THE SCIENCE BEHIND DIGESTIVE TOLERANCE

WEIGHING YOUR OPTIONS FOR DIETARY FIBRE

Nutrition Centre

TATE & LYLE

WHY DO SOME TYPES OF DIETARY FIBRE RESULT IN BETTER GASTROINTESTINAL TOLERANCE?

Dietary fibres are carbohydrate polymers that are not digested in the stomach or small intestine and pass intact to the large intestine (also called the colon). The gut microbiota ferment fibres in the colon to produce short chain fatty acids (SCFA) and carbon dioxide and hydrogen gases. Each type of fibre has its own unique solubility, viscosity, branching, structural components and degree of polymerisation (DP), also known as chain length or size (see Table 1 for examples). It is these variations that cause the microbiota to ferment each fibre differently and contribute to alterations in gastrointestinal tolerance of the fibre ingredient.

Potential gastrointestinal side effects of fibre can include bloating, borborygmi (intestinal noises), cramping, flatus and diarrhoea, particularly if the fibre is consumed at high doses. These effects are due primarily to the production of gases by fermentation as well as water-binding effects of fibre in the large intestine. In general, smaller chain fibres are rapidly fermented, and are thus more likely to cause flatulence, bloating and laxative effects or diarrhoea. Larger chain fibres that ferment more slowly are usually better tolerated.

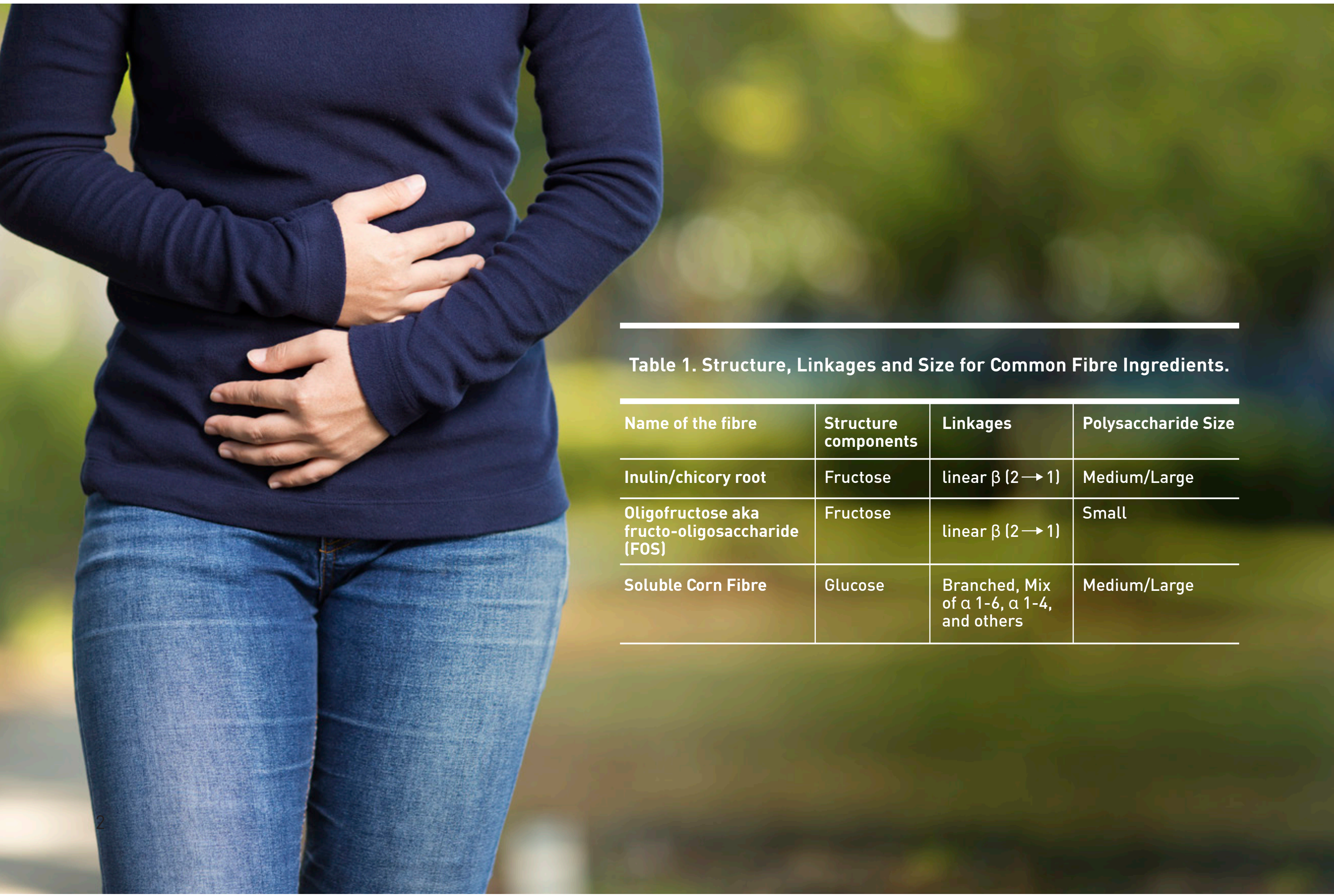


Table 1. Structure, Linkages and Size for Common Fibre Ingredients.

Name of the fibre	Structure components	Linkages	Polysaccharide Size
Inulin/chicory root	Fructose	linear β (2 $\rightarrow$ 1)	Medium/Large
Oligofructose aka fructo-oligosaccharide (FOS)	Fructose	linear β (2 $\rightarrow$ 1)	Small
Soluble Corn Fibre	Glucose	Branched, Mix of α 1-6, α 1-4, and others	Medium/Large

UNDERSTANDING THE VARIATION IN DIGESTIVE TOLERANCE

A number of *in vitro* models of the gut are able to explore the fermentation profile of fibres and shed light on the likely causes of variation in tolerance seen in humans.

The Simulator of the Human Intestinal Microbial Ecosystem (SHIME®), created by ProDigest, represents the gastrointestinal tract of an adult human.[1] The model involves a series of five vessels, each representing a part of the human gastrointestinal tract, as shown in Figure 1. The model helps to explore the fermentation profiles of fibres, including gas production, and to evaluate the impact of the fibres on the gut microbial composition, including any prebiotic effect. The first two vessels simulate the stomach and small intestine and include steps in food uptake and digestion: the next three vessels are maintained with a healthy adult faecal sample to best resemble conditions in the three parts of the human large intestine/colon.[2] Each fibre treatment period lasts three weeks with the amount of fibre added equal to 8.5 grams of fibre intake a day, which is physiologically relevant to human intake levels.*

* Due to the ingredient containing simple carbohydrates, water, etc. the amount of ingredient was calculated based on the analytical results of fibre analysis. 10g of PROMITOR® Soluble Fibre, 9.45g of Fibersol-2, 12.98g of Orafti L90 (FOS) and 9.45g of Inulin Frutafit HD (Inulin) was added to the SHIME® System.

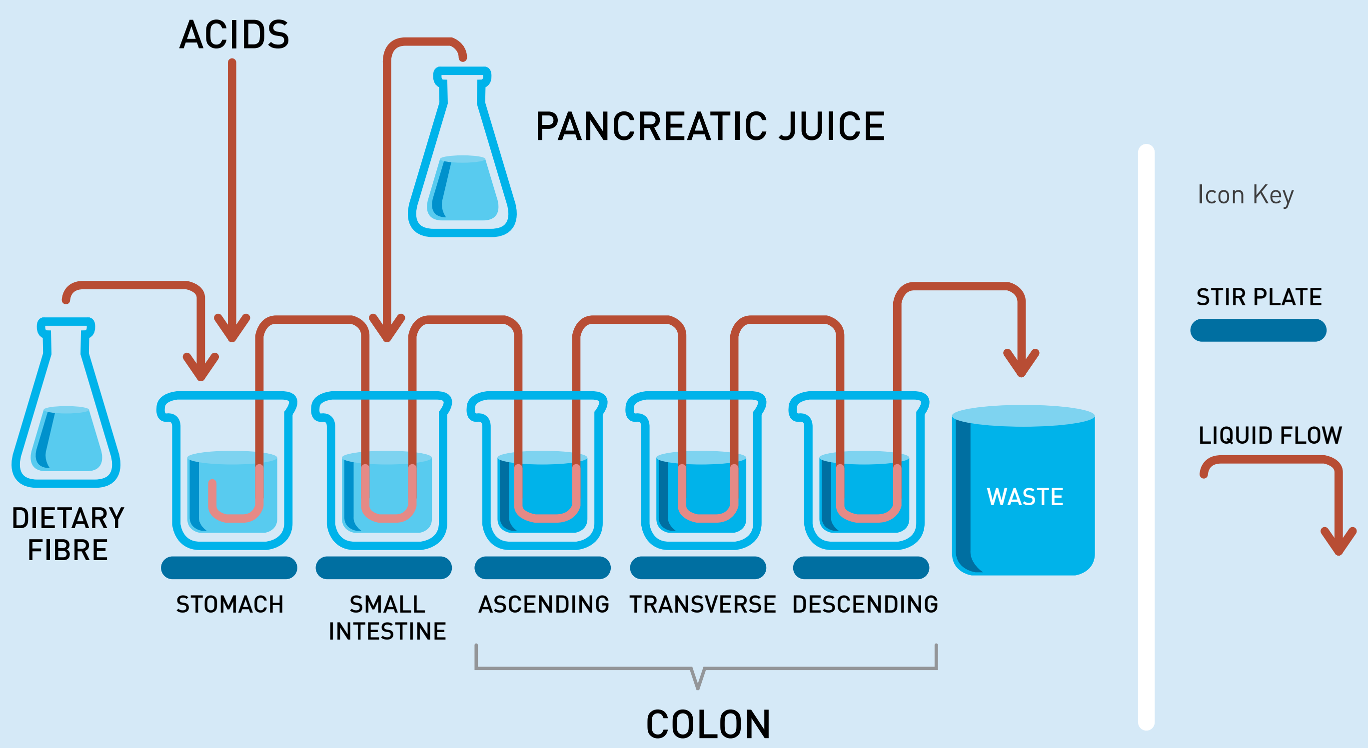
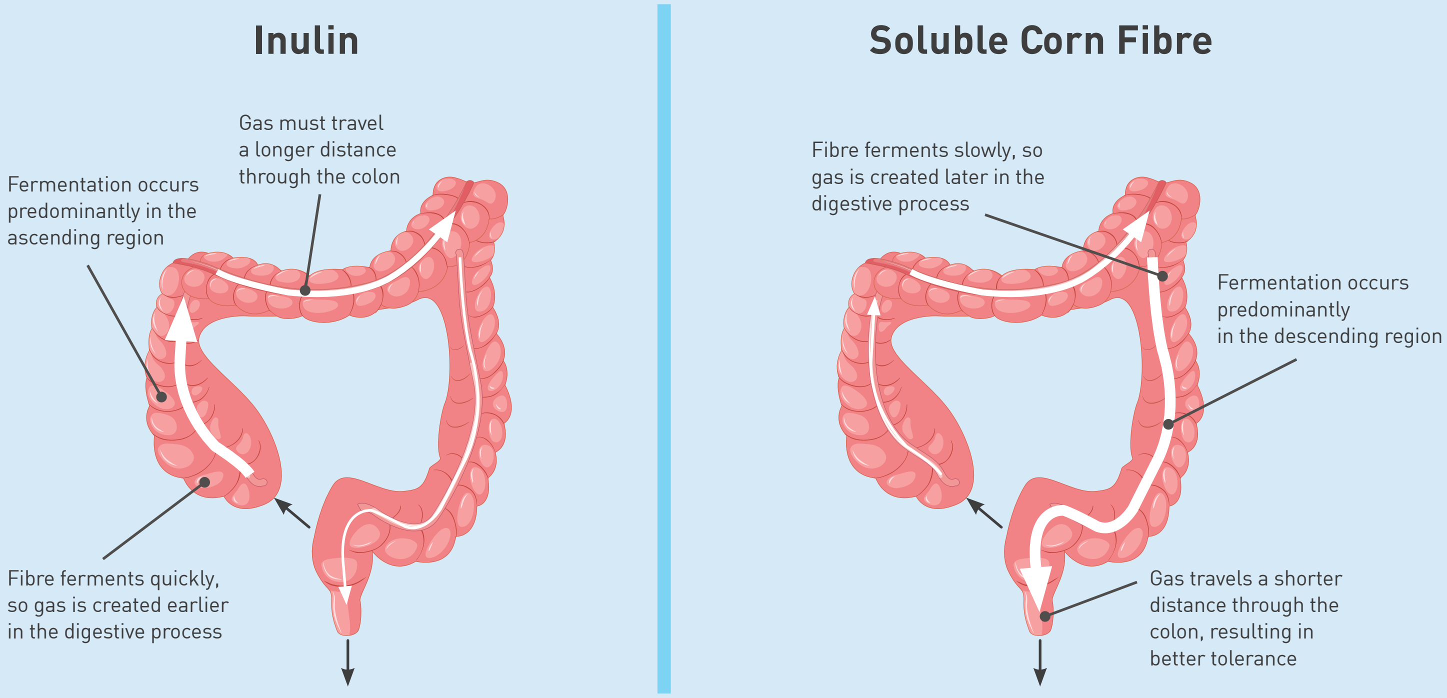


Figure 1. *The Simulator of the Human Intestinal Microbial Ecosystem (SHIME®) system*

For all fibres, almost all of the gas production occurs in the first 24 hours of incubation, indicating these fibres are easily fermented by the human colonic microbiota and act as prebiotics. The data from ProDigest's SHIME® system point to Tate & Lyle PROMITOR® Soluble Fibre having a lower gas production than inulin and FOS fibres. Quantity of the gas production as well as the location of fermentation within the colon are indicators of tolerance in humans. The model shows that PROMITOR® Soluble Fibre is predominantly fermented in the distal, or last section of the colon, indicating improved tolerance[3], whereas inulin produces gases in all areas of the colon and FOS generates gases in the ascending colon compartment of the SHIME® model, Figure 2.

Colon Fermentation Speed and Location Impact Tolerance



Density of arrow indicates degree of fermentation

Figure 2. *Approximate location of prebiotic fibre fermentation*

The SHIME® data correlates to human research showing superior tolerance of PROMITOR® Soluble Fibre compared to inulin.[4,5,6] Daily intake levels of 10 to 15 grams of inulin or FOS will result in most individuals experiencing mild gastrointestinal side effects, and at 20 grams, moderate to severe side effects.[5,7,8,9] PROMITOR® Soluble Fibre intake of 40 grams is well tolerated, and most individuals will not have noticeable gastrointestinal side effects.[5]

In addition, there are no clinically relevant symptoms when PROMITOR® Soluble Fibre is consumed up to 65 grams a day, divided into two to three doses throughout the day.[4,5,6,10,11,12,13] In summary, the digestive tolerance of PROMITOR® Soluble Fibre is more than two times that of inulin, and it is well-tolerated, even at high intake levels (40 g/day bolus and 65 g/day in multiple doses).

ADDITIONAL HEALTH BENEFITS OF FIBRE

The World Health Organization suggests worldwide a minimum fibre intake of 25 grams per day, but intakes in most countries fall well below this level, despite the widespread knowledge of fibre's role in a healthy diet.[14,15]

In addition to the commonly understood benefit of improving laxation, decades of research point to a variety of other benefits of dietary fibre. These include supporting normal cholesterol levels, tempering spikes in blood sugar after a meal, aiding weight management by promoting satiety and helping to reduce calorie content of foods, improving mineral absorption and promoting a healthy gut.

PROMITOR® Soluble Fibre, one of the offerings in Tate & Lyle's portfolio of fibres, provides a variety of health benefits desired by consumers around the world. PROMITOR® is commonly added to foods and beverages to boost fibre content without sacrificing taste, texture or enjoyment.

For more information on how PROMITOR® Soluble Fibre can help you meet consumer demand for fibre, go to: tateandlyle.com/ingredient/promitor-soluble-fibre

promitor® Soluble Fibre

Bone health-enhances mineral absorption

Prebiotic benefits

May assist with healthy weight management

Stool bulking and laxative effects

Supports healthy blood glucose levels

MAKING FOOD EXTRAORDINARY

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REFERENCES

[1]Molly, K., et al. (1993). "Development of a 5-step multichamber reactor as a simulation of the human intestinal microbial ecosystem." *Applied Microbiology and Biotechnology* 39(2): 254–58.

[2]Possemiers, S., K. Verthe, et al. (2004). "PCR-DGGE-based quantification of stability of the microbial community in a simulator of the human intestinal microbial ecosystem." *FEMS Microbiology Ecology* 49: 495–507.

[3]Wallace, T.C., M. Marzorati, L. Spence, C.M. Weaver, and P.S. Williamson. (2017). "New Frontiers in Fibers: Innovative and Emerging Research on the Gut Microbiome and Bone Health." *JACN* 36(3): 218–22.

[4]Boler, B.M., M.C. Serao, L.L. Bauer, M.A. Staeger, T.W. Boileau, K.S. Swanson, G.C. Fahey Jr. (2011). "Digestive physiological outcomes related to polydextrose and soluble maize fibre consumption by healthy adult men." *Br J Nutr* 106:1864–71.

[5]Housez, B., M. Cazaubiel, C. Vergara, J.M. Bard, A. Adam, A. Einerhand, and P. Samuel. (2012). "Evaluation of digestive tolerance of a soluble corn fibre." *J Hum Nutr Diet* 25:488–96.

[6]Timm, D.A., W. Thomas, T.W. Boileau, P.S. Williamson-Hughes, and J.L. Slavin. (2013). "Polydextrose and soluble corn fiber increase five-day fecal wet weight in healthy men and women." *J Nutr* 143:473–78.

[7]Carabin, I.G. and W.G. Flamm. [December 1999). "Evaluation of safety of inulin and oligofructose as dietary fiber." *Regul Toxicol Pharmacol* 30:268–82.

[8]Coussement, P.A.A. (1999). "Inulin and Oligofructose: Safe Intakes and Legal Status." *J Nutr* 129:1412S–17S.

[9]Roberfroid, M. "The digestive functions: inulin-type fructans as fermentable carbohydrates." In *Inulin-Type Fructans: Functional Food Ingredients.* ed. Wolinsky, I. and J. Hickson, 92–4. Boca Raton: CRC Press, 2004.

[10]Stewart, M.L., S.D. Nikhanj, D.A. Timm, et al. (2010). "Evaluation of the effects of four fibers on laxation, gastrointestinal tolerance and serum markers in health humans." *Ann Nutr Metabol* 56:91–98.

[11]Whisner, C.M., B.R. Martin, C.H. Nakatsu, G.P. McCabe, L.D. McCabe, M. Peacock, and C.M. Weaver. (2014). "Soluble maize fibre affects short-term calcium absorption in adolescent boys and girls: a randomised controlled trial using dual stable isotopic tracers." *Br J Nutr* 112:446–56.

[12]Karalus, M., M. Clark, K.A. Greaves, W. Thomas, Z. Vickers, M. Kuyama, and J. Slavin. (2012). "Fermentable fibers do not affect satiety or food intake by women who do not practice restrained eating." *J Acad Nutr Diet* 112:1356–62.

[13]Klosterbuer, A.S., M.A. Hullar, F. Li, E. Traylor, J.W. Lampe, W. Thomas, and J.L. Slavin. (September 28, 2013). "Gastrointestinal effects of resistant starch, soluble maize fibre and pullulan in healthy adults." *Br J Nutr* 110(6):1068–74.

[14]World Health Organization Diet, Nutrition and the Prevention of Chronic Diseases. Geneva: WHO, 2003.

[15]Stephen, A.M., M.M.-J. Champ, S.J. Cloran, et al. (December 2017). "Dietary fibre in Europe: current state of knowledge on definitions, sources, recommendations, intakes and relationships to health." *Nutrition Research Reviews* 30(2):149–90.

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