TATE & LYLE

POLYDEXTROSE: HEALTH BENEFITS AND PRODUCT APPLICATIONS

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

STA-LITE® Polydextrose

Nutrition Centre

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- 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 population 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.

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.

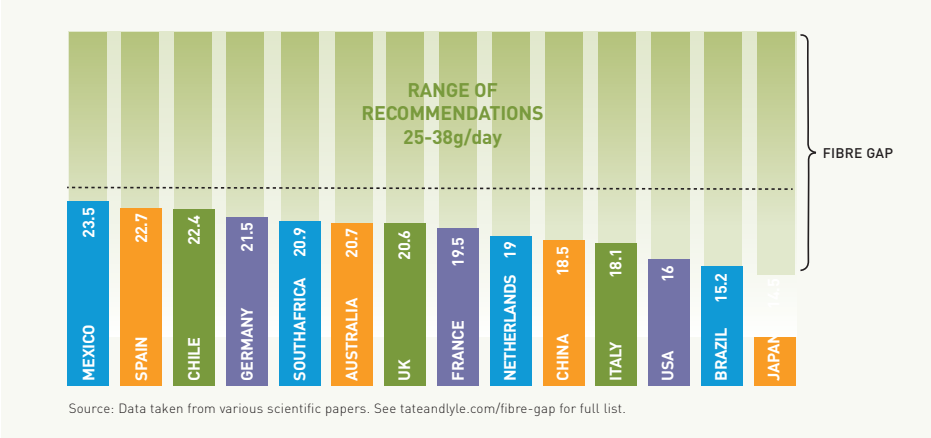
Tate & Lyle's ingredient, STA-LITE® Polydextrose is a low-calorie bulking and texturing ingredient commonly added to foods to boost fibre content and to replace sugar and fat without sacrificing taste, texture, or enjoyment. Studies have also demonstrated the health benefits of polydextrose.

Dietary fibre gap: intakes and guidelines

Recommendations for fibre intakes range from 25-38 g/day depending on country-specific guidelines.[2, 3] The World Health Organization suggests worldwide recommendations of 25 g/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]



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

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 90 g/day or 50 g 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]

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 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.

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]

* Labeling varies by regional and country regulations

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 8 g/day and 12 g/day of polydextrose for 28 days.

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 90 g/day or 50 g 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 8-30 g/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 29 g in faecal weight on a dry matter basis over a five-day period when 21 g of polydextrose was consumed compared to the control (Figure 2); an increase in faecal mass of 4.3 g was found per gram of fibre consumed.[30] The lowest effective dose was 8 g/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 4 g/day.[31]

Figure. 2

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

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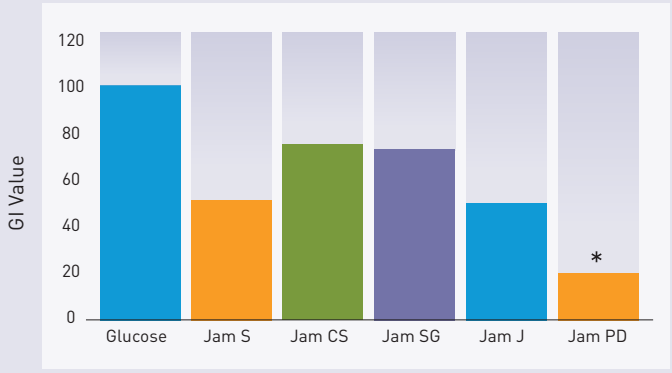
Favorable blood glucose and insulin response

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 12 g of polydextrose ingested with 50 g of glucose significantly lowered the glycaemic response compared to a 50 g 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 57 g 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]

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 6.25 g, 12.5 g and 25 g 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 15 g 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 6.25 g and 25.0 g 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 (56.7 g 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]

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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 influencing 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.

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.

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.

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

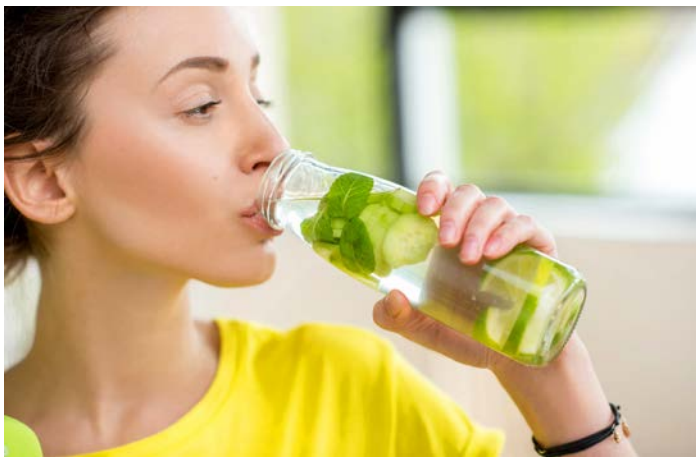
Tate & Lyle, a global leader in wellness innovation, is committed to delivering innovative ingredients that can be incorporated into great-tasting foods to help consumers meet their nutrition, health, and wellness needs every day. That is because Tate & Lyle invests heavily in innovation and research 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.

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

Better-for-you ingredients for health and wellness

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

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



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