Nutrition Centre

By TATE & LYLE

Soluble Corn Fibre: The science behind the health benefits

Innovating to meet nutrition, health, and wellness needs every day

Key points

PROMITOR®
Soluble Fibre

- Research indicates that diets higher in fibre are associated with improved health and reduced risk of certain diseases, including cardiovascular diseases and type 2 diabetes.
- Even though many consumers say that they are making efforts to consume diets higher in dietary fibre, current fibre intakes remain low.
- While the promotion of traditional sources of fibres like whole grains, fruits and vegetables should be actively encouraged, fibre fortification can help bridge the gap to meet global dietary fibre recommendations.
- Emerging scientific evidence indicates that prebiotic soluble fibres may play a role in metabolic and immune health and cognitive function.
- Tate & Lyle's **PROMITOR® Soluble Fibre** is a soluble corn fibre (SCF) ingredient that manufacturers can use in the development of new and innovative products.
- **PROMITOR® Soluble Fibre** provides health benefits including helping to maintain healthy postprandial (after-meal) blood glucose and supporting gastrointestinal health through prebiotic effects, as well as enhancing calcium absorption which may support bone health. All without sacrificing taste, texture, or enjoyment.

Introduction

Decades of research point to the health benefits of dietary fibre, including supporting cardiovascular health, tempering spikes in blood sugar, aiding weight management, and promoting a healthy gut.[1-7]

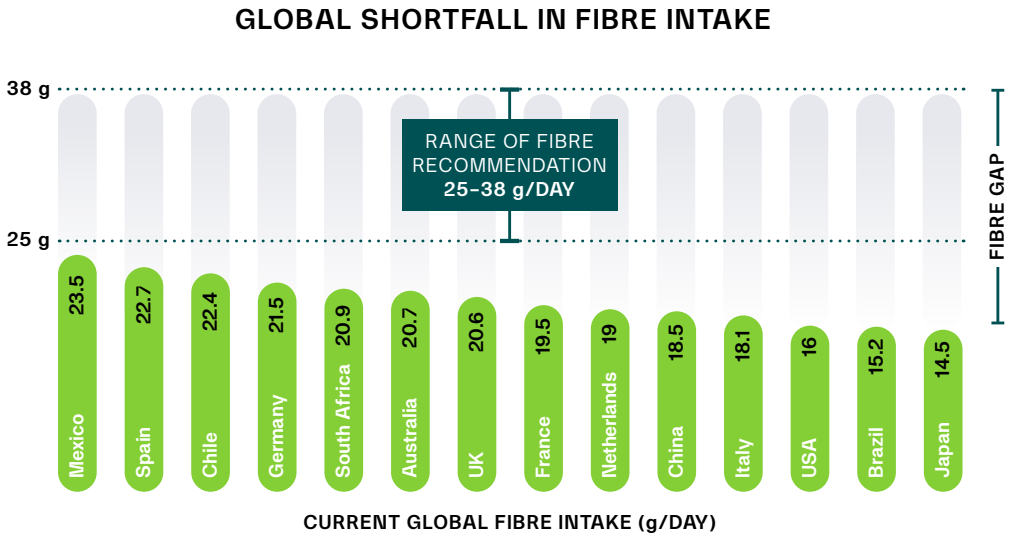
Yet, across the globe, average intakes are well below the recommended amount despite the widespread knowledge of fibre's role in a healthy diet.[1,3] An abundance of research continues to demonstrate that added fibres, also known as "functional fibres", provide similar benefits to fibres inherent in whole foods and could play a role in bridging the "fibre gap".

Dietary fibre gap: Intakes vs. recommendations

Recommendations for fibre intakes range from 25–38 g/day depending on country specific guidelines.[2,3,6] The World Health Organization suggests worldwide recommendations of greater than 25 g/day,[5] but fibre intakes in most countries are well below this level (Figure 1).[8–17] In the United States (US), for most age and gender groups, only 6% meet the dietary recommendations despite consistent messaging to the public to increase dietary fibre intake.[1]

Recommendations within individual European countries vary but average intakes for adult males in Europe range from 18 to 24 g/d and for females 16 to 20 g/d, below the 25 g/day established by the European Food Safety Authority to support normal laxation.[7] Fibre intakes in children and teenagers also fall short of recommendations in westernized countries.[3]

Figure 1. Average adult fibre intakes by country and fibre gap compared to recommendations.[8–17]



Fibre sources and the role of fortification

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 the colonic microbiota.[2] Added fibres, also known as "functional fibres," are non-digestible carbohydrates that are either isolated from a food source, or synthesized non-digestible carbohydrates that have beneficial physiological effects in humans.[2,6]

These fibres can be extracted from one food source and added to another (e.g., bran added to grain-based foods); manufactured from grains like corn or wheat (e.g., **STA-LITE® Polydextrose** and **PROMITOR® Soluble Fibre**) obtained from fruit, vegetables, legumes, nuts, and seeds; or the fibres can be modified forms of traditional fibres.[2,6]

Adding fibre to new or commonly consumed foods is one strategy to help bridge the gap between usual intakes and recommended intakes. The benefit of reformulation and fortification is that it generally requires minimal behaviour change so methods like these can be useful adjuncts to recommendations that do require a change in dietary habits.

To investigate the potential benefit of food fortification with fibre, a health and nutrition modelling study was undertaken based on current UK dietary patterns. It showed that increasing the fibre content of a selection of everyday foods including baked goods, dairy products, soups, smoothies, and dressings, would enable 50% more adults to achieve the recommended daily amount of fibre in their diets and could lower the risk of heart disease and type 2 diabetes for the majority of UK adults (Figure 2). The overall mean increase in fibre intake from fortifying a selection of foods was 2.2 g/day showing that even modest improvements could be beneficial.[18]

Figure 2. Tate & Lyle modelling study showing potential public health gains of adding fibre to everyday foods.[18]

Fibre fortification would enable **50%** more **UK adults** to consume the recommended amount of fibre.

6% of population would achieve a **weight reduction** because of fortification.

72% of population would achieve a reduction in **cardiovascular** risk and **type 2 diabetes** risk with fibre fortification.

Fibre Innovation For Health

Physiological functions and benefits of fibre

The **physical and chemical structure** of dietary fibre and its **fermentation capacity** are partially responsible for the many physiological benefits associated with dietary fibre consumption.

Increased dietary fibre has been associated in epidemiological studies with a reduced risk of coronary heart disease, stroke, hypertension, obesity, prediabetes, type 2 diabetes, certain gastrointestinal disorders, and some cancers.[1]

Evidence indicates that consumption patterns high in certain fibres are associated with lower total and LDL cholesterol, blood pressure, 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.[1–7,19]

Scientific understanding also continues to build for additional health benefits of fibre consumption in the areas of immune modulation and cognitive health.[19–21]

PROMITOR® Soluble Fibre

Characterisation and labelling of PROMITOR® Soluble Fibre

PROMITOR® Soluble Fibre is used in foods and beverages across the Americas, Europe, and the Asia Pacific as a potential solution to increase fibre intake. It is available in different formats:

- **PROMITOR® Soluble Fibre 70** provides a minimum of 70% dietary fibre and contains less than 10% sugar with a caloric content of 1.9 kcal/g.*
- **PROMITOR® Soluble Fibre 85** provides a minimum of 85% dietary fibre and contains less than 2% sugar with a caloric content of 1.1 kcal/g.*
- **PROMITOR® Soluble Fibre 90** provides a minimum of 90% dietary fibre and contains less than 2% sugar with a caloric content of 1.1 kcal/g.*
- **PROMITOR® Soluble Fibre 85** and **PROMITOR® Soluble Fibre 90** are therefore suitable for products requiring more fibre.

PROMITOR® Soluble Fibre

PROMITOR® products are low in viscosity, water-soluble and very stable to heat, pH and processing stresses. On a product's ingredient listing, **PROMITOR® Soluble Fibre** 70, 85 or 90 can be listed as soluble corn fibre, maltodextrin or resistant maltodextrin.† Its contribution to the product's overall fibre would be included in the fibre listing on the Nutrition Facts or Information Panel.†

** These caloric values reflect US labelling only. Caloric labelling varies based on global regulations.*

† Specific label names and nutrition labelling may vary in different countries or regions. Check with your local regulatory expert to determine appropriate labelling.

Resists digestion and is fermented in the large intestine

Fermentation of fibre in the large intestine by microorganisms is linked to the health benefits of fibre. **PROMITOR® Soluble Fibre** contains a mixture of linkages including α 1-6, α 1-4 as well as α 1-2 glucosidic linkages that contribute to the low digestibility of the ingredient in the small intestine as detailed in the research below. While changes in faecal short-chain fatty acids (SCFAs), pH, and breath hydrogen are useful indicators that gut fermentation is taking place in the large intestine (colon), SCFAs are quickly absorbed in humans, so animal and *in vitro* models are better for understanding colonic fermentation of fibre.

Animal, *in vitro* and human intestine simulator trials

- A study in pigs observed that at least 70% of **PROMITOR® Soluble Fibre** resists digestion in the small intestine and passes into the large intestine for fermentation.[22]
- Two *in vitro* evaluations using human faecal inoculum from healthy adults found that SCFA levels (acetate, propionate, and butyrate) were elevated with the addition of SCF.[23,24]
- An *in vitro* simulation of gastric digestion/large intestine fermentation using animal faecal material showed that SCF was the most fermented ingredient, followed by pullulan, polydextrose, soluble fibre dextrin, and resistant starch.[25]
- The Simulator of Human Intestinal Microbial Ecosystem (SHIME) model simulates the gastrointestinal tract of an adult human. Research has shown that **PROMITOR® Soluble Fibre** is well fermented in the distal colon and leads to positive effects on the activity of the gut microbiota and its composition with potential impact in strengthening the gut barrier.[26]

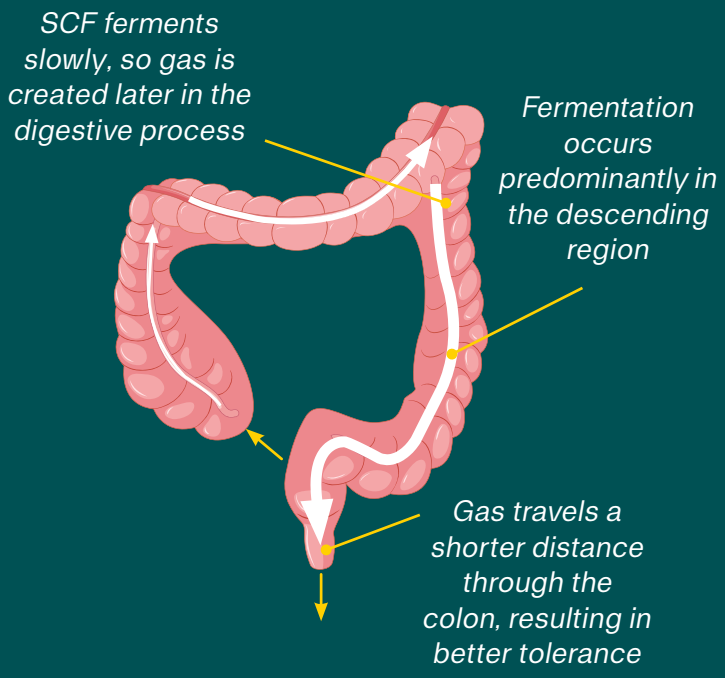
Human trials

- In a randomised, controlled, single-blind, crossover study, 24-hour breath hydrogen was found to be significantly increased (indicating colonic fermentation) after 18 overweight adults consumed breakfast and lunch foods in which 30% of the available carbohydrate was replaced with 55 g of **PROMITOR® Soluble Fibre**.[27]
- In a randomised controlled, double-blind, crossover trial that investigated the effects of 21 g/day of SCF from **PROMITOR® Soluble Fibre** in 21 overweight, healthy adult men, faecal pH was significantly lowered.[28]

PROMITOR® Soluble Fibre is well tolerated

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. In a trial of 20 healthy adult volunteers, **a single dose at 40 g of SCF or multiple doses reaching 65 g of SCF** over the day were well-tolerated.[29] Longer-term studies conducted over a minimum period of one to three weeks using **PROMITOR® Soluble Fibre** have shown doses of 12–25 g/day of fibre to be well tolerated.[28–32] A recent study in children aged 3 years to 9 years has shown that moderate intakes of **PROMITOR® Soluble Fibre** (5 g for very young children and 8 g for older children) were well tolerated. Fibre fortification at realistic levels of up to 8 g/day of SCF could help close the fibre gap in children without meaningful GI discomfort and can be important reformulation tool in a variety of food products.[33]

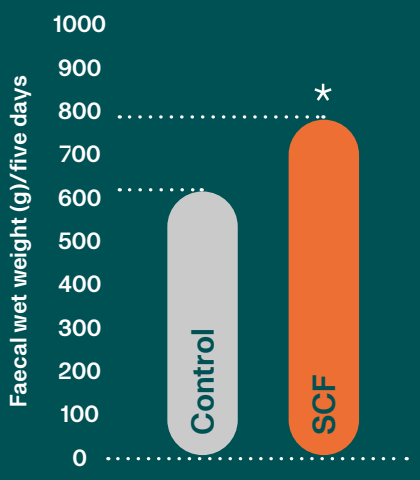
Figure 3. Location and transit of PROMITOR® Soluble Fibre through the colon to promote tolerance.



Improves bowel function

PROMITOR® Soluble Fibre helps maintain digestive health through its effect on laxation. Thirty-six healthy adults who consumed 20 g/day of fibre from SCF in breakfast cereal and muffins for ten days in a randomised placebo-controlled, double-blind crossover study experienced an increase in faecal wet weight (Figure 4).[34] Increased faecal wet weight was also observed in another randomised, placebo-controlled, double-blind, crossover study of 21 healthy overweight men who ingested 21 g/day of fibre from SCF for 21 days.[28]

Figure 4. Five-day faecal wet weight (g) of control vs. soluble corn fibre.[34]



*Significantly different from control. P<0.0007

Prebiotic effects: Modulation of gut microflora and bone health benefits

While the term 'probiotic' refers to live microorganisms, a 'prebiotic' essentially refers to substances that act as fuel for beneficial microbes in the gut. The International Scientific Association for Probiotics and Prebiotics (ISAPP) define a prebiotic *as "a substrate that is selectively utilized by host microorganisms conferring a health benefit".*[35] **PROMITOR® Soluble Fibre** may induce a prebiotic effect by promoting the growth of beneficial bacteria increasing SCFA production, which has been associated with increased calcium absorption.

Gut microflora changes

After the consumption of 21 g/day of SCF for 21 days, there was a 1 log increase in *Bifidobacterium spp*. in 21 healthy men compared to a no fibre control.[28] 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.[23,24]

In a small double-blind, randomised, parallel pilot study numbers of bifidobacteria were significantly higher when 6 g/day of SCF was given over 14 days compared to baseline.[36]

Increased calcium absorption and bone calcium retention

Adequate calcium consumption is important throughout the lifespan, particularly for building strong bones, optimising bone mass, and reducing the risk of osteoporosis.[37] Calcium intakes usually fall below the recommended levels, hence any attempts to increase calcium absorption and retention are of critical significance.[37]

- In a randomised, double-blind, placebo-controlled, crossover study of 24 adolescents, calcium absorption was increased by 12% when 12 g/day of fibre from SCF was consumed over 3 weeks, compared to a control with the background diet controlled to contain 600 mg/day of calcium.[38] 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 absorption. If the adolescents in this study had continued to consume SCF, allowing for increased calcium absorption, the researchers estimated that this would lead to an additional 41 mg/day of retained calcium, and if persistent over a year, would account for an additional 15 g of calcium, or about 1.8% of total body calcium.[38]

- Similar increases in calcium absorption were reported in a four-week, randomised, double-blind, placebo-controlled, crossover study in 26 free-living adolescent females who consumed 10 g and 20 g/day of fibre from **PROMITOR® Soluble Fibre** with their habitual diet containing ≤ 800 mg/day of calcium.[39]

- A third randomised, placebo-controlled double-blind, cross-over study in 14 healthy, free-living postmenopausal women demonstrated that bone calcium retention significantly increased in a dose-dependent manner with consumption of **PROMITOR® Soluble Fibre** at 10 g/day and 20 g/day over 50-day treatment periods with 5% and 7% increases in bone calcium retention, respectively (Figure 5).[40,41]

- While these human studies assessed calcium absorption and bone calcium retention, a 12-week study conducted in rats found that SCF 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 compared to cellulose control (Figure 6). Bone strength of the distal femur was also significantly improved by the ingestion of SCF.[41]

While additional long-term studies in humans are needed to assess the potential impact on bone indices, these data suggest that SCF may help support bone health by increasing calcium absorption and bone calcium retention while providing a source of fibre. Both of these are critical nutrition issues for various segments of the population, especially adolescents and postmenopausal women.

Figure 5. PROMITOR® Soluble Fibre increases bone calcium retention in postmenopausal women.[40]

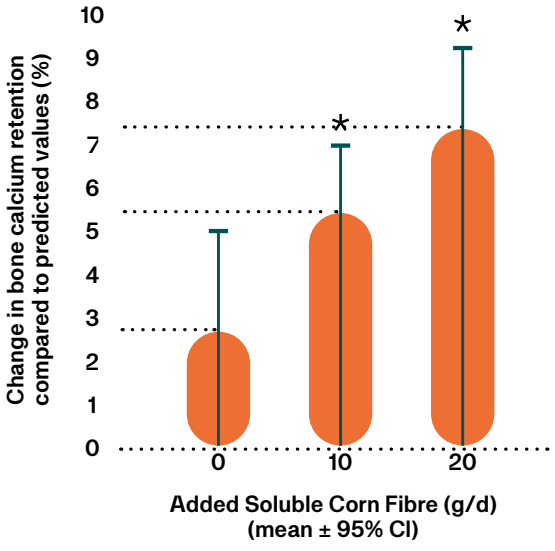
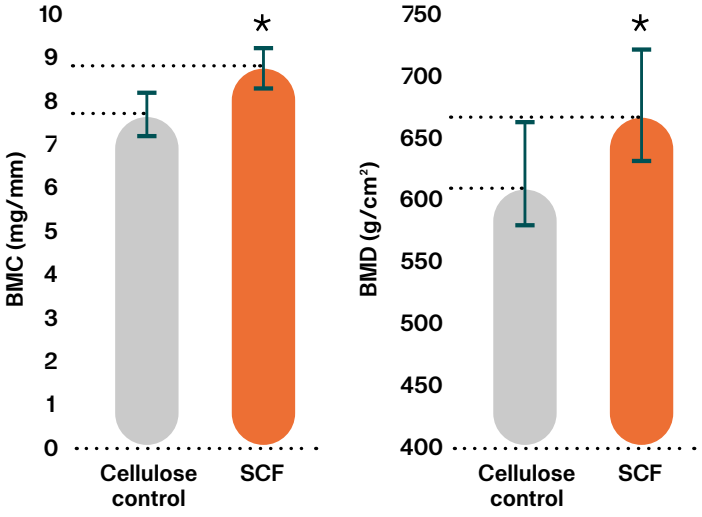


Figure 6. Effects of soluble corn fibre on bone mineral density and bone mineral content in Sprague-Dawley rats.[41]



*Significantly different from baseline, P<0.05

> **PROMITOR® Soluble Fibre may help support bone health by increasing calcium absorption and bone calcium retention while providing a source of fibre.**

Favourable blood glucose and insulin response

PROMITOR® Soluble Fibre elicits a low glycaemic response and is valuable for use in products for individuals with diabetes and in products intended to reduce glycaemic load. Three clinical studies and one animal study have evaluated the glycaemic effects of SCF to date.[27,42-44]

- The postprandial glycaemic response to SCF was compared to the glycaemic response to glucose in 12 healthy adults in a randomised, controlled, crossover study (Figure 7). SCF had a significantly lower incremental glucose and insulin response than the glucose control.[42]

- Similar findings were found when replacing 50% of the total carbohydrate in 50 g carbohydrate test rice meals and drinks with **PROMITOR® Soluble Fibre** in 22 healthy Chinese men. A significantly lower mean iAUC* for both insulin and glucose was found with partial **PROMITOR®** replacement in the 2 hours post-meal compared to glucose and maltodextrin comparisons (Figure 8).[43]

  ** iAUC: incremental area under the curve.*

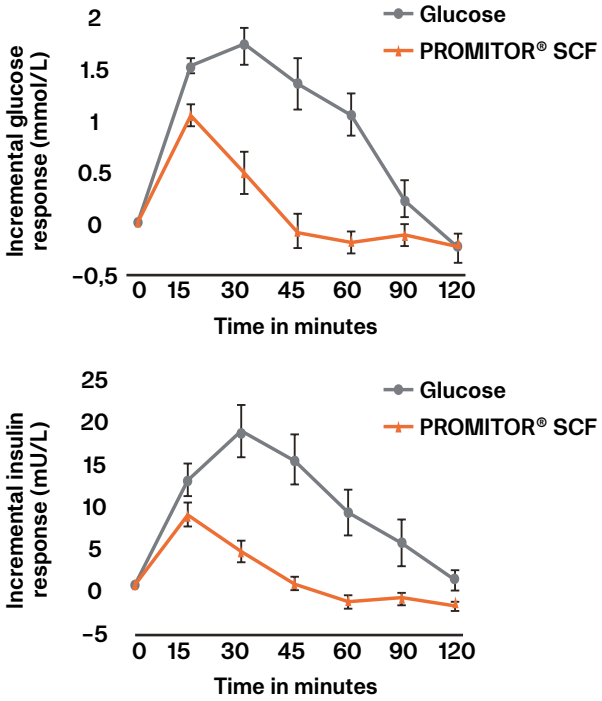
- Another acute study observed a significant lowering effect on peak postprandial blood glucose and insulin at a dose of 55 g of SCF (given with breakfast and lunch) in a randomised, single-blind, crossover study in 18 overweight adults compared to a full-calorie control.[27]

A series of SCF formulations investigated in an animal study were found to yield significantly lower postprandial blood glucose and insulin responses than a maltodextrin control.[44] To date, the data on SCF supports a blood glucose and insulin lowering effect when replacing carbohydrate. Thus, this ingredient can not only serve as a source of fibre, but may also lower blood glucose response, a desirable feature for healthy individuals as well as those with diabetes.

For those who need to manage their weight, **PROMITOR® Soluble Fibre** may assist with healthy weight management by providing minimal calories. Determining the energy (calorie) value of dietary non-digestible fibres that are fermented to varying degrees by intestinal microbes and metabolised to short chain fatty acids (that can provide energy) is important. In a randomised, double-blind, crossover study in 19 healthy men and women (18-34 years) breath hydrogen was quantified following consumption of beverages consisting of water with either inulin or **PROMITOR® Soluble Fibre**. From this, the available energy of the fibre portion of **PROMITOR®** SCF products was determined to be 0.2 kcal/g in this study.[45¥]

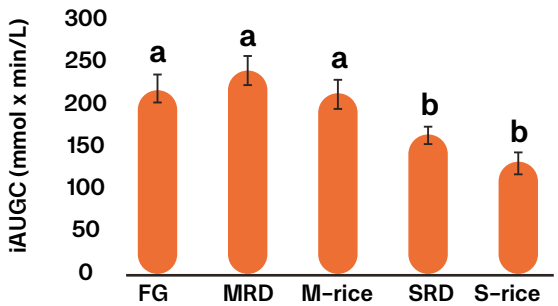
¥ Caloric labelling varies based on global regulations.

Figure 7. Effect of PROMITOR® Soluble Fibre on glucose and insulin response.[42]



*Significant difference between treatments at each timepoint at P<0,05

Figure 8. Comparison of mean incremental area under the curve for plasma glucose concentration.[43]



FG (glucose drink), SRD (SCF replaced drink), S-rice (SCF with rice), MRD (maltodextrin drink), M-rice (maltodextrin with rice). The error bars represent the SEM. For all plots, different alphabets represent statistically different mean values.

Emerging research: Synbiotic and immune health effects

Ageing is associated with a decline in immune function (immune-senescence) and adversely affects the gut microbiota. The effects of synbiotics (combinations of probiotics and prebiotics) is an area of increasing interest with the latter providing a potential food source for the probiotic.

A double-blind, placebo-controlled, randomised, crossover study in 40 healthy elderly subjects (60–80 years) was carried out to investigate the effects of **PROMITOR® Soluble Fibre** (12 g/day) with or without a probiotic *Lactobacillus rhamnosus GG* versus placebo (maltodextrin) during 3-week intervention periods.[20] All treatments, except for the placebo provided significant changes in gut microbiota (Figure 9). *L. rhamnosus GG* combined with SCF increased the genus *Parabacteroides* and *L. rhamnosus GG* combined with SCF, and SCF alone, increased concentrations of *Ruminococcaceae Incertae Sedis*. The synbiotic combination of *L. rhamnosus GG* with SCF showed a tendency to promote innate immunity by increasing Natural Killer (NK) cell activity in elderly women and 70 to 80-year-old volunteers compared to baseline. The use of SCF led to a significant decrease in the proinflammatory cytokine IL-6 compared to placebo (Figure 10).[20]

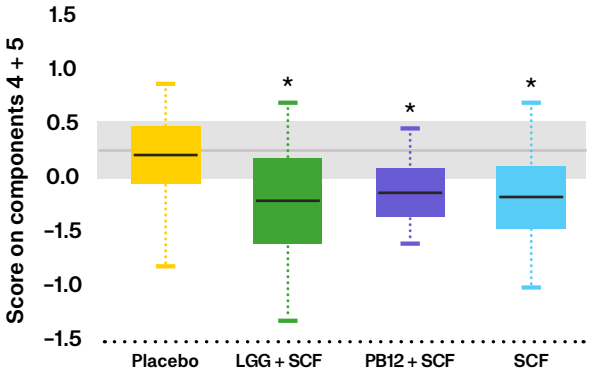
In an animal model, SCF was found to improve disease conditions of interleukin-10-deficient mice with inflammatory bowel disease by decreasing cytokines production and upregulating the suppressor of cytokine signalling 3.[45]

A study in mice fed a high-fat diet supplemented with or without soluble corn fibre demonstrated that the fibre reduced body weight gain, inhibited the development of fat mass and reduced certain markers of inflammation in subcutaneous adipose tissue.[46]

Further research is needed to better understand the effect of fibres on specific aspects of the immune system and to explore the effect on clinical outcomes across the lifespan.

Additional research is also needed before a claim regarding immunity benefits can be substantiated for **PROMITOR® Soluble Fibre**.

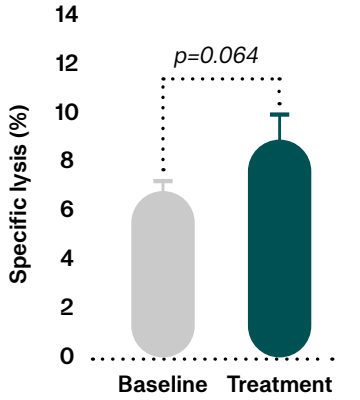
Figure 9. Synbiotic combination of PROMITOR® Soluble Fibre with lactobacilli strain on changes in gut microbiota.[20] (p<0.001 in comparison to placebo)



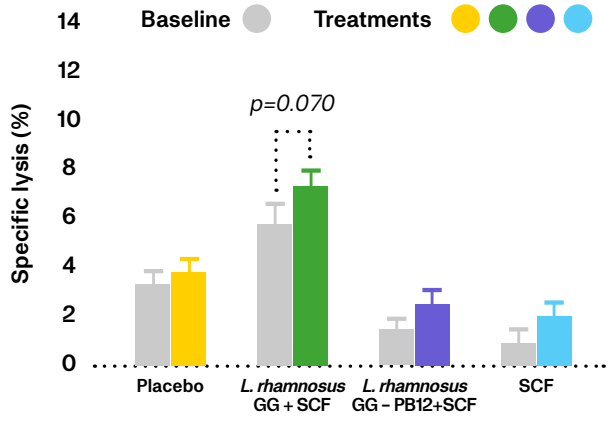
Principal coordinate analysis (PCoA) of the faecal microbiota composition in each group after the treatments.

*p=0,001

Figure 10. Effect of PROMITOR® Soluble Fibre/LGG Synbiotic on NK cell activity.[20]



Specific lysis after LGG + Soluble Corn Fibre (SCF) intervention in females. E/T = 100/1.



Specific lysis after all treatments in the older group (70-80 years old)

Consumer Insight on Fibre

Consumers want to eat more products with fibre, but struggle to find them. In fact, 22% of global consumers claim they are not eating more fibre because of the insufficient availability of products with fibre on the market.[47]

As people try to reach their recommended daily intake of fibre, they look to specific food and beverage categories to fill the gap. For example, an average of 64% of global consumers say they obtain fibre through cereals, 56% through baked goods and 63% through dairy.[47]

Adding small amounts of fibre to foods that contain some dietary fibre or to foods traditionally low in dietary fibre could help individuals meet their fibre requirements without exceeding calorie needs, which is a practical way to help address global public health concerns.[48] **PROMITOR® Soluble 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 flavoured water. Simple substitutions of similar foods made with SCF can help to close the fibre intake gap.

Conclusion

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

- Promotes **healthy laxation**[28,34] and produces fewer negative faecal metabolites[28]
- Is **well-tolerated**, even at high intake levels (40 g/day bolus and 65 g/day multiple doses), and has better overall tolerance than certain fructans such as inulin[28-33]
- Has **prebiotic properties**,[23,24,28,38,39] that stimulate the growth of specific bacteria, producing short-chain fatty acids and is associated with improved calcium absorption and bone calcium retention. Calcium is needed to support normal **bone health**
- Supports **healthy blood glucose** levels by decreasing postprandial glycaemic response[27,42-44]
- May assist with healthy **weight management** by providing minimal calories (1.2-2 kcal/g)[22,45]

While individuals should increase their consumption of dietary fibre from sources such as pulses, vegetables, fruits, and whole grains, the incorporation of added fibres like Tate & Lyle's **PROMITOR® Soluble Fibre** into new and innovative food products as part of a well-balanced diet can help close the intake gap between recommended and actual intakes.

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Nutrition Centre

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