end of week 4. If this amount was not tolerated, then the dose was dropped to 8g/day (Final intake of fiber 11.8±0.8g/day). At the beginning of week 5, all regular laxative use was discontinued and the PHGG was taken until week 8. Additional laxatives were taken when necessary. Fiber and laxative intake was recorded. Overall laxative use was reduced substantially and the side effect of increased flatulence didn’t cause anyone to drop out of the study.

Reduction of Diarrhea

Gastrointestinal side effects, such as diarrhea, are generally recognized as one of the most common complications associated with tube feeding. Diarrhea is one of the main reasons that enteral nutrition is discontinued, as it disturbs fluid and electrolyte balance and worsens nutritional status. In humans, dietary fiber is mainly degraded in the large intestine by bacterial flora, in which short-chain fatty acids (SCFA) are liberated. The SCFAs are absorbed by the colon, stimulating sodium transport in several species, including humans.\(^9,10\) This effect may be particularly important in acute diarrheal diseases in the colon and may cause colonic dysfunction.\(^11\) Luminal SCFA levels in the colon may therefore influence the clinical course of acute diarrheal conditions. Fiber added to tube-feeding formulas may aid in reduction of diarrhea, but this is dependant on both the physical and chemical characteristics of the fiber. It has been reported that children receiving either green plantain or pectin had significantly less stool output and duration of diarrhea.\(^12\) However, soluble fiber, such as guar gum, has limited use in tube-fed enteral formulas because its addition at physiologically effective concentrations results in liquid products with very high viscosity. The advancement of technology on fiber and formulas have made the addition of partially hydrolyzed guar gum possible. The following studies evaluate treatment of diarrhea with partially hydrolyzed guar gum and its benefits in clinical nutrition products.
Most research in this field has dealt with patients reliant on enteral feeding. The following double-blind study examines fiber supplementation on enteral feeding in patients with severe sepsis and septic shock. All patients (25 adults) were mechanically ventilated and enteral feeding was provided through a nasogastric tube for a minimum of 6 days. The patients received a control formula or one containing 22g/L PHGG. There was a reduction in incidence of diarrhea in the patients supplemented with PHGG.

This prospective, double-blind trial examined 100 patients receiving total or supplemental enteral nutrition that were randomized into a standard liquid diet group (SD) and the same diet with 20g of Sunfiber®/1000ml added. In both groups, the incidence of diarrhea decreased significantly with Sunfiber® administration compared to the standard diet. Flatulence was a noted side effect but did not cause anyone to discontinue the fiber supplementation. There were no subjects in the Sunfiber® diet group who discontinued enteral feeding.

Enterally-fed, adult patients with persistent diarrhea were randomized to receive a diet enriched with 2% PHGG (study group) or a fiber-free formula (control group) for 4 days. The study group (n=10) had significantly lower number of liquid stools by day 4 versus the control group (n=10). They also were able to tolerate higher feed volumes on the first, second and fourth days. There were more side effects in the control group than the study group, but not to a significant degree. This indicates the PHGG was extremely well tolerated.\textsuperscript{15}

A double-blind, randomized, controlled clinical trial included 150 male children aged 4-18 months who had non-cholera diarrhea. Subjects were assigned to receive a WHO-ORS standard diet (World Health Organization Oral Rehydration Solution) or one supplemented with 20g/L PHGG. Patients receiving PHGG had significantly reduced duration of diarrhea compared with the control group. The PHGG supplementation group also showed less stool output.

Diets:
- Group A = WHO glucose - electrolyte solution
- Group B = WHO glucose - electrolyte solution + 20g PHGG / L

The results of the previous study were supported by further research. Children with persistent diarrhea were randomized to a diet of comminuted chicken supplemented with PHGG or a control diet without PHGG. The 116 subjects (aged 5-24 months) received the standard WHO-ORS and the chicken diet. Results demonstrated a significantly greater resolution of diarrhea before the end of 7 days in children with PHGG supplementation (20g/L). Stool output was significantly reduced on days 4-7 and there was a reduction in the duration of diarrhea with the PHGG diet. This study shows that the addition of PHGG to a comminuted chicken diet enhances recovery of children from persistent diarrhea.  

Improvement of Terminal Ileum Villi Atrophy

Diarrhea induced by long-term consumption of a liquid diet is associated with the reduction of absorptive capacity and absorptive area due to the loss of brush border enzymes and mucosal cells. This is a potentially serious problem in chronic care patients who are fed exclusively on parenteral or enteral diets. Several studies have shown reduction of diarrhea incidence and duration in patients fed liquid diets supplemented with PHGG.

Different liquid diets with or without Sunfiber® were given to 5 week old Wistar rats for 2 weeks. The rats were divided into five groups: standard rat chow (MF), low-residue diet (LRD), elemental diet (ED), and LRD+ and ED+PHGG (1.5% w/v). The caecal weight and length of the rats fed the LRD+ and ED+PHGG were significantly higher than those without fiber and the control diet. The caecal pH was also lower. Photographs of the ileum villi showed a slight atrophy and shedding of the mucosal cells for the rats of the LRD and ED groups. This effect was moderated in the groups supplemented with Sunfiber®.

The activity of diamine oxidase was also monitored to determine structural and functional changes in the gut. The specific activity of diamine oxidase, alkaline phosphatase and maltase in mucosal scrapings was significantly lower in the ileum of rats in the LRD and ED groups than the MF group. In the LRD+ and ED+PHGG (Sunfiber®) groups, this effect was moderated. The average number of Lactobacillus bacteria was maintained in the LRD+ and ED+PHGG groups; whereas, in the LRD and ED groups, the numbers were significantly lower than the control.

Improvement of Intestinal Microflora Balance

Research has demonstrated that dietary fiber has beneficial effects on improving the intestinal environment. Studies have consistently demonstrated that galactomannan is readily fermented by fecal microflora. This fermentation may result in lower intestinal pH and increase production of short chain fatty acids (SCFA). A low pH may improve intestinal conditions by providing an ideal environment for the growth of beneficial bacteria and reducing formation of harmful bacterial metabolites.

Different liquid diets with or without Sunfiber® (PHGG) were given to 5 week old Wistar rats for 2 weeks. The rats were divided into five groups: standard rat chow (MF), low-residue diet (LRD), elemental diet (ED), and LRD+ and ED+PHGG (1.5% w/v). The caecal pH of the rats fed the LRD+ and ED+PHGG was significantly lower than those without fiber and the control diet. The average number of Lactobacillus bacteria was maintained in the LRD+ and ED+PHGG groups, whereas in the LRD and ED groups the numbers where significantly lower than the control.

Another study explored iron absorption and utilization in growing rats fed iron-deficient diets with or without Sunfiber®. The investigators found Sunfiber® supplementation lowered pH of caecal contents. This may be a result of increased production of SCFA. Increased levels of caecal SCFA were found in growing rats supplemented with a diet consisting of 5 and 10% PHGG. An in vitro study found hydrolyzed guar gum to produce the highest levels of total SCFA compared to other fibers, such as inulin and psyllium, and high levels of propionate and butyrate.

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Similar effects can be seen in human studies. Male volunteers given a liquid diet supplemented with 21g/L PHGG had increased levels of plasma SCFA. Stool consistency also improved. Sunfiber® (36g/day) given to 8 healthy men for 8 weeks resulted in increased frequency of defecation and increased fecal weight. There was no change in SCFA production but there was a decrease in the fecal pH in all four weeks of administration of Sunfiber®. Fecal pH was also reduced in 15 women who were supplemented with 11g/day of Sunfiber® for 3 weeks. The frequency of Lactobacillus spp. occurrence in the feces increased, but the average cell number of Lactobacillus spp. remained virtually unchanged. An in vitro study found Sunfiber® moderately enhanced the growth of several bacterial strains but had no effect on Bifidobacteria or Lactobacilli.

Human volunteers taking PHGG in a functional food had significantly increased numbers of bifidobacteria. Thirty-one people took 3 placebo biscuits or 3 biscuits containing 3.4g PHGG and 6.6g fructo-oligosaccharides daily for two 21 day cross-over periods. There was a correlation between subjects who had lower bifidobacteria values at the beginning of the trial and the degree of increase after ingestion of the biscuits. Therefore, prebiotic biscuits may prove efficacious for increasing bifidobacterial numbers in the gut.

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The effect of Sunfiber® (PHGG) intake on fecal microflora, pH and SCFA were investigated in nine healthy males (21g/day for 2 weeks). Bifidobacterium spp. and Lactobacillus spp. were significantly increased by PHGG intake. There were no significant changes in the volatile fatty acid levels but the pH was reduced during the 2nd week of Sunfiber® supplementation.

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Irritable Bowel Syndrome

Irritable bowel syndrome (IBS) is the most common disease diagnosed by gastroenterologists and presents symptoms of abdominal pain, bloating and defecation disregulation. IBS alters physiological function and it is difficult to diagnose by a specific abnormality. Patients with IBS are often recommended to consume 20-30g fiber/day but compliance is often a problem. Sunfiber® is easily incorporated into foods and, therefore, could be a practical solution to increasing fiber intake. PHGG supplementation (5g/day) was compared to a wheat bran diet (30g/day) normally recommended for IBS in a multicenter, randomized, open trial. PHGG was as effective as the wheat bran on improved bowel habits, regardless of the symptoms of the subject (constipation or diarrhea). Subjects (49 men and 139 women) with IBS took the prescribed supplement for 12 weeks. The study was an open trial and the subjects could switch from one treatment group to the other after 4 weeks based on their perception of treatment. Of the patients who decided to switch, 82.1% moved to the PHGG group and only 17.9% of patients switched out of the PHGG group. PHGG was better tolerated and preferred by the study subjects. PHGG reduced symptoms of IBS, such as flatulence, abdominal tension, and abdominal spasm after 3 weeks of consumption in normal and obese patients. Subjects were randomized according to BMI to a balanced, low or normal diet supplemented by 5g/day of PHGG.

The effects of PHGG were compared in IBS patients at 10 g/day (n=40) and 5 g/day (n=46) for 12 weeks. There was a significant improvement in symptoms and quality of life in both groups at one and three months compared to baseline. Improvements remained at 6 months (3 months after study end) compared to baseline but were less prominent than at the end of the treatment. This study had many limitations but showed that PHGG can produce beneficial results after one month administration.
Improvement of Glycemic Response

The glycemic index ranks food according to how they affect our blood glucose levels. The glycemic response is influenced by the body’s ability to respond to elevated blood glucose levels by releasing insulin, and for the tissues to react to increased insulin levels. Obtaining a low glycemic response may be beneficial for anyone with glucose intolerance or problems with blood glucose management, such as diabetes. Soluble dietary fiber has been demonstrated to reduce post-prandial glycemia in both normal and diabetic subjects. Improvement of glycemic control in long-term studies has also been seen. The following studies examine the research on glycemic response and PHGG.

Much research in this area examines the immediate post-prandial response of glucose and insulin to a test meal and PHGG. There are relatively few short-term trials. In a supplementation study, fasted blood samples were taken and glucose concentrations fell in 6 women taking 15g PHGG/day for 2 weeks. Enterally-fed adults with persistent diarrhea given 2% PHGG had reduced plasma glucose levels after 4 days of supplementation. This trend also appears after consumption of individual meals. A glucose tolerance test was given to five volunteers. The subjects were given 15g PHGG in 150ml water and 75g glucose dissolved in 200ml water. There was significant mean suppression of both glucose and insulin level increases at 60 and 90 minutes after glucose administration, respectively. A similar study involved 6 subjects given 30g sucrose and 5g Sunfiber®. The blood glucose level at 60 min after ingestion was significantly lower than with sucrose alone. There were no significant changes in insulin levels.

![Effect of Sunfiber® on Plasma Glucose](image)


TAIYO KAGAKU Co. Ltd.

2005/8/30
Hyperinsulemia induced by fructose feeding was improved by PHGG. Rats fed a dextrin or fructose-based diet with or without guar gum hydrolysate (75g/kg) for 30 days were given an oral glucose tolerance test on day 0, 14 and 28. The induced hyperinsulemia was improved by PHGG on day 28. PHGG also eliminated the reduction of glycogen concentrations in the gastrocnemius muscle caused by the dietary fructose. Positive effects on insulin levels can be seen in human subjects as well. Non-insulin-dependent diabetics (n=6) were given liquid test meals and testing was blinded and randomized. The standard enteral formula (FST) used sucrose as the main carbohydrate source and the other two contained fructose with (FFG) or without (FF) 20g/L Sunfiber®. The test meal containing Sunfiber® reduced plasma glucose levels at 2 hours after consumption. Incremental areas under the plasma insulin curve was reduced by the fructose containing test meal and even further reduced by Sunfiber® at 4 h after consumption.

![Incremental Area under Plasma Insulin Curve](image)

Incremental Area under Plasma Insulin Curve
4 hours following consumption of test meal

<table>
<thead>
<tr>
<th></th>
<th>FST</th>
<th>FF</th>
<th>FFG (Sunfiber®)</th>
</tr>
</thead>
<tbody>
<tr>
<td>662 ± 128</td>
<td>556 ± 109</td>
<td>448 ± 60</td>
<td></td>
</tr>
</tbody>
</table>

(a:b = p<0.05)

The addition of Sunfiber® to food can effectively reduce the glycemic index of those foods. A total of 11 normal and 9 diabetic subjects were given white bread and rice with different amounts of Sunfiber® (3 – 15g) added during baking or cooking. Using a randomized, cross-over design, the control and test foods were given following an overnight fast and blood samples were taken. Experiments were performed twice and the glycemic index was calculated. The glycemic index of white bread was significantly reduced with the addition of increasing levels of Sunfiber® in both the normal and diabetic subjects.

![Glycemic Index of Subjects consuming White Bread made with Sunfiber®](image)

*GI of White Bread is assumed to be 100
Letters (abcd) denote significant differences at a level of p<0.05

The glycemic index of rice was also significantly reduced in normal subjects when cooked with Sunfiber®.  

Sunfiber® also has the ability to reduce the glycemic index of white bread when taken in a beverage at the same time. The glycemic index was significantly reduced in normal and diabetic subjects taking a drink containing 5g Sunfiber® and white bread. There were some slight differences in the glycemic effect between normal and diabetic subjects in this experiment.

[Graphs showing glycemic index of subjects consuming rice and white bread with Sunfiber®]
Improvement of Lipid Profile

High cholesterol and triglyceride levels are considered key risk factors for many diseases, such as heart disease and stroke. Dietary fiber has drawn considerable attention because of its ability to improve lipid metabolism and thus reduce the risk for these diseases. It has been demonstrated that water-soluble dietary fiber has lipid-lowering effects. The improvement of blood lipid status by PHGG has been explored in many animal and human studies.

Animal Studies:

Rats fed hypercholesterolemic diets supplemented with PHGG at 5% for 21 days showed suppression of the elevation of plasma cholesterol and triglyceride levels. Sunfiber® given to rats for 3 weeks in a regular diet reduced serum cholesterol and triglyceride levels as much as guar gum but had less effect than guar gum on serum phospholipid levels. The hypertriglyceridemia associated with fructose feeding to obtain a dietary model of insulin resistance was ameliorated by supplementation with a guar gum hydrolysate. Sunfiber® was effective in reducing serum levels of cholesterol and triacylglycerol in rats fed high-fat diets. Rats were given experimental diets containing 25% fat for 24 days. Sunfiber® (8%) was added to the diet at the expense of sucrose. Sunfiber® reduced biliary bile acid, cholesterol, and phospholipid concentrations and excretions.

Hypocholesterolemic and Hypolipidemic Effect of PHGG

![Graph showing lipid levels before and after PHGG supplementation.](image)

Human Studies:

PHGG appears to influence lipid profile in human studies in short-term trials. In a human volunteer study, serum cholesterol was reduced in 8 subjects after consumption of Sunfiber® (36g/day) in a beverage for 4 weeks. Similar results were seen when 6 female volunteers took PHGG (15g/day) for 2 weeks. Fasting blood parameters were measured before and after supplementation. Serum cholesterol concentration decreased significantly and all subjects had a reduction in cholesterol levels. All subjects also had a reduction in serum free fatty acid concentrations. Enterally-fed adults with persistent diarrhea given 2% PHGG had reduced plasma cholesterol levels after 4 days of supplementation.

Results are also seen post-prandially after consumption of PHGG with a test meal or product. A short-term study showed reduction of blood cholesterol levels four hours after consumption of a test meal and 15g PHGG. Sunfiber® was added to yogurt in a single-blind, placebo-controlled crossover study. The yogurt sample (200g), with or without 6g Sunfiber®, was taken with 100g of high-fat food. There was a significant suppression of peak levels of serum triglyceride and RLP-cholesterol in the PHGG supplemented yogurt. The suppressive effect was still visible, but not significant, 4 hours after consumption. This research demonstrates the potential for PHGG to positively influence lipid profile.

**Enhancement of Mineral Absorption**

Traditionally, dietary fibers were thought to limit absorption of certain vitamins and minerals. The reports on dietary fiber’s influence on mineral absorption are controversial but some research has supported the idea that some soluble fibers can enhance absorption. High fiber diets have been shown to reduce the balance of calcium, magnesium and to have a negative effect on calcium transport.\(^{45,46}\) Lignin and psyllium were reported to inhibit iron absorption in dogs but calcium status was not affected by consumption of a high fiber diet in chicks.\(^{47,48}\) No changes were found in calcium, iron or zinc excretion in men consuming Sunfiber® in high amounts (36g/day) for 4 weeks.\(^{5}\)

**Iron:**

Iron deficiency anemia can occur as a result of many factors, such as blood loss, pregnancy, inadequate dietary intake, or malabsorption.\(^{49}\) Iron absorption and utilization were investigated in growing rats fed iron-deficient diets, with or without Sunfiber®. It was demonstrated that Sunfiber® prevented the loss of iron from hemoglobin, serum iron and iron storage in the liver that was apparent in the rats fed the iron-deficient diet without fiber. Also, in an 3 day iron balance test, Sunfiber® intake corresponded with an increase in iron absorption. Sunfiber® (PHGG) may be effective in improving iron status in individuals with iron deficiency.\(^{23}\)

![Enhancement of Iron Absorption by Sunfiber®](image)

**Enhancement of Iron Absorption by Sunfiber®**

3 day Iron Balance Test in five-week old Wistar Rats

<table>
<thead>
<tr>
<th>Condition</th>
<th>Iron Absorption Ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron-Sufficient (IS) diet</td>
<td>27.8</td>
</tr>
<tr>
<td>25% Iron-Deficient (ID) diet</td>
<td>29.1</td>
</tr>
<tr>
<td>50% Iron-Deficient (ID) diet</td>
<td>29.8</td>
</tr>
<tr>
<td>IS + Sunfiber® (5%)</td>
<td>32.3</td>
</tr>
<tr>
<td>25% ID + Sunfiber® (5%)</td>
<td>36.7</td>
</tr>
<tr>
<td>50% ID + Sunfiber® (5%)</td>
<td>39.9</td>
</tr>
</tbody>
</table>

\(p< 0.05 / a : b = significant difference, a : ab = no significant difference\)

Calcium:
Recent studies have reported that certain soluble fibers, such as PHGG, may enhance calcium absorption. Enterally-fed patients with persistent diarrhea given 2% PHGG had significantly increased plasma calcium levels after 4 days of supplementation.

PHGG promoted calcium and magnesium absorption and reduced excretion in rats. Calcium absorption in five-sixths nephrectomized (NPX) rats was considerably lower than in sham operated rats, but the absorption in NPX rats with PHGG added to the diet were just slightly lower than in sham operated rats with PHGG. The authors attribute the increases in calcium absorption to the caecum and large intestine. They suggested that nephrectomy does not influence the absorption of calcium in the large intestine induced by PHGG feeding, and the increase in caeco-colonic adsorption compensates the decreasing proximal intestinal calcium transport associated with nephrectomy. The following figure shows the difference in calcium and magnesium absorption between the normal (sham operated for caecectomy) rats feed for 7 days supplemented with 5% Sunfiber®.

Enhancement of mineral absorption (Ca & Mg) by Sunfiber®

Improvement of skin conditions

The following charts are from “In-house” data and examine improvement of skin conditions after supplementation with Sunfiber®. Twelve females with constipation were treated with 21g/day of Sunfiber® for 4 weeks. There were noticeable results on skin conditions, such as acne, seborrhea and xeroderma. Skin was less dry microscopically when examined after one month of supplementation. The water content of the skin was also increased significantly.

In-house data
**Effect of Sunfiber® on Skin Improvement**

**Microscope (×100)**

**Before**
- Planar
- Dry skin

**After 4 weeks**
- Steric
- Normal skin

**Effect of Sunfiber® on Water Content of Skin**

Corneometer; measured by electrostatic capacitance of low frequency

<table>
<thead>
<tr>
<th>Capacitance (a.u.)</th>
<th>Before</th>
<th>After 1 month</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60.9</td>
<td>67.8*</td>
</tr>
</tbody>
</table>

Temperature: 21±1°C, Humidity: 60±5%, 30min.

* p < 0.05

In-house data
Weight Control

Populations that consume high-fiber diets have lower rates of obesity than those with low-fiber intake. There are many confounding dietary factors in epidemiological studies. For example, diets low in fiber tend to be higher in fat and energy density. A large, cross-cultural cohort study showed that physical activity and dietary fiber intake, and not dietary fat, were important determinants of body fat. Dietary fiber was inversely correlated to subscapular skinfold thickness. Consumption of high-fiber diets in healthy adult subjects have demonstrated increased satiety, reduced hunger, reduced energy intake and body weight in many studies. The beneficial effects of fiber on energy regulation were seen with both soluble and insoluble fibers, when using foods naturally high in fiber and fiber supplements.

Growing rats fed diets of 5 or 10% PHGG added to a standard diet for 3 weeks had severe depression of body fat. Results showed that increasing PHGG supplementation by more than 5% increases the dietary excretion of PHGG and fat into feces. Values for digestible and metabolizable energy and efficiency of energy utilization declined in PHGG-fed rats. No change in body protein or protein retention was observed, and food consumption was similar. Male rats given liquid diets supplemented with Sunfiber® had decreased destruction of the intestinal villi and normalization of the colon. No differences were observed between body weight gain of the Sunfiber® supplemented rats and the equivalent control diet. Body weight gain and feed intake was not affected by Sunfiber® in nephrectomized and normal rats. These models were not designed to look at the effects of PHGG on weight loss but on other factors, such as calcium absorption, in growing rats. A study looking at rats fed fructose diets to induce a dietary model of insulin resistance found a reduction of body weight gain and food intake in the PHGG supplemented group. However, this study was not looking at reduction of body weight in overweight rats but glucose tolerance in growing rats. There are presently no studies looking directly at the effect of PHGG supplementation on body weight loss or food intake in rats or other animals.

There is little direct evidence to support the reduction of food intake in humans by supplementation with PHGG, but it has been shown to reduce hunger ratings. There is, however, evidence that a high-fiber diet or fiber supplementation has an effect on body weight reduction or maintenance of reduced body weight.
References:


Physiological Effects


Functionality in Food

Guar gum forms a viscous colloidal solution when hydrated in cold water, whereas Sunfiber® (PHGG) remains clear with a lower viscosity. The viscosity of a 1% aqueous solution of food-grade guar gum ranged from 2000 to 3000 cps. A 5% solution of PHGG was less than 10cps. The low viscosity of Sunfiber® provides many advantages in medical and food products.

Comparison of Viscosity of Guar Gum Solution and Sunfiber® Solution

1%(w/w) guar gum  (More than 2,000 mPa·s)
10% (w/w) Sunfiber®  (20mPa·s, 5°C)
Physical Properties

Sunfiber® is a white powder, which is soluble, colorless, virtually tasteless, and transparent in water solution. The chemical structure of Sunfiber® does not change when exposed to high temperature over long periods of time, and its viscosity decreases consistently with increasing temperature. This makes its application in manufacturing with high temperature exceptionally viable. Sunfiber® is stable and soluble at various pH levels commonly found in foods, and is resistant to heat, acid, salt, high pressure and digestive enzymes.\textsuperscript{1,2}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{physical_properties.png}
\caption{Physical Properties of Sunfiber®}
\end{figure}

\begin{itemize}
\item Sunfiber® is soluble in water and has a low viscosity.
\item Viscosity of Sunfiber® is not influenced by pH.
\end{itemize}

*Viscosity Measurement: B type viscometer, 5°C

In-house data
Physical Properties of Sunfiber®

*Viscosity Measurement: B type viscometer, 5°C

**Sunfiber®** is stable under acidic conditions (pH3.5) at room temperature.

**Sunfiber®** has a lower degree of browning than isomerized sugars.

Sugar concentration = 10%  Glycine = 0.5 %  Temperature = 100°C

In-house data
Stability of Sunfiber® in Acid Drinks

In-house data

Samples:
Sunfiber®R (PHGG)
Orafti (Inulin)

Method:
H₂O 100ml (final volume)
Add: Sunfiber® or Inulin (10g)
Citric Acid (pH 3.6)
Pasteurization (100°C, 10 sec)
Storage at 50°C for 4 weeks
Dietary Fiber Measurement (AOAC)

Sunfiber® and Inulin in acid conditions at 50°C
Storage at 50°C, Acid drink at 10 brix., pH3.6

HPLC
Milk, Sunfiber® (3%) and starter yogurt (20%) were mixed and incubated at 40°C for 15 hours in aerobic conditions. Dietary Fiber measurements were taken after fermentation and again after one week.

**Stability of Sunfiber® in Yogurt**

- **Fiber content stability of Sunfiber® in yogurt**
  - After fermentation: 95%
  - After one week (4°C): 80%

**Effect of Sunfiber® on bacterial content of yogurt**

- **Mean of log10 Lactic Acid Bacteria (count/ml)**
  - Control (no fiber)
  - Sunfiber®
  - Inulin
  - Polydextrose
  - Resistant Dextrin

In-house data
**Applications as a Food Additive**

*Sunfiber®* appears to have little or no interaction with common food ingredients. *Sunfiber®* does not destabilize emulsions, change the viscosity of protein solutions, affect the flavor or color of products, or cause soluble materials to precipitate. In addition, PHGG prolongs the shelf-life of high starch foods, such as bread, by decreasing the turbidity of dextrin when it is added to a dextrin solution at low temperatures. The specific chemical and physical properties of *Sunfiber®* make it a unique ingredient for improving the quality of food items. As well as being a source of dietary fiber, addition of PHGG can improve processing by increasing the flow-ability of cereals, providing body and mellow flavor in most beverages, stabilizing the colloid system of dry and liquid meal replacements, mellowing tartness and firming texture in yogurt, stabilizing the foam system of shakes, improving the suspension of particulate matter in soups and dressings, and improving the quality of baked goods.\(^3\) PHGG (*Sunfiber®*) is presently used in many different capacities in beverages and food. The following diagram describes some of these functions.
**Prevention of Noodle Tangling**

5% Sunfiber® added into seasoning sauce and kept at 5°C for 2 hours

**Sugar Anti-caking Effect**

Sunfiber® and Oligofructose mixed and kept at 30°C, 70% RH for 2 weeks

<table>
<thead>
<tr>
<th>0%</th>
<th>5%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunfiber® 0%: Moistening</td>
<td>Sunfiber® 5%: Caking</td>
<td>Sunfiber® 10%: No caking</td>
</tr>
</tbody>
</table>

**Stabilization of Whipped Cream**

1% Sunfiber® added to whipped cream and kept at room temperature for 3 hours

In-house data
### Sunfiber® as a Food Additive

In-house data

<table>
<thead>
<tr>
<th>Application</th>
<th>Effect</th>
<th>Dosage</th>
<th>Preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noodle</td>
<td>Prevention of tangling</td>
<td>5 – 10%</td>
<td>Soaking or spray</td>
</tr>
<tr>
<td>Powdered sugar</td>
<td>Anti-caking</td>
<td>2 – 7%</td>
<td>Mixing or Granulation</td>
</tr>
<tr>
<td>Beverage with artificial sweetener</td>
<td>Masking of unpleasant taste of artificial sweetener</td>
<td>0.1%</td>
<td></td>
</tr>
<tr>
<td>Whipped cream</td>
<td>Stabilization of foam</td>
<td>1 – 2%</td>
<td>Mix with sugar in advance</td>
</tr>
<tr>
<td>Nuts</td>
<td>Anti-oxidation by forming film on the surface of nuts</td>
<td></td>
<td>Soak in 20% solution</td>
</tr>
<tr>
<td>Soft candy</td>
<td>Prevention of adhesion to teeth</td>
<td>1 – 3%</td>
<td></td>
</tr>
<tr>
<td>Cookies</td>
<td>Improvement of texture</td>
<td>10 – 15%</td>
<td>Powder-powder mixing</td>
</tr>
</tbody>
</table>

References:

## Comparison of Sunfiber® with other Dietary Fibers

<table>
<thead>
<tr>
<th>Partially Hydrolyzed Guar Gum</th>
<th>Arabinogalactan</th>
<th>Polydextrose</th>
<th>Indigestible Dextrin</th>
<th>Inulin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Brand Names</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunfiber®</td>
<td>FiberAid®</td>
<td>Litesse</td>
<td>Fibersol 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ImmunoEnhancer™</td>
<td>StarLite®</td>
<td>InstaFiber</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Polydextrose</td>
<td>CrystalLean</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ActiStar</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Raffilin ST</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Insulation®</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>FrutaFit®</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Oligo-fiberTM</td>
<td></td>
</tr>
<tr>
<td><strong>Structural Components</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Galactomannans</td>
<td>3,6-ß-D-galactan</td>
<td>12-unit</td>
<td>D-glucose polymers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>type</td>
<td>polysaccharide</td>
<td>(90% digestion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- galactose:arabinose 6:1</td>
<td></td>
<td>resistant)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- sm. amt. glucoronic acid</td>
<td></td>
<td>Chains of fructose molecules - fructans (2-60 units)</td>
<td></td>
</tr>
<tr>
<td><strong>Fiber conc.</strong></td>
<td>more than 76%</td>
<td>10%</td>
<td>40%</td>
<td>4%</td>
</tr>
<tr>
<td>AOAC Method</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enzymatic hydrolysis and purification</td>
<td>Patented hot water extraction - no solvents</td>
<td>Chemical Synthesis (vacuum thermal polymerization)</td>
<td>Chemical Synthesis</td>
<td>Hot Water Extraction</td>
</tr>
<tr>
<td><strong>Raw Material</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guar Gum</td>
<td>Larch Wood</td>
<td>Dextrin</td>
<td>Pyrolysis and enzymatic hydrolysis of cornstarch (or potato starch)</td>
<td></td>
</tr>
<tr>
<td>(Western Larch Tree)</td>
<td>(Western Larch Tree)</td>
<td>(Citric Acid)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td>6 - 7</td>
<td>2.5 - 3.5</td>
<td>3 - 5</td>
<td>5 - 7</td>
</tr>
<tr>
<td><strong>M.W.</strong></td>
<td>20 000</td>
<td>2 000</td>
<td>2.500</td>
<td>2 000</td>
</tr>
<tr>
<td>(10 000 - 100 000)</td>
<td>(162 - 20 000)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>USA</strong></td>
<td>Dietary Fiber</td>
<td>Dextrin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dietary Fiber</td>
<td>Bulking Agent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Calories</strong></td>
<td>4 kcal/g</td>
<td>1 kcal/g</td>
<td>3 kcal/g</td>
<td>1.5 kcal/g</td>
</tr>
<tr>
<td><strong>Viscosity</strong></td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High?</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>Powder - odorless, colorless, tasteless</td>
<td>Powder with a slight pine-like odor and sweetish taste</td>
<td>Powder - odorless, colorless, tasteless</td>
<td>Neutral taste, odor and color - may be very slightly sweet</td>
</tr>
<tr>
<td><strong>Solubility</strong></td>
<td>100% water soluble</td>
<td>100% water soluble</td>
<td>High water solubility 80% at 25°C</td>
<td>100% water soluble</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAIYO KAGAKU Co., Ltd.</td>
<td>-48-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005/8/30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Recommended Daily Intake

The estimated total dietary fiber intake varies between 10-25 g/d in most developed countries. The American Heart Association and the American Diabetes Association recommend 25-30 g/day of fiber. The desired intake value of 20-30 g/day of dietary fiber based on a 2,000-2,500 kcal/day has been recommended in Japan. The “Dietary Guidelines for Americans” recommends 26 g/day based on a 2000 kcal/day diet. Many people are not meeting the daily requirements recommended.

Administration of Sunfiber® (36 g/day) for 4 weeks to adult men resulted in no side effects. Other studies have suggested that a daily intake of 20-40 g/day of Sunfiber® is well tolerated and shows no serious side effects.

Sunfiber® can easily be used in food or as a dietary supplement to provide the recommended levels of dietary fiber.

Partially hydrolyzed guar gum (Sunfiber®) has been approved as a constituent for “Food for Specified Health Use (FOSHU) by the Japan Health Food and Nutrition Food Association.

Health Benefits: Helps maintain a healthy gastrointestinal condition
Effective Dose: 5-15 grams/day
References:


Recipes

Sunfiber® can be used in many different recipes and is very stable at low pH and high temperature. The following is a list of recipes that can be used to improve product quality or to increase dietary fiber intake. Sunfiber® can also reduce calories by replacing fat or sugar.

### Carbonated drink

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar</td>
<td>10.0</td>
</tr>
<tr>
<td><strong>Sunfiber®</strong></td>
<td>5.0</td>
</tr>
<tr>
<td>Citric Acid</td>
<td>0.2</td>
</tr>
<tr>
<td>Sodium citrate</td>
<td>0.1</td>
</tr>
<tr>
<td>Water</td>
<td>39.7</td>
</tr>
<tr>
<td>Carbonated water</td>
<td>50.0</td>
</tr>
</tbody>
</table>

**Directions / Notes:**

Sunfiber can be added up to 5% in carbonated and replaces sugar.

### Custard pudding

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>48.0</td>
</tr>
<tr>
<td>Whole egg</td>
<td>32.0</td>
</tr>
<tr>
<td>Sugar</td>
<td>15.3</td>
</tr>
<tr>
<td><strong>Sunfiber®</strong></td>
<td>1.7</td>
</tr>
<tr>
<td>Water</td>
<td>3.0</td>
</tr>
</tbody>
</table>

**Directions / Notes:**

Sunfiber can be added up to 1.7% in custard pudding and does not affect the taste and texture.
### Yogurt drink

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fermented Milk</td>
<td>70.0</td>
</tr>
<tr>
<td>Pectin</td>
<td>0.4</td>
</tr>
<tr>
<td>Sugar</td>
<td>6.0</td>
</tr>
<tr>
<td>Sunfiber®</td>
<td>5.0</td>
</tr>
<tr>
<td>Water</td>
<td>18.6</td>
</tr>
</tbody>
</table>

**Directions / Notes:**
Sunfiber can be added up to 5% in yogurt drinks and replaces sugar.

### Ice cream

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>40.0</td>
</tr>
<tr>
<td>Fresh cream</td>
<td>12.0</td>
</tr>
<tr>
<td>Condensed milk</td>
<td>18.0</td>
</tr>
<tr>
<td>Starch syrup</td>
<td>6.0</td>
</tr>
<tr>
<td>Sunfiber®</td>
<td>4.0</td>
</tr>
<tr>
<td>Emulsifier</td>
<td>0.2</td>
</tr>
<tr>
<td>Water</td>
<td>19.8</td>
</tr>
</tbody>
</table>

**Directions / Notes:**
Sunfiber improves the texture of ice cream due creation of smaller ice crystals.
<table>
<thead>
<tr>
<th>Whipped cream</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ingredients</strong></td>
</tr>
<tr>
<td>Fresh cream</td>
</tr>
<tr>
<td>Sugar</td>
</tr>
<tr>
<td>Sunfiber®</td>
</tr>
</tbody>
</table>

**Directions / Notes:**
Sunfiber replaces sugar in whipped cream. It improves the protectivity, extrusion properties and prevents free water release.

<table>
<thead>
<tr>
<th>Fat-free Chocolate Chip Cookies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ingredients</strong></td>
</tr>
<tr>
<td>Chocolate chips</td>
</tr>
<tr>
<td>All purpose flour</td>
</tr>
<tr>
<td>Brown Sugar</td>
</tr>
<tr>
<td>Water</td>
</tr>
<tr>
<td>White sugar</td>
</tr>
<tr>
<td>Whole egg</td>
</tr>
<tr>
<td><strong>Sunfiber®</strong></td>
</tr>
<tr>
<td>Salt</td>
</tr>
<tr>
<td>Baking soda</td>
</tr>
<tr>
<td>Vanilla</td>
</tr>
</tbody>
</table>

**Directions / Notes:**
Mix dry ingredients except chocolate chips. Add in vanilla, water and egg and blend. Fold in chocolate chips. Bake on ungreased cookie sheet in preheated oven at 375°F for about 10 minutes or until golden brown. Allow to cool before removing from pan.
### Biscuits

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour</td>
<td>56.00</td>
</tr>
<tr>
<td>Shortening</td>
<td>18.00</td>
</tr>
<tr>
<td>Sugar</td>
<td>14.50</td>
</tr>
<tr>
<td>Water</td>
<td>7.50</td>
</tr>
<tr>
<td><strong>Sunfiber®</strong></td>
<td>2.00</td>
</tr>
<tr>
<td>Milk solids (no fat)</td>
<td>1.00</td>
</tr>
<tr>
<td>Salt</td>
<td>0.70</td>
</tr>
<tr>
<td>Baking Soda</td>
<td>0.20</td>
</tr>
<tr>
<td>Baking Powder</td>
<td>0.10</td>
</tr>
</tbody>
</table>

**Directions / Notes:**

Blend dry ingredients except flour. Add shortening and mix. Add water and mix. Add flour and mix. Leave for 20 minutes. Roll out to 3mm thickness and cut with biscuit cutter. Bake for 4 minutes at 400°F. **Sunfiber®** makes a lighter biscuit and can be used at up to 5%.
Awards

The Innovative Technology and Food Development Award was established by the Japanese Food Newspaper in 1987 to honor food products developed using innovative technologies, biotechnologies, and associated technologies. In 1999, the award was presented to Taiyo Kagaku Co. Ltd. for their product Sunfiber®, a novel product that expanded the perspective of the food industry, was the driving force for new developments in the field, and enhanced the value of the technology used for its development.

Sunfiber® is a water soluble dietary fiber derived from the enzymatic hydrolysis of guar gum. In addition to the physiological effects of dietary fibers, Sunfiber® has many other beneficial properties, such as the ability to enhance the absorption of minerals and to aid in the treatment of diarrhea in susceptible populations.

Tokyo, Japan
# Sunfiber®

## Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Units</th>
<th>Sunfiber R</th>
<th>Sunfiber HG</th>
<th>Sunfiber IG</th>
<th>Sunfiber AG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>--</td>
<td>Off-white powder</td>
<td>Off-white powder</td>
<td>Off-white granulated powder</td>
<td>Off-white granulated particles</td>
</tr>
<tr>
<td>Particle Size</td>
<td>%</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
</tr>
<tr>
<td>Loss on Drying</td>
<td>%</td>
<td>&lt; 7.0</td>
<td>&lt; 7.0</td>
<td>&lt; 7.0</td>
<td>&lt; 7.0</td>
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<tr>
<td>Loose Density</td>
<td>g/cc</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>0.20-0.24</td>
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<tr>
<td>Typical particle size</td>
<td>%</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>Not Specified</td>
<td>&lt; 2 through USBS #20 sieve</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt; 40 through USBS #80 sieve</td>
</tr>
<tr>
<td>Protein</td>
<td>%</td>
<td>&lt; 1.0</td>
<td>&lt; 1.0</td>
<td>&lt; 1.0</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>Ash</td>
<td>%</td>
<td>&lt; 2.0</td>
<td>&lt; 2.0</td>
<td>&lt; 2.0</td>
<td>&lt; 1.5</td>
</tr>
<tr>
<td>pH (5%, 20°C)</td>
<td>--</td>
<td>6.0 - 7.0</td>
<td>6.0 - 7.0</td>
<td>6.0 - 7.0</td>
<td>6.0 - 7.0</td>
</tr>
<tr>
<td>Viscosity (5% solution)</td>
<td>mP·s</td>
<td>&lt; 13</td>
<td>5-13</td>
<td>&lt; 13</td>
<td>7.0 - 12.0</td>
</tr>
<tr>
<td>Dietary Fiber</td>
<td>%</td>
<td>&gt; 75.0</td>
<td>&gt; 75.0</td>
<td>&gt; 75.0</td>
<td>&gt; 75.0</td>
</tr>
<tr>
<td>Arsenic</td>
<td>ppm</td>
<td>&lt; 1.5</td>
<td>&lt; 1.5</td>
<td>&lt; 1.5</td>
<td>&lt; 1.5</td>
</tr>
<tr>
<td>Heavy Metals (as Lead)</td>
<td>ppm</td>
<td>&lt; 10</td>
<td>&lt; 10</td>
<td>&lt; 10</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Common Bacteria</td>
<td>CFU</td>
<td>&lt; 3000</td>
<td>&lt; 3000</td>
<td>&lt; 3000</td>
<td>&lt; 3000</td>
</tr>
<tr>
<td>Coliforms</td>
<td>Presence</td>
<td>Negative/0.1g</td>
<td>Negative/0.1g</td>
<td>Negative/0.1g</td>
<td>Negative/0.1g</td>
</tr>
<tr>
<td>Yeasts and Molds</td>
<td>CFU</td>
<td>&lt; 100</td>
<td>&lt; 100</td>
<td>&lt; 100</td>
<td>&lt; 100</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>Presence</td>
<td>Negative/25g</td>
<td>Negative/0.02g</td>
<td>Negative/25g</td>
<td>Negative/25g</td>
</tr>
<tr>
<td>Salmonella</td>
<td>Presence</td>
<td>Negative/25g</td>
<td>Negative/25g</td>
<td>Negative/25g</td>
<td>Negative/25g</td>
</tr>
</tbody>
</table>
1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY

1.1 Identification of the substance or preparation:
Sunfiber®

1.2 Intended use:
As a food and beverage ingredient to enrich dietary fiber.

1.3 Company Identification:
Noriyuki Ishihara
Bio Nutrition Division
Taiyo Kagaku Co., Ltd.
1-3, Takaramachi, Yokkaichi, Mie 510-0844 Japan
Phone: +81-593-47-5409 Fax: +81-593-47-5417

2. COMPOSITION / INFORMATION ON INGREDIENTS

<table>
<thead>
<tr>
<th>Components</th>
<th>%</th>
<th>CAS No.</th>
<th>Hazardous Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galactomannan</td>
<td>100.0</td>
<td>N.A.</td>
<td>Not hazardous</td>
</tr>
</tbody>
</table>

Chemical Structure
Gal

(Man-Man)n  Gal: Galactose, Man: Mannose

3. HAZARDS IDENTIFICATION

No hazardous ingredients
4. FIRST-AID MEASURES

4.1 Skin exposure:
Remove contaminated clothes. Wash skin with large volumes of water (or soap and water). If irritation persists, or any sign of tissue damage is apparent, obtain medical advice immediately.

4.2 Eye exposure:
Irrigate copiously with water at least 10 minutes. Obtain medical advice if any irritation or evidence of tissue damage persists.

4.3 Accidental ingestion:
Rinse mouth with water. If large amounts were swallowed, obtain medical advice immediately.

4.4 Excessive inhalation:
Not expected to require such first aid measures.

4.5 General comments:
As in all cases of potential poisoning, supportive therapy is of the utmost importance.

5. FIRE-FIGHTING MEASURES

In the event of fire, dry powder, carbon dioxide, alcohol-resistant foam or water mist extinguishers should be used. Avoid inhalation of smoke and fumes. In case of insufficient ventilation, wear suitable respiratory equipment.

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions:
Good personal washing routines should be followed after accidental releases.

6.2 Environmental precautions:
None required.

6.3 Methods for cleaning up:
Gross spillage should be sweep together, and disposal of this should be in accordance with Government regulations.
7. HANDLING AND STORAGE

7.1 Handling:
Avoid contact with eyes.
Gloves (natural rubber is the preferred material) and eye / face protection recommended.

7.2 Storage:
It is good general practice to store at room temperature (or cooler) in closed containers.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Exposure controls:
Do not subject to unnecessarily high temperature during processing.

8.2 Personal protection:
Respiratory protection: where ventilation may be inadequate, wear self-contained breathing apparatus.
Hand protection: where gloves are indicated, natural rubber preferred material.
Eye protection: where eye protection is indicated, safety goggles are recommended.
Skin protection: depending on working situation these should include wearing protective clothing, which will also limit the odor contamination of personal clothing. Good personal washing routines should be followed.
9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Appearance: powder
9.2 Odor: Characteristic odor
9.3 Color: off-white
9.4 Flash point (closed cup): N.A.
9.5 Relative density (d 20/20): N.A.
9.6 pH: 6.0 – 7.0 (5% water solution)
9.7 Boiling point/boiling range: N.A.
9.8 Melting point/melting range: N.A.
9.9 Autoflammability: None
9.10 Explosive properties: None
9.11 Oxidizing properties: None
9.12 Vapor pressure (Pa): N.A.
9.13 Partition coefficient: n-octanol/water: N.A.
9.14 Water solubility (20°C): soluble

10. STABILITY AND REACTIVITY

It is good general practice to store at room temperature (or cooler) in closed containers. Dangerous decomposition products will not form if the temperature is slightly higher than recommended.

11. TOXICOLOGICAL INFORMATION

The safety of this product was confirmed with acute toxicity, subacute toxicity and mutagenicity tests. No toxicity was found with the above tests.
12. ECOLOGICAL INFORMATION

This preparation has not been subjected to ecotoxicological testing as an entity. In view of the difficulty of using current standard ecotoxicological evaluation techniques to predict the impact of particular modes of release on vulnerable or localized parts of the ecosystem, this preparation should be considered and handled as if displayed potential environmental hazards, and treated in consequence with all possible precautions.

13. DISPOSAL CONSIDERATIONS

Residual quantities of the product should be treated according to the instructions given under points 6, 7 and 8 above. Wastes should be eliminated according to national or regional regulatory requirements currently in force.

14. TRANSPORT INFORMATION

In case of accidental spillage or fire during transport, refer to instructions given under points 5, 6, 7 and 8 above.

14.1 UNO:

UN number: -----  
UN hazard class: -----  
UN packing group: -----  

14.2 ADR/RID:

UN-Nr.: -----  
Class: -----  
PG: -----  

14.3 IMDG:

UN-Nr.: -----  
Class: -----  
PG: number: -----  

14.4 ICAO/IATA

UN/ID-Nr.: -----  
Class: -----  
PG: -----
15. REGULATORY INFORMATION

No specific regulation about handling of this material is known by manufacturer.

16. OTHER INFORMATION

16.1 Recommended uses and restrictions
For further information, please refer to specific advice provided in technical data sheets or available from the manufacturer at the address indicated.

We believe that the information contained herein is current as of the date of this Material Safety Data Sheet. Since the use of this information and the conditions of use of the product are not within the control of Taiyo Kagaku Co., Ltd., it is the user’s obligation to determine conditions of safe use of product.
Publications

(PHGG and Sunfiber®)


