Nutrition Centre

By TATE & LYLE

STA-LITE®

Polydextrose

Health benefits and product applications

Nutrition Centre
By TATE & LYLE

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

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 such as coronary heart disease and type 2 diabetes.

Added fibres can help bridge the gap between current intake and global dietary recommendations.

Functional properties of STA-LITE® Polydextrose make it a good candidate for manufacturers to use in developing new and innovative products to meet the fibre needs of the populatio without increasing energy intake.

Research demonstrates that polydextrose provides several physiological benefits that include supporting gastrointestinal health, a low postprandial blood glucose response, and a satiety effect, thus potentially promoting healthy weight.

Nutrition Centre
By 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 healthy 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 its role in a healthy diet.[3]

While traditional sources of fibres like whole grains, fruits, and vegetables should be encouraged, fibres added to foods 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 ingredient, STA-LITE® Polydextrose is a low-calorie bulking and texturing ingredient commonly added to foods to boost fibre content and to replace sugar and fat without sacrificing taste, texture, or enjoyment. Studies have also demonstrated the health benefits of polydextrose.

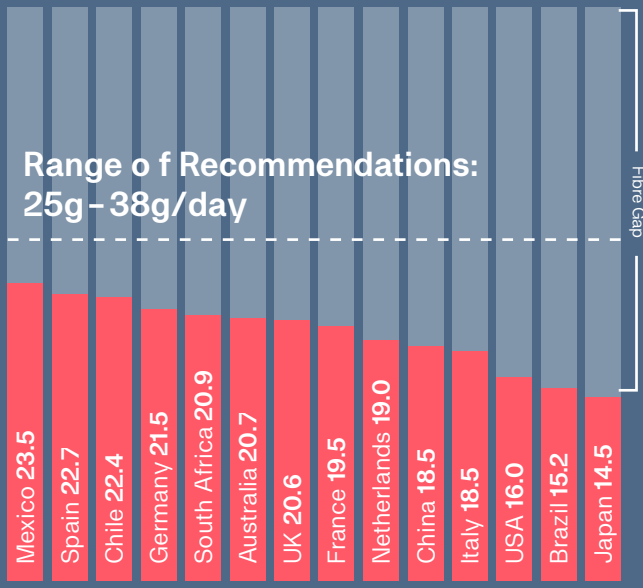
Dietary fibre gap: intakes and guidelines

Recommendations for fibre intakes range from 25-38g/day depending on country-specific guidelines.[2-3]

The World Health Organization suggests worldwide recommendations of 25g/day [4], but fibre intakes in most countries are well below this level [5-11] (Figure 1.)

In the United States (US), for most age and gender groups, 5% or fewer of the population meet the dietary recommendations for fibre despite consistent messaging to the public to increase dietary fibre intake.[12 -13]

Figure 1.
Global shortfall in fibre intakes
Average daily fibre intakes by country (g/day)[5-11]



Data taken from various scientific papers. See tateandlyle.com/fibre-gap for full list.

Nutrition Centre
By TATE & LYLE

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 are non-digestible carbohydrates that are isolated from a food source, or synthesized non-digestible 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.

Polydextrose (STA-LITE®) is a source of dietary fibre that can be added to a variety of regular and sugar-reduced, no-added sugar, and sugar-free versions of cereals, snacks, bakery items, beverages, dairy products, and sauces to help reduce sugar and/or to increase the fibre content.

Health benefits

Polydextrose has been tested by a number of independent researchers to validate its effectiveness and to demonstrate its physiologycal health benefits.

The following are some highlights on the health benefits of polydextrose:

- Well-tolerated,[18, 20, 28,31] even up to 90g/day or 50g as a single dose[18]
- Supports healthy blood glucose levels by eliciting a lower blood glucose response[31, 39, 40, 43]
- May help promote regularity, as a result of its faecal bulking effect[29-32, 36, 37]
- May support the growth of beneficial gut bacteria[21, 22, 31]
- May support a healthy gut by producing short-chain fatty acids (SCFAs), which feed the beneficial bacteria in the colon[23, 30, 31]
- Is ideal for reduced-calorie foods and may assist with weight management by providing negligible calories (1 kcal/g)[19, 20] and a satiety benefit, as suggested by emerging data[40,43, 44]

Nutrition Centre
By TATE & LYLE

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 cancers.[1]

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 other additional health benefits of fibre consumption such as fermentation by colonic microbiota and immunomodulation.[17]

STA-LITE® Polydextrose

STA-LITE® Polydextrose is an ingredient supplied by Tate & Lyle as one of its solutions to help increase fibre intake.

Polydextrose is approved as a food additive in the US (21 CFR 172.841), the European Union [(EC) No 1333/2008], and most other countries worldwide.

Nutrition Centre
By TATE & LYLE

Characterization of Sta-Lite® Polydextrose

Polydextrose is a highly branched, randomly bonded glucose polymer produced by the condensation of glucose in the presence of sorbitol and small amounts of food grade citric acid or phosphoric acid.[18]

Polydextrose has a broad molecular weight range (162-20,000 mw) with 90% of the molecules being between 504 and 5,000 mw. Its high stability in heat and acidic environments, low viscosity, high solubility in water, bulking and texturing properties, and bland taste lends itself to a wide variety of food and beverage formulations.[19]

Polydextrose resists digestion and absorption and has the physiological effects of dietary fibre. In most countries, polydextrose is usually declared as a dietary fibre, and depending on its usage level, fibre claims can normally be made for foods containing polydextrose.* STA-LITE® Polydextrose ingredient provides a minimum of 90% polydextrose and contains a maximum of 4% sugar with a caloric content of 1 kcal/g.

Resists digestion and fermented in the gut

Polydextrose is minimally absorbed in the small intestine and is fermented in the large intestine by gut microbiota, leading to the production of the SCFAs propionate, butyrate, and acetate.

Polydextrose resists digestion due to the atypical linkages found between glucose units in its structure;[19] about 30-50% is excreted undigested.[19,20] In vitro experiments that simulate human colon fermentation by using human faecal inoculum demonstrate that polydextrose is slowly fermented and produces less gas[23, 24] compared to many other dietary fibres. Most in vitro studies of polydextrose observe an increase in the production of the SCFA propionate,[21-26] followed by butyrate[21, 22, 25-27] and acetate.[21, 22, 25-27]

While some clinical evaluations[28,30] report no significant increase in faecal SCFAs, one study[31] observed a significant increase in faecal acetate and butyrate levels with the intake of 8g/day and 12g/day of polydextrose for 28 days.

Nutrition Centre
By TATE & LYLE

Excellent digestive tolerance

Polydextrose is well-recognized as a fibre with excellent digestive tolerance. Several clinical studies have evaluated the gastrointestinal tolerance of polydextrose and have found that it is generally well tolerated.[18, 20, 28–31, 37]

The fact that less gas[23, 24] is produced during fermentation is likely a contributing factor. The Joint FAO/WHO Expert Committee on Food Additives and the European Commission Scientific Committee for Food concluded that up to 90g/day or 50g as a single dose of polydextrose may be consumed without any detrimental effects (maximum laxative threshold).[18]

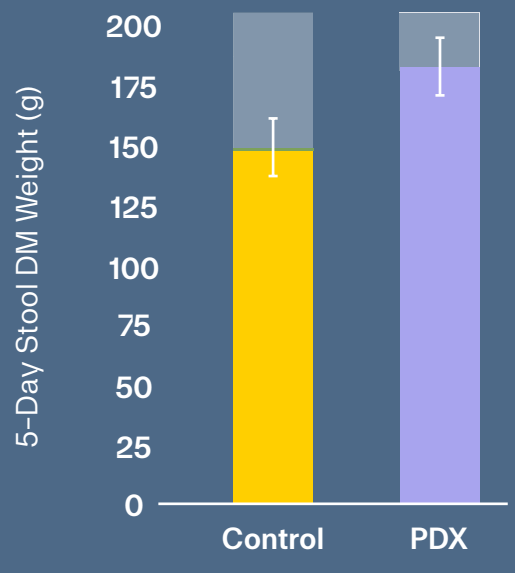
Supports healthy laxation

Polydextrose has been shown to have positive bowel function benefits. In many developed countries, chronic constipation is a common condition among adults and children.[1] The European Food Safety Authority (EFSA) Panel on Dietetic Products, Nutrition, and Allergies has noted that changes in bowel function such as reduced transit time, more frequent bowel movements, increased faecal bulk, or softer stools may be considered beneficial physiological effects provided they do not result in diarrhoea [in the context of the European Health Claims Regulation (Regulation EC 1924/2006)].[35]

Clinical studies to date have demonstrated that polydextrose consumption increases faecal bulk/weight,[29–32, 36, 37] faecal consistency,[28, 29, 36] ease of defecation,[31] and faecal frequency[29, 31] and decreases transit time[32] in healthy adults.

Faecal bulk effects were shown to be effective between 8–30g/day across studies from the US, Britain, Germany, China, and Japan. A randomized, double-blind, placebo-controlled study of 21 healthy, overweight men observed an increase of 29g in faecal weight on a dry matter basis over a five-day period when 21g of polydextrose was consumed compared to the control (Figure 2); an increase in faecal mass of 4.3g was found per gram of fibre consumed.[30] The lowest effective dose was 8g/day for improvements in faecal bulk[31] and faecal consistency,[28] whereas ease of defecation and faecal frequency was enhanced with a dose as low as 4g/day.[31]

Figure. 2
Faecal weight with 21g/day polydextrose vs. control for 21 days in males[33]



Nutrition Centre
By TATE & LYLE

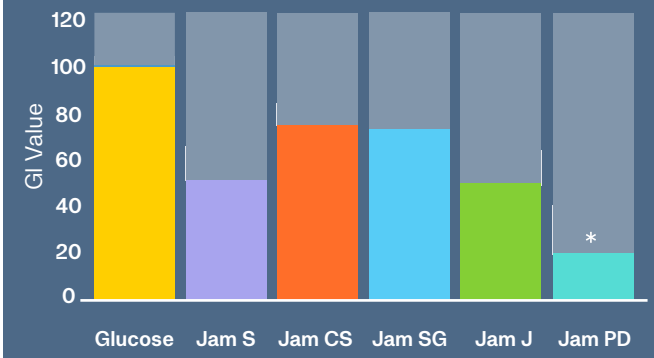
Favorable blood glucose and insulin response

There is increasing evidence that polydextrose decreases postprandial glycaemic and insulinaemic responses. In their evaluation of multiple doses of polydextrose, Jie et al.[31] reported that 12g of polydextrose ingested with 50g of glucose significantly lowered the glycaemic response compared to a 50g glucose control in healthy adults.

Kurotobi et al.[38] compared the glycaemic index of five strawberry jams made with sugar (Jam S), corn syrup and sugar (Jam CS), sugar and glucose (Jam SG), apple juice (Jam J), and 40% polydextrose (Jam PD) in 30 healthy adults.

The glycaemic index for the polydextrose jam was significantly lower than the glucose control and all the other jams[38] (Figure 3).

Figure. 3
Glycaemic index for jams[38]



*Significant difference compared to all groups at P<0.01.

An EFSA Panel provided a positive scientific opinion on the replacement of sugar with polydextrose and the reduction of postprandial glycaemic responses.[39]

The EFSA opinion noted that reducing postprandial glucose responses may be beneficial, particularly in those who have impaired glucose tolerance, as long as postprandial insulin responses are not disproportionately increased.

The Panel concluded that a cause-and-effect relationship has been established between the consumption of foods/drinks containing polydextrose and the reduction of postprandial blood glucose responses as compared to sugar-containing foods/drinks.

Clinical studies have reported significantly lower blood glucose and insulin responses with polydextrose consumption. Konings et al.[40] conducted a randomized, single-blind, crossover study in 18 overweight adults, finding a lower postprandial peak glucose response accompanied by a reduction in insulin following the consumption of 57g of polydextrose split between two meals compared to similar full-calorie meals.

The acute effects of a commercial fat- and lactose-free milk enriched with polydextrose was compared with a regular, fat-free milk or a fat- and lactose-free milk in the study by Lummela et al.[41]

After an overnight fast, [26] healthy adults consumed the milks in a randomized block design. A significantly lower rise in blood insulin was observed after consumption of the polydextrose milk compared to the other two milks.

The reduction in postprandial blood glucose and insulin responses has also been observed in individuals with type 2 diabetes when the consumption of sweetened, dried cranberries was compared to polydextrose- containing, reduced-sugar cranberries in a randomized, controlled, crossover study.[42]

Nutrition Centre
By TATE & LYLE

Satiety and weight management

Research indicates that diets rich in fibre are associated with lower body weight and that dietary fibres may enhance satiety and decrease food intake thus reducing the risk of obesity.

Human studies have shown polydextrose to have a beneficial effect on feelings of hunger and reducing caloric intake at the next meal.[43,44] A dose-dependent effect of polydextrose at 6.25g, 12.5g and 25g on decreasing energy intake 90 min before an ad libitum lunch was reported by Astbury et al.[45]

Konings et al. found a pronounced decrease in hunger, increase in whole-body fat oxidation, and reduced postprandial peak glucose and insulin response when 30% of the daily carbohydrate intake was replaced by polydextrose at breakfast and lunch.[40]

Olli et al. showed that the supplementation of 15g polydextrose to a high-fat meal reduced feelings of hunger, which was accompanied by increased satiety-stimulating incretin glucagon-like peptide-1 (GLP-1).[46] Longer-term studies have shown a reduced total daily energy intake with the addition of polydextrose in the diet.[47]

There have been two meta-analyses and systematic reviews assessing polydextrose consumption and subjective appetite ratings and energy intake.[48,49]

Ibarra et al. (2016) conducted a meta-analysis and systematic review of seven studies assessing subjective feelings of appetite post-polydextrose consumption at levels between 6.25g and 25.0g in a single dose per day, which are within the commercial application range for foods and dietary supplements.[48]

Some studies demonstrate that polydextrose consumption significantly impacts subjective feelings of appetite including reductions in desire to eat, which may explain reported reductions in energy intake at a subsequent meal. For other subjective feelings of appetite such as hunger, satisfaction, or fullness, this meta-analysis showed no significant differences with polydextrose consumption. When high doses of polydextrose have been tested (56.7g over the duration of the day) as in a study by Konings et al., subjective feelings of appetite including hunger and desire to eat have been reduced while feelings of fullness and satisfaction have been increased.[40] Ibarra et al. (2015) also conducted a meta-analysis and systematic review of studies assessing the effects of polydextrose consumption on energy intake.[49]

All of the studies included in this meta-analyses provided the polydextrose dose at a mid-morning snack then assessed energy intake at the subsequent ad libitum lunch (six studies) or assessed energy intake for the remainder of the day (three studies).

The meta-analysis demonstrated that the consumption of polydextrose is significantly associated with a reduction in energy intake at lunch but no significant effect on energy intake during the remainder of the day or daily energy intake. Ibarra et al. concluded that consumption of polydextrose reduces voluntary energy intake at a subsequent meal and this energy intake reduction occurs in a dose-dependent manner.

The timing and dose of polydextrose consumption is an important factor on infuencing energy intake.

Polydextrose may help support weight management strategies through its incorporation into lower calorie food formulations given that its calorie contribution is only 1 kcal/g.

Nutrition Centre
By TATE & LYLE

Nutritional impact of the use of Sta-Lite® Polydextrose

STA-LITE® Polydextrose is a source of dietary fibre that can be added to a variety of foods such as sugar-reduced, no added sugar, and sugar-free cereals, snacks, bakery items, beverages, dairy products, and sauces. It can also be used in regular bakery items, beverages, dairy products, and sauces.

STA-LITE® Polydextrose is used to provide body and texture in reduced-calorie and reduced-fat foods. Simple substitutions of similar foods made with Sta-Lite® Polydextrose can help to close the fibre gap and may help to lower calorie intake.

STA-LITE® Polydextrose is well-tolerated and research to date suggests that it supports digestive health and laxation, may help decrease postprandial glycaemic response, and may support weight management strategies by providing a satiety effect.

STA-LITE®
Polydextrose

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.[50]

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.[50] 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.[50]

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.[51] 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.

Nutrition Centre
By TATE & LYLE

Conclusions

While individuals should increase their consumption of naturally-occurring dietary fibre from legumes, other vegetables, fruits, and whole grains,[1] the consumption of foods with added fibres such as STA-LITE® Polydextrose is an additional strategy towards closing the gap between recommended and actual intakes.

A recent comparison has shown that polydextrose has many similar functionalities as inherent plant cell wall-associated fibres, particularly in the gastrointestinal tract.[52]

The physio-chemical and functional properties of STA-LITE® Polydextrose make it a good candidate for manufacturers to use in developing new and innovative products to meet the fibre needs of the population without increasing energy intake.

Further, research to date suggests physiological benefits include supporting gastrointestinal health, promoting favourable postprandial blood glucose response, and potentially aiding in weight management via its satiety effect.

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.

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.

References

1. Dietary Guidelines Advisory Committee. Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 2015.

2. Institute of Medicine, Food and Nutrition Board. Dietary Reference Intakes: Energy, Carbohydrates, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids. Washington, DC: National Academies Press; 2002/2005.

3.Stephen AM, Champ MM J, Cloran, SJ, et al. Dietary fibre in Europe: current state of knowledge on definitions, sources, recommendations, intakes and relationships to health. Nutrition Research Reviews. July 2017.

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

5. Auestad N, Hurley J, Fulgoni VL, et al. Contribution of Food Groups to Energy and Nutrient Intakes in Five Developed Countries. Nutrients. 2015 Jun 8;7(6):4593-618.

6. Murphy N, Norat T, Ferrari P, et al. Dietary fibre intake and risks of cancers of the colon and rectum in the European prospective investigation into cancer and nutrition (EPIC). PLoS One. 2012;7:e39361.

7. Wang HJ et al. Trends in dietary fiber intake in Chinese aged 45 years and above, 1991-2011. Eur J Clin Nutr. 2014 May;68(5):619-22.

8. CODEX-aligned dietary fiber definitions help to bridge the 'fiber gap'. Jones JM. Nutr J. 2014;13:34.

9. Flores M, Macias N, Rivera M, et al. Dietary patterns in Mexican adults are associated with risk of being overweight or obese J Nutr. 2010 Oct;140(10).

10. Dehghan M, Martinez S, Zhang X, Seron P, et al. Relative validity of an FFQ to estimate daily food and nutrient intakes for Chilean adults. Public Health Nutr. 2013 Oct;16(10):1782-8.

11. Sardinha AN, Canella DS, Martins AP, et al. Dietary sources of fiber intake in Brazil. Appetite. 2014 Aug;79:134-8.

12. Mobley A, Slavin JL, Hornick BA. The future of recommendations on grain foods in dietary guidance. J Nutr 2013;143:1527S_32S.

13. Storey M, Anderson P. Income and race/ethnicity influence dietary fiber intake and vegetable consumption. Nutr Res 2014;34:844_50.

14. Howlett JF, Betteridge VA, Champ M, et al. The definition of dietary fiber – discussions at the ninth Vahouny fiber symposium: building scientific agreement. Food Nutr Res.2010;54:1–5.

15. Codex Alimentarius Commission. Guidelines on Nutrition Labeling: CAC/GL 2-1985.: Joint FAO/WHO Food Standards Programme, Secretariat of the CODEX Alimentarius Commission; Rome, Italy 2010.

16. EFSA Publication (2011). EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA); Scientific Opinion on Dietary Reference Values for carbohydrates and dietary fibre. Parma, Italy: European Food Safety Authority. (The EFSA Journal; No. 1462). DOI:10.2903/j.efsa.2010.1462.

17. Kaczmarczyk MM, Miller MJ, Freund GG. The health benefits of dietary fiber: Beyond the usual suspects of type 2 diabetes mellitus, cardiovascular disease and colon cancer. Metabolism. 2012;61:1058-66.

Nutrition Centre
By TATE & LYLE

References cont.

18. Flood MT, Auerbach MH, Craig SA. A review of the clinical toleration studies of polydextrose in food. Food Chem Toxicol. 2004;42:1531-42.

19. Auerbach MH, Craig SA, Howlett JF, et al. Caloric availability of polydextrose. Nutr Rev. 2007;65:544-9.

20. Achour L, Flourié B, Briet F, et al. Gastrointestinal effects and energy value of polydextrose in healthy nonobese men. Am J Clin Nutr. 1994;59:1362-8.

21. Beards E, Tuohy K, Gibson G. Bacterial, SCFA and gas profiles of a range of food ingredients following in vitro fermentation by human colonic microbiota. Anaerobe. 2010;16:420-425.

22. Probert HM, Apajalahti JH, Rautonen N, et al. Polydextrose, lactitol, and fructo-oligosaccharide fermentation by colonic bacteria in a three-stage continuous culture system. Appl Environ Microbiol. 2004;70:4505-11.

23. Hernot DC, Boileau TW, Bauer LL, et al. in vitro fermentation profiles, gas production rates, and microbiota modulation as affected by certain fructans, galactooligosaccharides, and polydextrose. J Agric Food Chem. 2009;57:1354-61.

24. Vester Boler BM, Hernot DC, Boileau TW, et al. Carbohydrates blended with polydextrose lower gas production and short-chain fatty acid production in an in vitro system. Nutr Res. 2009;29:631-9.

25. Mäkeläinen HS, Mäkivuokko HA, Salminen SJ, et al. The effects of polydextrose and xylitol on microbial community and activity in a 4-stage colon simulator. J Food Sci. 2007;72:M153-9.

26.Mäkivuokko H, Kettunen H, Saarinen M, et al. The effect of cocoa and polydextrose on bacterial fermentation in gastrointestinal tract simulations. Biosci Biotechnol Biochem. 2007;71:1834-43.

27. Pylkas AM, Juneja LR, Slavin JL. Comparison of different fibers for in vitro production of short chain fatty acids by intestinal microflora. J Med Food. 2005;8:113-6.

28. Costabile A, Fava F, Röytiö H, et al. Impact of polydextrose on the faecal microbiota: a double-blind, crossover, placebo-controlled feeding study in healthy human subjects. Br J Nutr.www.cnpp. usda. gov/dgas 2010-dgacreport.htm.

29. Timm DA, Thomas W, Boileau TW, et al. Polydextrose and soluble corn fiber increase five-day fecal wet weight in healthy men and women. J Nutr. 2013;143:473-478.

30. Vester Boler BM, Serao MC, Bauer LL, et al. Digestive physiological outcomes related to polydextrose and soluble maize fibre consumption by healthy adult men. Br J Nutr. 2011;106:1864-71.

31. Jie Z, Bang-Yao L, Ming-Jie X, et al. Studies on the effects of polydextrose intake on physiologic functions in Chinese people. Am J Clin Nutr. 2000;72:1503-9.

32. Endo K, Kumemura M, Nakamura K, et al. Effect of high cholesterol diet and polydextrose supplementation on the microflora, bacterial enzyme activity, putrefactive products, volatile fatty acid (VFA) profile, weight and pH of the faeces in healthy volunteers. Bifidobacteria Microflora. 1991;10:53-64.

33. Hengst C, Ptok S, Roessler A, et al. Effects of polydextrose supplementation on different faecal parameters in healthy volunteers. Int J Food Sci Nutr. 2009;60 Suppl 5:96-105.

34. Pronczuk A, Hayes KC. Hypocholesterolemic effect of dietary polydextrose in gerbils and humans. Nutr. Res. 2006:26:27-31.

35. EFSA Panel on Dietetic Products, Nutrition and Allergies. Guidance on the scientific requirements for health claims related to gut and immune function. EFSA J. 2011;9:1984.

36. Saku K, Yoshinaga K, Okura Y, et al. Effects of polydextrose on serum lipids, lipoproteins, and apolipoproteins in healthy subjects. Clin Therapeutics. 1991;13/2:254-258.

37. Tomlin J, Read NW. A comparative study of the effects on colon function caused by feeding ispaghula husk and polydextrose. Aliment Pharmacol Ther. 1988;2:513-9.

38. Kurotobi T, Fukuhara K, Inage H, et al. Glycemic index and postprandial blood glucose response to Japanese strawberry jam in normal adults. J Nutr Sci Vitaminol. 2010;56:198-202.

39. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA); Scientific Opinion on the substantiation of health claims related to the sugar replacers xylitol, sorbitol, mannitol, maltitol, lactitol, isomalt, erythritol, D-tagatose, isomaltulose, sucralose and polydextrose and maintenance of tooth mineralisation by decreasing tooth demineralisation (ID 463, 464, 563, 618, 647, 1182, 1591, 2907, 2921, 4300), and reduction of post-prandial glycaemic responses (ID 617, 619, 669, 1590, 1762, 2903, 2908, 2920) pursuant to Article 13(1) of Regulation (EC) No 1924/2006. EFSA J. 2011;9:2076. www.efsa. europa. eu/efsajournal.

40. Konings E, Schoffelen PF, Stegen J, et al. Effect of polydextrose and soluble maize fibre on energy metabolism, metabolic profile and appetite control in overweight men and women. Br J Nutr. 2013 Jul 23:1-11. [Epub ahead of print].

41. Lummela N, Kekkonen RA, Jauhiainen T, et al. Effects of a fiber-enriched milk drink on insulin and glucose levels in healthy subjects. Nutr J. 2009;8:45.

42. Wilson T, Luebke JL, Morcomb EF, et al. Glycemic responses to sweetened dried and raw cranberries in humans with type 2 diabetes. J Food Sci. 2010;75:H218-H223.

43. Hull S, Re R, Tiihonen K, et al. Consuming polydextrose in a mid-morning snack increases acute satiety measurements and reduces subsequent energy intake at lunch in healthy human subjects. Appetite 2012; 59:706–712.

44. Ranawana V, Muller A, Henry CJK. Polydextrose: its impact on short-term food intake and subjective feelings of satiety in males – a randomized controlled cross-over study. Eur J Nutr 2013; 52:885–893.

45. Astbury NM, Taylor MA, Macdonald IA. Polydextrose results in a dose dependent reduction in ad libitum energy intake at a subsequent test meal. Br J Nutr 2013;110:934–942.

46. Olli K, Salli K, Alhoniemi E, et al. Postprandial effects of polydextrose on satiety hormone responses and subjective feelings of appetite in obese participants. Nutr J 2015;14:2.

47. Astbury NM, Taylor MA, French SJ, et al. Snacks containing whey protein and polydextrose induce a sustained reduction in daily energy intake over 2 weeks under free-living conditions. Am J Clin Nutr 2014;99:1131–1140.

48. Ibarra A, Astbury NM, Olli K, Alhoniemi E, Tiihonen K et al. Effect of Polydextrose on Subjective Feelings of Appetite during the Satiation and Satiety Periods: A Systematic Review and Meta-Analysis. Nutrients. 2016;8:45.

49. Ibarra A, Astbury NM, Olli K, Alhoniemi E, Tiihonen K. Effects of polydextrose on different levels of energy intake: A systematic review and meta-analysis. Appetite. 2015;87:30–37.

50. Internal research for Tate & Lyle conducted by Qualtrics; 8,800 global respondents (800 per country), 2015 (Turkey and Saudi Arabia 2016).

51. Nicklas TA, O'Neil CE, Liska DJ, et al. Modeling dietary fibre intakes in US adults: implications for public policy. Food Nutr Sci. 2011;2:925-931.

52. Raninen K, Lappi J, Mykkänen H, et al. Dietary fiber type reflects physiological functionality: comparison of grain fiber, inulin, and polydextrose. Nutr Rev. 2011;69:9-21.

Nutrition Centre
By TATE & LYLE

To learn more about Tate & Lyle ingredients and innovations as well as health benefits and relevant research, please visit www.tateandlyle.com/nutrition-centre

This leaflet is provided for general circulation to the nutrition science and health professional community and professional participants in the food industry, including prospective customers for Tate & Lyle food ingredients. It is not designed for consumer use. The applicability of label claims, health claims and the regulatory and intellectual property status of our ingredients varies by jurisdiction. You should obtain your own advice regarding all legal and regulatory aspects of our ingredients and their usage in your own products to determine suitability for their particular purposes, claims, freedom to operate, labeling or specific applications in any particular jurisdiction. This product information is published for your consideration and independent verification. Tate & Lyle accepts no liability for its accuracy or completeness.