



SOLUBLE CORN FIBRE: HEALTH BENEFITS AND PRODUCT APPLICATIONS

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



TATE & LYLE



FIBRE INTAKES AND RECOMMENDATIONS

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.¹⁻³ Yet, across the globe, average intakes are well-below the recommended amount despite the widespread knowledge of fibre's role in a healthy diet.³

While traditional sources of fibres like whole grains, fruits and vegetables should be encouraged, fibres added to foods, also known as added fibres, are important contributors to dietary fibre intakes. An abundance of research continues to demonstrate that added fibres provide similar benefits as fibres inherent in whole foods.

Tate & Lyle's soluble corn fibre ingredient, PROMITOR® Soluble Fibre, is commonly added to foods to boost fibre content without sacrificing taste, texture, or enjoyment. Studies have also demonstrated health benefits of this SCF.

Dietary fibre gap: Intakes vs. recommendations

Recommendations for fibre intakes range from 25-38 g/day depending on country specific guidelines.^{2,3} The World Health Organization suggests worldwide recommendations of greater than 25 g/day,⁴ 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 fewer meet the dietary recommendations for fibre despite consistent messaging to the public to increase dietary fibre intake.^{12,13}

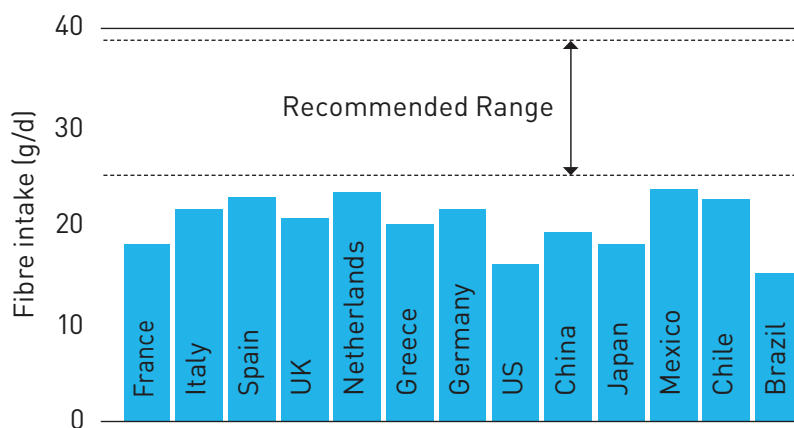
Fibre sources

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 microbiota.² Added fibres, also known as "functional fibres," are non-digestible carbohydrates that are isolated from a food source, or synthesized non-digestible

- 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, including cardiovascular diseases and diabetes.
- Added and functional fibres can help bridge the gap between actual intake and global dietary recommendations.
- 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 helps to meet fibre needs of the population and provides health benefits including supporting gastrointestinal health, maintenance of healthy blood glucose, and enhancing calcium absorption, thus potentially supporting bone health.

Figure 1

Average adult fibre intakes by country⁵⁻¹¹



HEALTH BENEFITS

PROMITOR® Soluble 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 Fibre:

- Promotes healthy laxation^{20,30} and produces fewer negative faecal metabolites²⁰
- Is well-tolerated,^{20,27-30} even at high intake levels (40 g/day bolus and 65 g/day multiple doses), and has better overall tolerance than inulin or FOS²⁹
- Has prebiotic properties,^{20,23,24,31,34} which may support a healthy gut by stimulating the growth or activity of specific bacteria and producing short-chain fatty acids
- May assist with healthy weight management by providing minimal calories (1.2-2 kcal/g)^{18,38}
- Supports healthy blood glucose levels by decreasing postprandial glycaemic response^{19,22,32}
- May support bone health by increasing calcium absorption and bone calcium retention^{21,31,34,35}

carbohydrates, that have beneficial physiological effects in humans.² These fibres can be extracted from one food source and added to another (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 Fibre) or from fruit, vegetables, legumes, nuts, and seeds;² or the fibres can be modified forms of traditional fibres.² Adding fibre to new or commonly consumed 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. SCF is a source of dietary fibre that can be added to a variety of foods.

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. Increased dietary fibre has been associated in epidemiological studies with the reduced risk

of coronary heart disease, stroke, hypertension, obesity, prediabetes, type 2 diabetes, certain gastrointestinal disorders, and some 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.^{1-3,14-17} While the breadth of scientific evidence supports these effects, science continues to build on additional health benefits of fibre consumption such as fermentation by colonic microbiota and immunomodulation.¹⁷

PROMITOR® Soluble Fibre is 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 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 90 are produced by the removal of low molecular weight sugars from PROMITOR® Soluble Fibre 70, yielding products with a higher fibre content and reduced sugar content for products requiring more fibre, with minimal additional sugars or calories. PROMITOR® products are produced through the enzymatic hydrolysis of corn starch and are 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 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 Fibre resists

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

digestion in the small intestine and passes into the large intestine for fermentation.¹⁸ Changes in faecal short-chain fatty acids (SCFA), pH, and breath hydrogen are indicators that gut fermentation is taking place. Animal and *in vitro* models are better utilized for assessment of faecal SCFA to understand colonic fermentation of fibre because in humans SCFA are readily absorbed. However, in humans, breath hydrogen is easily measured as an indicator of colonic fermentation. 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 Fibre.¹⁹

Faecal pH was significantly lowered in a randomized 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.²⁰ In rats fed SCF, reduced pH levels were observed in the cecum and colon²¹ and increased concentrations of the SCFAs acetate and propionate were detected in the cecum.^{21, 22} 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 SCF.^{23, 24} In another *in vitro* simulation of gastric digestion and large bowel fermentation using animal faecal material, SCF was the most fermented ingredient, followed by pullulan, polydextrose, soluble fibre dextrin, and resistant starch.²⁵

Further, *in vitro* research using the SHIME model (Simulator of Human Intestinal Microbial Ecosystem) has shown that

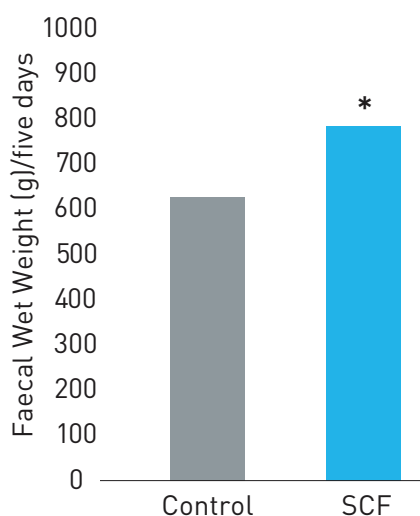
PROMITOR® Soluble Fibre is well fermented in the distal colon and leads to positive effects on the activity of the gut microbiota and its composition. Although additional research is needed, this effect *in vitro* may indicate that the fibre has immunomodulatory properties and could strengthen the gut barrier *in vivo*.²⁶

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 Fibre is well-tolerated at various doses.^{20, 27-30} Clinical trials assessing the gastrointestinal tolerance of SCF at doses of 12-27 g/day of fibre found it to be well-tolerated over a period of ten days to three weeks.^{20, 27, 28, 30} In a trial of 20 healthy volunteers, SCF in both a single dose at 40 g of fibre and in multiple doses reaching 65 g of fibre over the day were well-tolerated.²⁹

Figure 2

Five day faecal wet weight (g) of control vs. soluble corn fibre³⁰



*Significantly different from control, P<0.0007.

Improves laxation

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 randomized placebo-controlled, double-blind crossover study experienced an increase in faecal wet weight (Figure 2).³⁰ Increased faecal wet 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 SCF for 21 days.²⁰

Prebiotic benefits

PROMITOR® Soluble 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 SCF for 21 days, there was a 1 log increase in *Bifidobacterium spp.* in 21 healthy men compared to a no fibre control.²⁰

Another study in 24 adolescents noted an increase in beneficial bacteria – *Bacteroides*, *Butyricicoccus*, *Oscillibacter* and *Dialister* – which was correlated with an increase in calcium absorption when 12 g/day of fibre from SCF was consumed for three weeks.³¹ 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}

Favorable 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. Two clinical studies^{19,32} and one animal study²² have evaluated the glycaemic effects of SCF. The postprandial glycaemic response to SCF was compared to the glycaemic response to glucose in 12 healthy adults in a randomized, controlled, crossover study (Figure 3).³² SCF had a significantly lower incremental glucose and insulin response than the glucose control. Another acute study¹⁹ observed a significant lowering effect on postprandial blood glucose and insulin at a dose of 55 g of SCF in a randomized, single-blind, crossover study in 18 overweight adults compared to a full-calorie control. Finally, 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.²² To-date, the data on SCF supports a blood glucose and insulin lowering effect. 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.

Potential bone health benefits

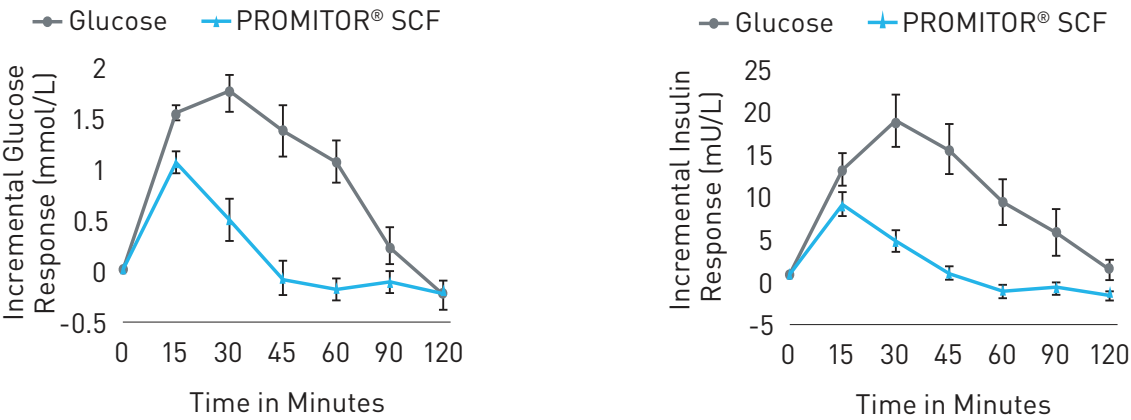
Adequate calcium consumption is important throughout the lifespan, particularly for building strong bones, optimizing bone mass, and reducing the risk of osteoporosis.³³ Calcium intakes usually fall below the recommended levels, hence any attempts to increase calcium absorption and retention are of critical significance.³³

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 SCF was consumed, compared to a control, in conjunction with a background controlled diet that contained 600 mg/day of calcium.³¹ 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 absorption.³¹ 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 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.³¹

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 g and 20 g/day of fibre from PROMITOR® Soluble Fibre with their habitual diet containing ≤ 800 mg/day of calcium.³⁴ A third randomized, placebo-controlled double-blind, cross-over study in 14 healthy, free-living post-menopausal women³⁵ demonstrated that bone calcium

Figure 3
Effect of PROMITOR® Soluble Fibre on glucose and insulin response³²



Significant difference between treatments at each timepoint at P<0.05.

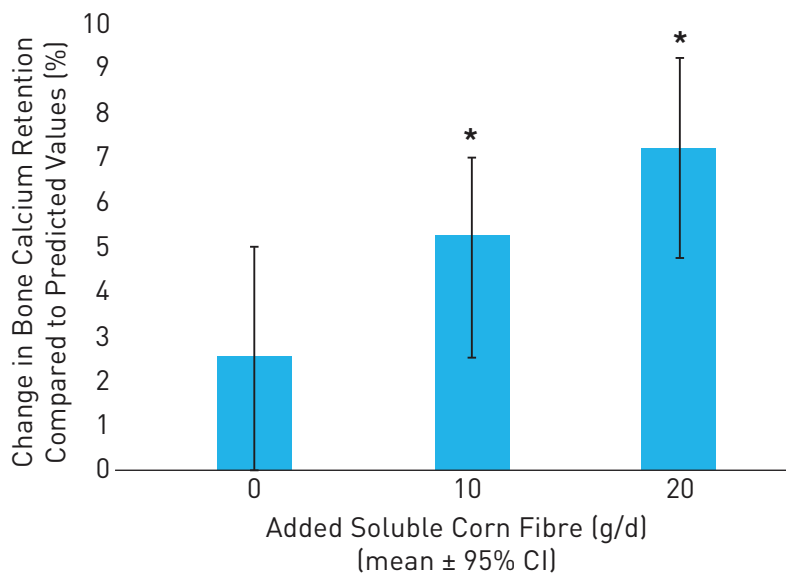
PROMITOR® Soluble Fibre may help support bone health by increasing calcium absorption and bone calcium retention while providing a source of fibre.



retention significantly increased in a dose-dependent manner with consumption of PROMITOR® Soluble Fibre at 10 g/d and 20g/d over 50-day treatment periods with 5% and 7% increases in bone calcium retention, respectively (Figure 4).³⁵

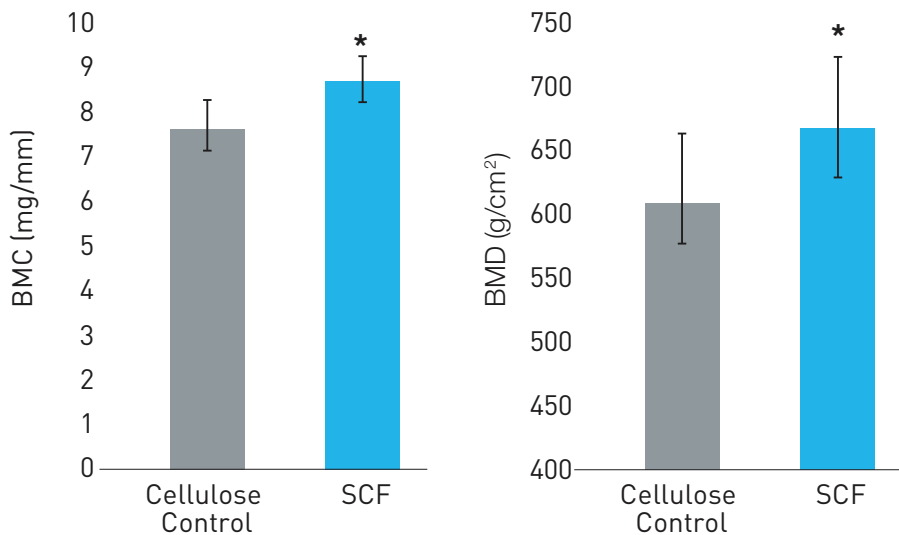
While these human studies only assessed calcium absorption and bone calcium retention, a 12-week study conducted in rats investigated the impact of PROMITOR® Soluble Fibre on bone indices as well as calcium metabolism.²¹ Compared to a cellulose control, SCF improved total bone mineral content (BMC), total bone mineral density (BMD), trabecular BMC and BMD, cortical BMC, and cortical area and thickness in the distal femur (Figure 5).²¹ Bone strength of the distal femur was also significantly improved by the ingestion of SCF.²¹ While additional long-term studies in humans are needed to assess 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 4
PROMITOR® Soluble Fibre increases bone calcium retention in postmenopausal women³⁵



*Significantly different from baseline, P<0.05.

Figure 5
Effects of soluble corn fibre on BMD and BMC in Sprague-Dawley rats²¹



*Significantly different from control, P<0.05.



NUTRITIONAL IMPACT OF THE USE OF PROMITOR® SOLUBLE FIBRE

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 flavored water.

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 Panel.

Globally, average fibre intakes fall well below recommended intakes. Diets high in fibre have been associated with a lower risk of heart disease and improved blood glucose levels while also supporting digestive health and laxation and aiding in healthy weight management.¹⁻³

Simple substitutions of similar foods made with SCF can help to close the fibre intake gap. In this menu example, fibre increases by 20 g. PROMITOR® Soluble 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 and bone calcium retention.

[†] Specific label names may vary in different countries or regions. Check with your local regulatory expert to determine appropriate labeling.

2,000-CALORIE MENU, BASELINE*

Breakfast:

1 cup cinnamon toast crunch cereal
¾ cup low-fat milk
1 cup grapefruit sections
1 slice toast with 1 tbsp apricot jam
1 cup latte with ¼ cup low-fat milk

Lunch:

1 cup tomato soup
Antipasto salad:
2 cups 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 & 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

WITH PROMITOR® SOLUBLE FIBRE** SUBSTITUTIONS

Breakfast:

1 cup cinnamon oat crunch cereal, made with PROMITOR® Soluble Fibre**
¾ cup low-fat milk
1 cup grapefruit sections
1 slice toast with 1 tbsp apricot spread, made with PROMITOR® Soluble Fibre**
1 cup latte with ¼ cup low-fat milk

Lunch:

1 cup creamy tomato basil soup, made with PROMITOR® Soluble Fibre**
Antipasto salad:
2 cups 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 & green bell peppers
½ cup onion, 1 tbsp sour cream
½ cup Spanish rice
1 cup low-fat milk

Snack:

1 cup apple juice
1 fruit-filled cereal bar, made with PROMITOR® Soluble Fibre**

NUTRITION FACTS

		Change	% Change
Baseline menu	Menu with PROMITOR® Soluble Fibre		
Calories	1,980	Calories	1,970
Total Fat	66 g	Total Fat	64 g
Saturated Fat	22 g	Saturated Fat	22 g
Cholesterol	225 mg	Cholesterol	215 mg
Sodium	2,950 mg	Sodium	2,750 mg
Total Carbohydrate	266 g	Total Carbohydrate	278 g
Dietary Fibre	15 g	Dietary Fibre	35 g
Sugars	119 g	Sugars	128 g
Protein	82 g	Protein	84 g

* Menu based on Healthy US Style Eating Pattern, Dietary Guidelines for Americans, 2015-2020.

** These values reflect US labeling only. Labeling varies based on global regulations.

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



INNOVATING TO MEET NUTRITION, HEALTH, AND WELLNESS NEEDS EVERY DAY

Nutrition professionals' opportunity to educate consumers

While many people acknowledge the added health benefits of fibre, only 25% of consumers around the world report daily consumption of fibre.³⁶

Consumers want to consume more products with fibre, but struggle to find them. In fact, 33% of consumers claim they are not eating more fibre, because not enough products with fibre are available on the market.³⁶

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 68% of global consumers say they obtain fibre through cereals, 53% through baked goods and 45% through dairy.³⁶

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.³⁷ 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 grains,¹ the incorporation of added fibre like SCF 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 Fibre is a soluble corn fibre ingredient that manufacturers can use in the development of new and innovative products. PROMITOR® Soluble Fibre can help to meet fibre needs of the population and provides health benefits including supporting gastrointestinal health, maintenance of healthy blood glucose levels 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 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.

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