

Soluble Corn Fibre*: Health Benefits and Product Applications



**Innovating to Meet Nutrition,
Health, and Wellness Needs Every Day**

***PROMITOR® Soluble Corn Fibre
PROMITOR® Soluble Gluco Fibre in Europe**



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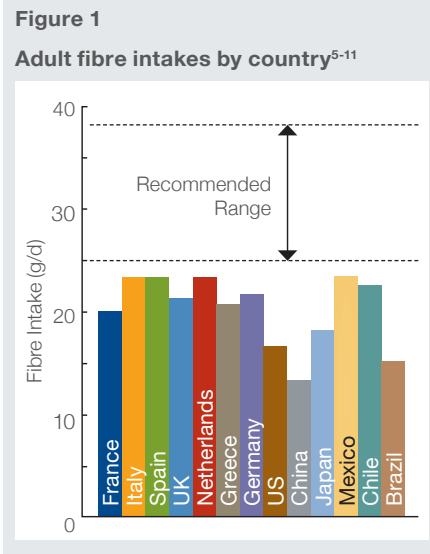


Fibre Intakes and Recommendations

- **Despite the fact that many consumers say that they are making efforts to consume diets high in dietary fibre current fibre intakes remain low.**
- **Research indicates that diets higher in fibre are associated with improved health and reduced risk of certain diseases.**
- **Added and functional fibres can help bridge the gap between actual intake and global dietary recommendations.**
- **Tate & Lyle's PROMITOR® Soluble Corn Fibre* is a good example of an ingredient that manufacturers can use in the development of new and innovative products to meet the population's fibre needs and that provides health benefits including supporting gastrointestinal health, maintenance of healthy blood glucose, and potentially supporting bone health.**

Decades of research indicate that diets higher in fibre are associated with reduced risk for heart disease, diabetes^{1,2}, and obesity¹ as well as improved gut health and digestive health², yet average intakes are well below the recommended amount^{1,3}. Continued low fibre intakes among global populations have long-term public health implications^{1,3}.

Data indicate that consumers believe fibre is important to health and that they recognize the lack of fibre in their diets⁴. Yet, closing the fibre intake gap historically has not been easy, as many diets continue to lack adequate servings of fruits, vegetables, whole grains, and fibre-fortified foods. Recent innovations are making it easier for food manufacturers to fortify their products with fibre to help boost fibre content and close this intake gap. An abundance of research continues to demonstrate that fibres added to foods provide similar benefits as "intact" fibres inherent to whole foods.



Tate & Lyle's Soluble Corn Fibre (PROMITOR®*) is commonly added to foods to boost fibre content without sacrificing taste, texture, or enjoyment. Studies have also demonstrated health benefits of soluble corn fibre, an added or functional fibre.

Dietary fibre gap: Intakes vs. recommendations

Recommendations for fibre intakes range from 25-38 g/day depending on country specific guidelines^{2,5}. The World Health Organization suggests worldwide recommendations of 25 g/day⁵, but fibre intakes in most countries are well below this level⁵⁻¹¹ (Figure 1). In the United States (US), for most age and gender groups, 5% or less meet the dietary recommendations for fibre¹² despite consistent messaging to the public to increase dietary fibre intake.

Fibre sources

Dietary fibres are non-digestible carbohydrates in the diet that, when consumed, pass through the small intestine into the large intestine where they may be partially or completely fermented by colonic microbiota². While traditional sources of fibre like whole grains, fruits, and vegetables should be encouraged, added fibres are also important contributors to dietary fibre intake. Added fibres, also known as "functional," are isolated or synthesized non-digestible carbohydrates that have beneficial physiologic effects in humans². These fibres can be extracted from the original food source that they are being added back to (e.g., bran added to grain-based foods); or they can be manufactured from grains like corn or wheat (e.g., STA-LITE® Polydextrose and PROMITOR® Soluble Corn Fibre*), or from fruit, vegetables, legumes, nuts, and seeds²; or the fibres can be modified forms of traditional fibres². Adding fibre to commonly consumed foods or to new foods is one strategy to increase the dietary fibre intake of target populations in order to bridge the gap between usual intakes and recommended intakes. PROMITOR® Soluble Corn Fibre* is a source of dietary fibre that can be added to a variety of foods.

* PROMITOR® Soluble Corn Fibre, PROMITOR® Soluble Gluco Fibre in Europe

Fibre Innovation for Health

Physiological functions and benefits of fibre

The physical and chemical structure of a dietary fibre and its fermentation capacity are partially responsible for the many physiological benefits associated with dietary fibre consumption. Dietary fibre has been inversely associated in epidemiological studies with the risk of coronary heart disease, stroke, hypertension, obesity, prediabetes, type 2 diabetes, certain gastrointestinal disorders, and various cancers¹. Evidence indicates that consumption patterns high in certain fibres are associated with lower total and LDL cholesterol, blood pressure, and blood glucose in healthy individuals and in those with prediabetes and type 2 diabetes; can help with both weight loss and maintenance; and can improve bowel regularity, laxation, and gastrointestinal health^{1,5,13-18}. While the breadth of scientific evidence supports these effects, science continues to build on other additional health benefits of fibre consumption such as fermentation by colonic microbiota and immunomodulation¹⁸.

PROMITOR® Soluble Corn Fibre* is a fibre ingredient developed by Tate & Lyle and used in foods and beverages across the Americas, Europe and Asia Pacific as a potential solution to increase fibre intake.

Characterization of PROMITOR®

PROMITOR® Soluble Corn Fibre* 70 provides a minimum of 70% dietary fibre and contains less than 20% sugar with a

Benefits

PROMITOR® Soluble Corn Fibre* has been tested by a number of independent researchers to validate its effectiveness and demonstrate physiological health benefits. The following are some highlights of the research on the health benefits of PROMITOR® Soluble Corn Fibre*:

- **Is well-tolerated¹⁹⁻²³, even at high intake levels (40 g/day bolus and 65 g/day multiple doses), and has been found to be better tolerated than inulin²¹**
- **Promotes healthy laxation^{22,23} and produces fewer negative faecal metabolites²³**
- **Has prebiotic properties^{23-25,27,33} which may support a healthy gut by producing short chain fatty acids that feed the beneficial bacteria in the intestines**
- **May assist with weight control by providing minimal calories (1.2-2 kcal/g)^{28,29}**
- **Supports healthy blood glucose control by decreasing postprandial glycaemic response³⁰⁻³²**
- **May support bone health by increasing calcium absorption^{26,27,33}**

caloric content of 2 kcal/g**. PROMITOR® Soluble Corn Fibre* 85 provides a minimum of 85% dietary fibre and contains less than 2% sugar with a caloric content of 1.2 kcal/g**. The latter is produced by the removal of low molecular weight sugars from PROMITOR® Soluble Corn Fibre* 70, yielding a product with a higher fibre content and reduced sugar content for the formulation of “no sugar added” foods and beverages. Both products are produced through the enzymatic hydrolysis of corn starch. They are both low in viscosity, water soluble, and are very stable to heat, pH, and processing stresses.

Resists digestion and is fermented in the gut

PROMITOR® Soluble Corn Fibre* contains a mixture of α 1-6, α 1-4, and α 1-2 glucosidic linkages

that contribute to the low digestibility of the ingredient. A study in pigs observed that at least 70% of PROMITOR® Soluble Corn Fibre* resists digestion in the small intestine and passes into the large intestine for fermentation²⁸. Changes in faecal short chain fatty acids (SCFA), pH, and breath hydrogen are indicators that gut fermentation is taking place. However, in humans, it is difficult to directly measure the extent to which a dietary fibre resists digestion and is fermented by colonic microbiota, because the SCFA are readily absorbed; animal and in vitro models are better utilized for this purpose. In a randomized, controlled, single-blind, crossover study, 24-hour breath hydrogen was found to be significantly increased after 18 overweight adults consumed breakfast and lunch foods in which 30% of the available carbohydrate was replaced with 55 g of PROMITOR® Soluble Corn Fibre*³¹.

* PROMITOR® Soluble Corn Fibre, PROMITOR® Soluble Gluco Fibre in Europe

**These values reflect US ingredient only. Calories vary based on global regulations.

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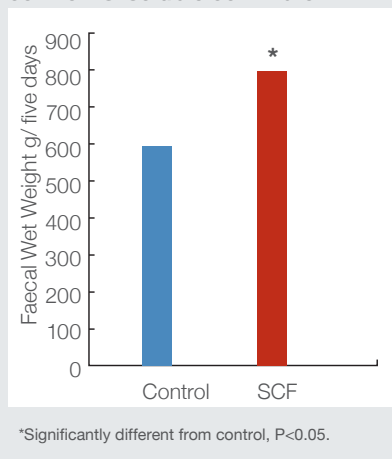
Faecal pH was significantly lowered in a randomized controlled, double-blind, crossover trial that investigated the effects of 21 g/day of fibre from PROMITOR® Soluble Corn Fibre* in 21 overweight, healthy adult men²³. In rats fed PROMITOR® Soluble Corn Fibre*, reduced pH levels were observed in the cecum and colon³³ and increased concentrations of the SCFAs acetate and propionate were detected in the cecum^{32,33}. Similarly, two in vitro evaluations that utilized human faecal inoculum from healthy adults found acetate, propionate, and butyrate levels were elevated with the addition of PROMITOR® Soluble Corn Fibre*^{24,25}. In another in vitro simulation of gastric digestion and large bowel fermentation using animal faecal material, PROMITOR® Soluble Corn Fibre* was the most fermented ingredient, followed by pullulan, polydextrose, soluble fibre dextrin, and resistant starch³⁴.

Good digestive tolerance

It is well known that a sudden increase in dietary fibre may cause mild gastrointestinal disturbances, but these are generally transient and improve with adaptation to the dietary fibre source. PROMITOR® Soluble Corn Fibre* is well tolerated at various doses¹⁹⁻²³. Clinical trials assessing the gastrointestinal tolerance of PROMITOR® Soluble Corn Fibre* at doses of 12-27 g/day of fibre found it to be well tolerated over a period of ten days to three weeks^{19,20,22,23}. In a trial of 20 healthy volunteers, PROMITOR® Soluble Corn Fibre* in both a single dose at 40 g of fibre and in multiple doses reaching 65 g of fibre over the day were well-tolerated²¹.

Figure 2

Five day faecal wet weight (g) of control vs. soluble corn fibre²²



Improves laxation

PROMITOR® Soluble Corn Fibre* improves digestive health through its effect on laxation. Thirty-six healthy adults who consumed 20 g/day of fibre from PROMITOR® Soluble Corn Fibre* in breakfast cereal and muffins for ten days in a randomized placebo-controlled, double-blind crossover study experienced an increase in faecal weight (Figure 2)²². Increased faecal weight was also observed in another randomized, placebo-controlled, double-blind, crossover study of 21 healthy overweight men who ingested 21 g/day of fibre from PROMITOR® Soluble Corn Fibre* for 21 days²³.

Prebiotic benefits

PROMITOR® Soluble Corn Fibre* may induce a prebiotic effect by promoting the growth of beneficial bacteria while limiting the growth of less desirable bacteria. After the consumption of 21 g/day of fibre

from PROMITOR® Soluble Corn Fibre* for 21 days, there was a 1 log increase in *Bifidobacterium* spp. in 21 healthy men compared to a no fibre control²³. Another study in 24 adolescents noted an increase in beneficial bacteria – *Bacteroides*, *Butyricoccus*, *Oscillibacter* and *Dialister* – which was correlated with an increase in calcium absorption when 12 g/day of fibre from PROMITOR® Soluble Corn Fibre* was consumed for three weeks²⁶. The significant increase in beneficial bacteria observed in human studies has been supported by in vitro studies that have used human faecal inoculum under conditions that simulate the human gastrointestinal tract^{24,25}.

Favorable blood glucose and insulin response

PROMITOR® Soluble Corn Fibre* elicits a low glycaemic response and is valuable for use in products for diabetes control and in products intended to reduce glycaemic load. Two clinical studies^{30,31} and one animal study³² have evaluated the glycaemic effects of PROMITOR® Soluble Corn Fibre*. The postprandial glycaemic response to PROMITOR® Soluble Corn Fibre* was compared to the glycaemic response to glucose in 12 healthy adults in a randomized, controlled, crossover study (Figure 3)³⁰. PROMITOR® Soluble Corn Fibre* had a significantly lower incremental glucose and insulin response than the glucose control. Another acute study³¹ observed a significant lowering effect on postprandial blood glucose and insulin at a dose of 55 g of PROMITOR® Soluble Corn Fibre* in randomized, single-blind, crossover study in 18 overweight Dutch adults compared to a full calorie control. Finally, a series of soluble corn fibre formulations investigated in an

* PROMITOR® Soluble Corn Fibre, PROMITOR® Soluble Gluco Fibre in Europe



animal study were found to yield significantly lower postprandial blood glucose and insulin responses than a maltodextrin control³². To date, the data on PROMITOR® Soluble Corn Fibre* supports a blood glucose and insulin lowering effect. Thus, this product can not only serve as a good source of fibre, but may also lower blood glucose response, a desirable feature for those with diabetes and healthy individuals.

optimizing bone mass, and reducing the risk of osteoporosis³⁵. Calcium is a shortfall nutrient, hence any attempts to increase calcium absorption and retention is of critical significance³⁵. In a three-week, randomized, double-blind, placebo-controlled, crossover study of 24 adolescents, calcium absorption was increased by 12% when 12 g/day of fibre from PROMITOR® Soluble Corn Fibre* was consumed, compared to a control, in conjunction with a background diet that contained 600 mg/day of calcium²⁶. Additionally, the researchers found that when the adolescents consumed SCF, there was an increase in specific strains of beneficial gut bacteria, namely the phylum *Bacteroidetes*, and these increases were positively correlated with increases in calcium absorption²⁶. If the adolescents in this study had continued to consume SCF, allowing for increased calcium absorption, the researchers estimated that this would lead to additional 41 mg/day retained calcium and if persistent over a year would account for an additional 15 g of calcium, or about 1.8% of total body calcium²⁶. Similar increases in calcium absorption were reported in a four-week, randomized, double-blind, placebo-controlled, crossover study in 26 free-living adolescent females who consumed 10 and 20 g/day of fibre from PROMITOR® Soluble Corn Fibre* with their habitual diet containing ≤ 800 mg/day of calcium²⁷. While these human studies only assessed calcium absorption, a 12-week study conducted in rats investigated the impact of PROMITOR® Soluble Corn Fibre* on bone indices as well as calcium metabolism³³. Compared to a cellulose control, soluble corn fibre improved total bone mineral content (BMC), total bone mineral density (BMD), trabecular BMC and BMD, cortical BMC, and cortical area and thickness in the distal femur (Figure 4)³³. Bone strength of the

distal femur was also significantly improved by the ingestion of PROMITOR® Soluble Corn Fibre*³³. While additional long term studies in humans are needed to assess potential impact on bone indices, these data suggest that PROMITOR® Soluble Corn Fibre* may help support bone health by increasing calcium absorption while providing a source of fibre. Both of these are critical nutrition issues for various segments of the population, especially adolescents and women.

Figure 3

Effect of PROMITOR® Soluble Corn Fibre on glucose and insulin response³⁰



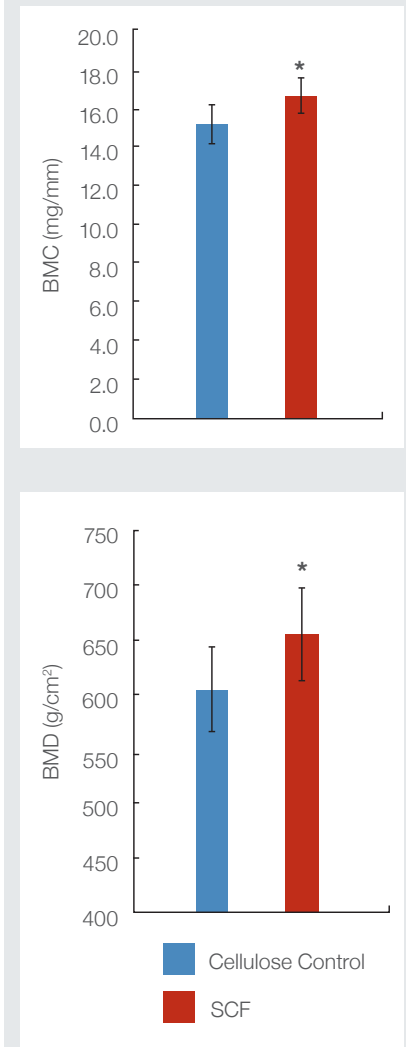
Significant difference between treatments at each time point at $P < 0.05$.

Potential bone health benefits

Adequate calcium consumption is important throughout the lifespan, particularly for building strong bones,

Figure 4

Effects of soluble corn fibre on BMD and BMC in Sprague-Dawley rats³³



*Significantly different from control, $P < 0.05$.

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Nutritional Impact of the Use of PROMITOR® Soluble Corn Fibre*



Soluble corn fibre can be used in a wide variety of prepared foods, beverages, and condiments including, cereals, baked goods, candy, dairy products, frozen foods, soups, salad dressings, fruit drinks, carbonated beverages, meal replacement drinks, and flavored water.

On a product's ingredient listing, in the case of PROMITOR® Soluble Corn Fibre* 70, it can normally be listed as *soluble corn fibre, corn syrup or corn syrup solids* and in the case of PROMITOR® Soluble Corn Fibre* 85, it can normally be listed as *soluble corn fibre or maltodextrin*. Its contribution to the product's overall fibre would be included in the fibre listing on the Nutrition Facts Panel.

To learn more about PROMITOR® Soluble Corn Fibre*, please visit www.promitorfibre.com.

Current fibre intakes are very low among US adults, at about one-half of the US daily fibre recommendation of 25-38 grams/day for women and men^{2,36}. In other nations⁵, average fibre intakes also fall well below recommended intakes. Diets high in fibre have been associated with lower risk of heart disease and improved blood glucose control while also supporting digestive health and laxation and aiding in weight management^{37,38}.

Simple substitutions of similar foods made with PROMITOR® Soluble Corn Fibre* can help to close the fibre intake gap. In this menu example, fibre increases by 20 g. PROMITOR® Soluble Corn Fibre* is well tolerated and research to date suggests that it supports digestive health and laxation, may help decrease postprandial glycaemic response, has prebiotic benefits, and may support bone health through its ability to increase calcium absorption.

Nutrition Facts		Change	% Change
Baseline menu:	Menu with PROMITOR® Soluble Corn Fibre*:		
Calories 1,980	Calories 1,970		
Total Fat 66 g Saturated Fat 22 g	Total Fat 64 g Saturated Fat 22 g		
Cholesterol 225 mg	Cholesterol 215 mg		
Sodium 2,950 mg	Sodium 2,750 mg		
Total Carbohydrate 66 g Dietary Fibre 15 g Sugars 119 g	Total Carbohydrate 278 g Dietary Fibre 35 g Sugars 128 g	+20 g fibre	+133%
Protein 82 g	Protein 84 g		



2,000-calorie menu, baseline**	With PROMITOR® Soluble Corn Fibre* substitutions
Breakfast: 1 cup cinnamon toast crunch cereal ¾ cup low-fat milk 1 cup grapefruit sections 1 slice toast w/ 1 tbsp apricot jam 1 cup latte w/ ¼ cup low-fat milk	Breakfast: 1 cup cinnamon oat crunch cereal, made with PROMITOR® Soluble Corn Fibre* ¾ cup low-fat milk 1 cup grapefruit sections 1 slice toast w/1 tbsp apricot spread, made with PROMITOR® Soluble Corn Fibre* 1 cup latte w/ ¼ cup low-fat milk
Lunch: 1 cup tomato soup Antipasto salad: 2 cup romaine lettuce, 1 oz salami, 1 ½ oz provolone cheese, 2 tbsp chopped hard-cooked egg, 1 tbsp olives, 2 tbsp oil & vinegar dressing 1 slice Italian bread 1 cup unsweetened iced tea	Lunch: 1 cup creamy tomato basil soup, made with PROMITOR® Soluble Corn Fibre* Antipasto salad: 2 cup romaine lettuce, 1 oz salami, 1 ½ oz provolone cheese, 2 tbsp chopped hard-cooked egg, 1 tbsp olives, 2 tbsp oil & vinegar dressing 1 slice Italian bread 1 cup unsweetened iced tea
Dinner: Chicken fajitas: 2 six-inch flour tortillas, 1 cup sautéed red and green bell peppers, ½ cup onion, 1 tbsp sour cream ½ cup Spanish rice 1 cup low-fat milk	Dinner: Chicken fajitas: 2 six-inch flour tortillas, 1 cup sautéed red and green bell peppers, ½ cup onion, 1 tbsp sour cream ½ cup Spanish rice 1 cup low-fat milk
Snack: 1 cup apple juice 2 oatmeal-raisin cookies	Snack: 1 cup apple juice 1 fruit-filled cereal bar, made with PROMITOR® Soluble Corn Fibre*

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**Menu based on USDA Food Pattern, Dietary Guidelines for Americans, 2010

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Nutrition professionals opportunity to educate consumers

Despite the fact that many consumers say that they are making efforts to consume diets high in dietary fibre and that they review labels for dietary fibre content when purchasing products, current fibre intakes remain low^{4,5}. This has long-term implications for public health related to risk of coronary heart disease, stroke, hypertension, certain gastrointestinal disorders, obesity, and the continuum of metabolic dysfunctions including prediabetes and type 2 diabetes^{1,18}. According to a 2014 food and health survey of US consumers by the International Food Information Council, 53% of Americans stated that they are trying to consume more dietary fibre⁴. Nutrition professionals can help to move consumers toward the goal of increasing fibre intake with education on benefits and sources of dietary fibre as consumers desire to make dietary changes.

Conclusions

While individuals should increase their consumption of dietary fibre from sources such as beans and peas, other vegetables, fruits, and whole grains¹, the incorporation of added fibre like PROMITOR® Soluble Corn Fibre* into foods as part of a well-balanced diet can help close the intake gap between recommended and actual intakes. Tate & Lyle's PROMITOR® Soluble Corn Fibre* is a good example of an ingredient that manufacturers can use in the development of new and innovative products to meet the population's fibre needs and that provides health benefits including supporting gastrointestinal health, maintenance of healthy blood glucose, and potentially supporting bone health.

A commitment to innovation

Tate & Lyle, a global leader in wellness innovation, is committed to delivering innovative ingredients that can be incorporated into great-tasting foods to help consumers meet their nutrition, health, and wellness needs every day. That is because Tate & Lyle invests heavily in innovation and research and in developing ingredients that can be incorporated into a wide variety of great-tasting food and beverage solutions. Teams of food and nutrition scientists are continuously innovating, researching, and testing ingredients that will meet current and future health and nutrition needs.

At the same time, Tate & Lyle has a robust market research program designed to provide the necessary insights on market preferences around the world. The research program allows Tate & Lyle to customize its offerings and provide tailor-made solutions in local and regional markets.

Better-for-you ingredients for health and wellness

In response to global public health efforts calling for people to reduce calories and sodium and increase fibre intakes, Tate & Lyle offers a number of innovative ingredient solutions that meet these needs.

To learn more about Tate & Lyle ingredients and innovation as well as health benefits and relevant research, please visit www.foodnutritionknowledge.info and www.tateandlyle.com.



Tate & Lyle's global Commercial and Food Innovation Center, Hoffman Estates, Illinois, USA

* PROMITOR® Soluble Corn Fibre, PROMITOR® Soluble Gluco Fibre in Europe

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