TATE & LYLE

PROMITOR® Soluble Fibre

PROMITOR® Soluble Fibre and mineral absorption

Dietary fibres are important nutrients for human health. Fibre-rich diets contribute to gastrointestinal health, gut function, positive changes in the gut microbiota, increased satiety, reduced blood glucose and cholesterol markers, and immune health. Increasing fibre intake is a favourable nutritional strategy for reducing the risk of chronic diseases such as obesity, type 2 diabetes, cardiovascular disease, and cancer.[1-5]

The relationship between dietary fibre and mineral absorption has been studied for many years, yet it remains controversial in the scientific literature. Although *in-vitro* (lab-based) studies have presented conflicting outcomes, both animal and human studies have failed to demonstrate negative effects of fibre on the bioavailability of micronutrients. On the contrary, they have highlighted some positive results on the absorption of minerals such as calcium, magnesium, iron and zinc.[6-9]

Fibre-rich diets contribute to:

- Gastrointestinal health
- Gut function
- Positive changes in the gut microbiota
- Increased satiety
- Reduced blood glucose and cholesterol markers
- Immune health

Nutrition Centre

The complexity of mineral absorption

Micronutrient bioavailability is the rate and extent to which micronutrients, such as mineral and vitamins, are absorbed in the gut and enter the bloodstream to be used by the body.[10] Bioavailability mechanisms are complex and depend on many factors that need to be taken into account. In addition to the amount of nutrient present in a food or beverage and the chances that nutrient-nutrient interactions will occur, when it comes to the individual, age, genetics, lifestyle, nutritional status and health status also play a role.[11]

Antinutritional factors, for example, are substances that interfere with the digestibility, absorption and use of minerals and vitamins and that can negatively affect micronutrient bioavailability. Also known as antinutrients, these substances include phytates, oxalates, tannins, nitrites, and nitrates. Dietary fibre is sometimes mistaken for an antinutritional factor.[12]

Fibre and mineral absorption

Dietary fibres, categorised by their chemical structure and functional properties, may have different effects on mineral bioavailability.[13] In the literature, there is still no conclusive evidence of the effects of fibres on mineral absorption and, although several reviews of dietary fibres have been published in the last decade, little emphasis has been placed on the effects of dietary fibres on mineral bioavailability.[6]

Although some early studies, mainly performed *in-vitro*, have reported negative effects of fibre on mineral absorption, animal and human studies have failed to confirm these results.[4,6,14] In humans, several studies of fibre interventions have shown positive effects on mineral absorption.[15-20]

In general, insoluble fibres, those that are not soluble in water and are susceptible to limited fermentation, may bind minerals forming unabsorbable complexes. Soluble fibres, on the other hand, have a more variable effect, frequently promoting mineral absorption.[19,21,22]

Prebiotic fibres and the gut microbiota's role in mineral absorption

The gastrointestinal tract houses the largest and most complex community of bacterial species in the human body.[23] There is a growing interest in the role of the gut microbiome in physiological processes that affect health, acknowledging the importance of bacteria for gut barrier function, energy metabolism, nutrient supply, immune and inflammatory responses, and the prevention and treatment of disease.[24] Substances generated by bacterial metabolism can also enable communication with peripheral tissues, via gut-brain, gut-bone, and gut-skin axes.[25]

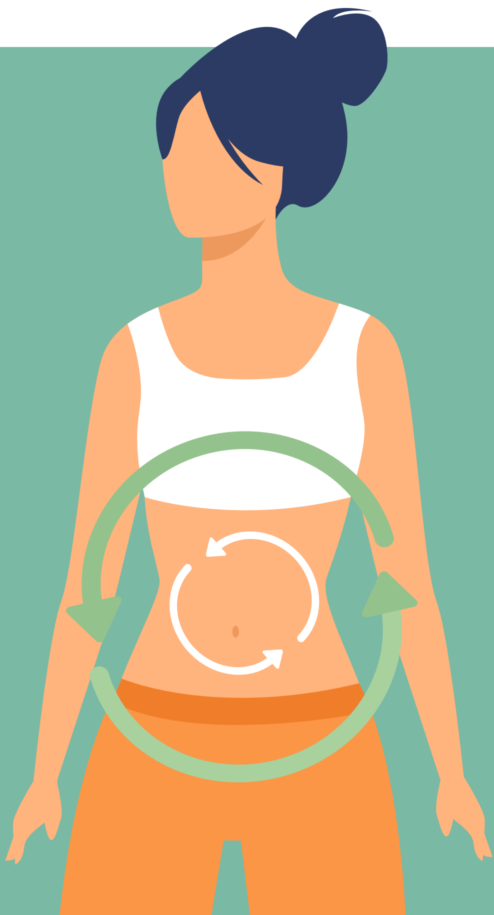
A prebiotic is defined as a substrate that is selectively utilised by host microorganisms conferring a health benefit.[26] This definition covers both dietary fibres and ingredients that are non-carbohydrate-based (e.g. polyphenols and polyunsaturated fatty acids), recognising their efficacy and ability to promote beneficial gut microbiota modulation.[24] Changes in the composition of the colon microbiota can increase the number and activity of specific bacteria associated with mineral absorption.[24]

Dietary fibres are the most studied nutrients in the context of gut microbiota modulation via their prebiotic properties. Prebiotic fibre serves as a substrate for producing short-chain fatty acids (SCFAs) and preserving the gut barrier. Metabolites produced by bacteria in the gut nourish cells and lead to increased crypt depth, intestinal cell density, and cecal blood flow, potentially increasing the absorption surface for minerals such as calcium, magnesium and zinc.[9,27]

Another potential mechanism explaining the relationship between intestinal microbiota and mineral absorption relates to changes in the gut environment. Fermentation of prebiotic fibres by certain bacteria that are able to break down carbohydrates, leads to SCFA production and subsequent reduction in the gut pH that could ionize calcium from negatively charged compounds in the colon, thus allowing it to be absorbed into the bloodstream.[24]

Potential mechanisms of fibre promoting mineral absorption[24]

- Dietary fibre can alter the composition of the colon microbiota and can increase the number and activity of specific bacteria associated with mineral absorption.
- Soluble fibre fermentation can produce short-chain fatty acids (SCFAs) increasing the intestinal absorption surface area, improving the absorption of minerals such as calcium, zinc and magnesium.
- Increased SCFAs production decreases the gut pH, increasing the solubilisation of minerals and improving their absorption and use.



Soluble corn fibre: prebiotic potential for improved mineral absorption

Prebiotic fibres beneficially modulate the bacterial composition in the colon, which impacts the gut environment and can lead to benefits in mineral absorption.[24,28]

Soluble corn fibre increases beneficial bacteria and total faecal SCFAs and demonstrates improved mineral absorption benefits, confirming its prebiotic effects.[7,24,29-31]

Figure 1. How calcium absorption can be promoted by prebiotic fibre[8,9,32,33]

Soluble fermentable fibers

↓

Increased SCFAs

Decreased colon pH

↓

Enhanced mineral solubility

↓

Increased mineral absorption

↓

Potential impact on bone health

Soluble corn fibre prebiotic effects and mineral absorption

Study Reference	Objectives	Design	Results	Conclusion
MAATHUIS et al., 2009 [34]	Prebiotic potential of maize-based fibres including soluble corn fibre (SCF) and its influence on the composition and activity of the microbiota	Dynamic, validated, *in vitro* model of the large intestine.	Increased short-chain fatty acids (SCFAs), showing that fibres were fermentable especially soluble dietary fibre test products with SCF, pullulan and soluble fibre dextrin. Increase of *Bifidobacterium* and some *Lactobacillus* species.	Fibres showed prebiotic activity in tems of increases in growth and or activity of beneficial bacteria.
COSTABILE et al., 2016 [35]	Determine changes to microbiota and fermentation of SCF in healthy adult subjects	Double-blind, randomised, parallel study. 24 healthy adults. 14 days. 8 g, 14 g and 21 g SCF in 250 ml of drink.	Results indicate a significant increase in *Bifidobacterium* spp. with the intake of 6 g of SCF. With the dose of 14 g of SCF, there was a reduction in the pathogenic bacteria *C. perfringens* gp.	Prebiotic effect of SCF observed during a short-term intervention.
BOLER et al., 2011 [31]	Digestive physiological outcomes of functional fibres (SCF)	Randomised, double-blind, placebo-controlled, cross over study; 21 days. 21 healthy adult men. 21g/d SCF (3 snack bars).	*Bifidobacterium* spp. concentrations were significantly greater ($p<0{,}05$) on the group consuming SCF vs no fibre.	SCF appears to be beneficial to gut health with minimal gastrointestinal upset.
WHISNER et al., 2014 [7]	SCF effect on Ca absorption and correlation between gut bacterial genera and Ca absorption	Double-blind, cross over, randomized trial. 24 adolescents. 2 x 3-weeks study. 12g/d SCF (fruit snack) vs control (0g/d).	Increased SCFA-producing bacteria in the intervention group. *Firmicutes* decreased and average proportion of *Bacteroidetes* was significantly greater with SCF vs control. Ca absorption 12% greater with SCF.	Intake of SCF increased Ca absorption. Increase in *Bacteroidetes* and a trend towards a greater increase in *Bifidobacterium* were observed, suggesting SCF stimulated beneficial bacteria capable of fermenting fibres/ producing SCFA.
WHISNER et al., 2016 [29]	SCF effect on Ca absorption associated with shifts in the gut microbiota	Double-blind, cross over study. 28 heathy female adolescents. 4 weeks + 3-4 w washout. Dose response (0, 10g, 20g) SCF (muffin and beverage).	Significant differences in fecal microbial community diversity with SCF intake. Calcium absorption increased significantly with 10 g (13.3%) and 20 g (12.9%) SCF vs control.	Intervention beneficially changed the composition of the gut microbiota, significantly increasing the number and diversity of bacteria. Increased calcium absorption with two groups of bacteria potentially involved, one directly fermenting SCF and the second fermenting SCF metabolites further.

PROMITOR® Soluble Fibre enhances calcium absorption

The gut microbiome is a key regulator of bone health. The use of dietary fibre is considered an effective method to increase calcium absorption and bone mineral density especially among individuals with inadequate calcium intake. Adequate calcium intake and absorption is considered an economic and sustainable approach to help improving skeletal health and/or fracture prevention during all stages of life.[24]

During pubertal growth, when insufficient calcium intake can negatively influence the achievement of peak bone mass, soluble corn fibre increased the absorption of calcium by 6-12%, compared to control treatments.[7,29,36]

PROMITOR® Soluble Fibre demonstrates prebiotic effects and increases calcium absorption, helping to meet bone health needs, particularly in adolescents.[7,24,29]

PROMITOR® Soluble Fibre

PROMITOR® Soluble Fibre demonstrates prebiotic action increases calcium absorption by 12% in adolescents.[7]

References

1. GILL, Samantha K.; et al. Dietary fibre in gastrointestinal health and disease. Nature Reviews Gastroenterology & Hepatology. [S.L.], v. 18, n. 2, p. 101-116, 18 Nov. 2020. Springer Science and Business Media LLC.

2. PARTULA, Valentin; et al. Associations between consumption of dietary fibres and the risk of cardiovascular diseases, cancers, type 2 diabetes, and mortality in the prospective NutriNet-Santé cohort. The American Journal Of Clinical Nutrition, [S.L.], v. 112, n. 1, p. 195-207, 5 May 2020. Oxford University Press (OUP).

3. REYNOLDS A., et al. Carbohydrate quality and human health: a series of systematic reviews and meta-analyses. Lancet, v.393, n.10170, p.434-445. Jan. 2019.

4. SHAH, M.; et al. Effect of a High-Fibre Diet Compared With a Moderate-Fibre Diet on Calcium and Other Mineral Balances in Subjects With Type 2 Diabetes. Diabetes Care, [S.L.], v. 32, n. 6, p. 990-995, Mar. 2009. American Diabetes Association.

5. CHANDALIA, Manisha; et al. Beneficial Effects of High Dietary Fibre Intake in Patients with Type 2 Diabetes Mellitus. New England Journal Of Medicine, [S.L.], v. 342, n. 19, p. 1392-1398, 11 May 2000. Massachusetts Medical Society.

6. BAYE, Kaleab; et al. The unresolved role of dietary fibres on mineral absorption. Critical Reviews In Food Science And Nutrition, [S.L.], v. 57, n. 5, p. 949-957, 28 Dec. 2016. Informa UK Limited.

7. WHISNER, Corrie M.; et al. Soluble maize fibre affects short-term calcium absorption in adolescent boys and girls: a randomised controlled trial using dual stable isotopic tracers. British Journal Of Nutrition, [S.L.], v. 112, n. 3, p. 446-456, May 2014. Cambridge University Press (CUP).

8. WEAVER, Connie M.; et al. Novel Fibers Increase Bone Calcium Content and Strength beyond Efficiency of Large Intestine Fermentation. Journal Of Agricultural And Food Chemistry, [S.L.], v. 58, n. 16, p. 8952-8957, Aug. 2010. American Chemical Society (ACS).

9. PEREZ-CONESA, D.; et al. Effect of Probiotic, Prebiotic and Synbiotic Follow-up Infant Formulas on Iron Bioavailability in Rats. Food Science and Technology International, v. 13, n. 1, p. 69-77, Feb 2007. SAGE journals.

10. MELSE-BOONSTRA, Alida. Bioavailability of Micronutrients from Nutrient-Dense Whole Foods: Zooming in on Dairy, Vegetables, and Fruits. Frontiers in Nutrition, v. 7, p. 101, Jul 2020.

11. BECHOFF, Aurélie; DHUIQUE-MAYER, Claudie. Factors influencing micronutrient bioavailability in biofortified crops. Annals Of The New York Academy Of Sciences, [S.L.], v. 1390, n. 1, p. 74-87, 23 Dec. 2016. Wiley.

12. SAMTIYA, Mrinal; et al. Plant food anti-nutritional factors and their reduction strategies: an overview. Food Production, Processing And Nutrition, [S.L.], v. 2, n. 1, p. 1-14, Mar. 2020. Springer Science and Business Media LLC.

13. BERNAUD, Fernanda S.R.; RODRIGUES, Ticiana C. Fibra alimentar: ingestão adequada e efeitos sobre a saúde do metabolismo. Arquivos Brasileiros de Endocrinologia & Metabologia, [S.L.], v. 57, n. 6, p. 397-405, Aug. 2013. FapUNIFESP (SciELO).

14. COUDRAY, C.; et al. Effects of Dietary Fibers on Magnesium Absorption in Animals and Humans, The Journal of Nutrition, v.133, n. 1, p. 1–4, Jan. 2003. Oxford Academic.

15. HICKS, Penni D.; et al. Total calcium absorption is similar from infant formulas with and without prebiotics and exceeds that in human milk-fed infants. Bmc Pediatrics, [S.L.], v. 12, n. 1, p. 1-1, 7 Aug. 2012. Springer Science and Business Media LLC.

16. HOLLOWAY, Leah; et al. Effects of oligofructose-enriched inulin on intestinal absorption of calcium and magnesium and bone turnover markers in postmenopausal women. British Journal Of Nutrition, [S.L.], v. 97, n. 2, p. 365-372, Feb. 2007. Cambridge University Press (CUP).

17. YAP, K.W.; et al. Dose-response effects of inulin on the faecal short-chain fatty acids content and mineral absorption of formula-fed infants. Nutrition & Food Science, [S.L.], v. 35, n. 4, p. 208-219, Aug, 2005.

18. HEUVEL, Ellen G. H. M. van Den; et al. Transgalactooligosaccharides Stimulate Calcium Absorption in Postmenopausal Women. The Journal of Nutrition, [S.L.], v. 130, n. 12, p. 2938-2942, 1 Dec. 2000. Oxford University Press (OUP).

19. COUDRAY, C.; et al. Effect of soluble or partly soluble dietary fibres supplementation on absorption and balance of calcium, magnesium, iron and zinc in healthy young men. European Journal Of Clinical Nutrition, [S.L.], v. 51, n. 6, p. 375-380, Jun. 1997. Springer Science and Business Media LLC.

20. CUMMINGS, J. H.; et al. The digestion of pectin in the human gut and its effect on calcium absorption and large bowel function. British Journal Of Nutrition, [S.L.], v. 41, n. 3, p. 477-485, May 1979. Cambridge University Press (CUP).

21. FILISETTI, T.M.C.C.; LOBO A.R. Dietary fiber and its effect on the bioavailability of minerals. Bioavailablity of Nutrients, p. 175-215, 2007. Manole.

22. WONG, Julia M. W.; JENKINS, David J. A. Carbohydrate Digestibility and Metabolic Effects. The Journal Of Nutrition, [S.L.], v. 137, n. 11, p. 2539-2546, Nov. 2007. Oxford University Press (OUP).

23. CRESCI, G. A.; BAWDEN, E. Gut Microbiome: What We Do and Don't Know. Nutrition in clinical practice : official publication of the American Society for Parenteral and Enteral Nutrition v. 30, n. 6, p. 734-46, Oct. 2015. Wiley.

24. WHISNER, Corrie M.; CASTILLO, Luisa F. Prebiotics, Bone and Mineral Metabolism. Calcified Tissue International, [S.L.], v. 102, n. 4, p. 443-479, Oct. 2018. Springer Science and Business Media LLC.

25. WEAVER, Connie M. Diet, Gut Microbiome, and Bone Health. Current Osteoporosis Reports, [S.L.], v. 13, n. 2, p. 125-130, Jan. 2015. Springer Science and Business Media LLC.

26. GIBSON G.R.; et al. Expert consensus document: The International Scientific Association for Probiotics and Prebiotics (ISAPP) consensus statement on the definition and scope of prebiotics. Nature Reviews Gastroenterology & Hepatology, v. 14, n. 8, p. 491-502, Aug. 2017. Nature.

27. DONOHOE, Dallas R.; et al. The Microbiome and Butyrate Regulate Energy Metabolism and Autophagy in the Mammalian Colon. Cell Metabolism, [S.L.], v. 13, n. 5, p. 517-526, May 2011. Elsevier BV.

28. SCHOLZ-AHRENS, KE; SCHREZENMEIR, J. Inulin, oligofructose and mineral metabolism — experimental data and mechanism. British Journal Of Nutrition, [S.L.], v. 87, n. 6, p. 179-186, May 2002. Cambridge University Press (CUP).

29. WHISNER, Corrie M; et al. Soluble Corn Fibre Increases Calcium Absorption Associated with Shifts in the Gut Microbiome: a randomized dose-response trial in free-living pubertal females. The Journal Of Nutrition, [S.L.], v. 146, n. 7, p. 1298-1306, Jun. 2016. Oxford University Press (OUP).

30. KLOSTERBUER, A.S.; et al. Gastrointestinal effects of resistant starch, soluble maize fibre and pullulan in healthy adults. British Journal of Nutrition, v. 110, n. 6, p. 1068-74, Sep 2013. Cambridge.

31. BOLER, B.M.; et al. Digestive physiological outcomes related to polydextrose and soluble maize fibre consumption by healthy adult men. British Journal of Nutrition, v. 106, n. 12, p. 1864-71, May 2011. Cambridge.

32. BONGERS, Anke; VANDEN HEUVEL, Ellen G.H.M. Prebiotics and the Bioavailability of Minerals and Trace Elements. Food Reviews International, v. 19, n. 4, p. 397-422. Taylor & Francis Online.

33. RASCHKA, L.; DANIEL H.; Mechanisms underlying the effects of inulin-type fructans on calcium absorption in the large intestine of rats. Bone, v. 37, n. 5, p. 728-735, Nov 2005. Elsevier.

34. MAATHUIS, Annet; et al. The Effect of the Undigested Fraction of Maize Products on the Activity and Composition of the Microbiota Determined in a Dynamic In Vitro Model of the Human Proximal Large Intestine. Journal Of The American College Of Nutrition, [S.L.], v. 28, n. 6, p. 657-666, Dec. 2009. Informa UK Limited.

35. COSTABILE, Adele; et al. Prebiotic Potential of a Maize-Based Soluble Fibre and Impact of Dose on the Human Gut Microbiota. Plos One, [S.L.], v. 11, n. 1, p. 1-1, 5 Jan. 2016. Public Library of Science (PLoS).

36. GRIFFIN, Ian J.; et al. Enriched chicory inulin increases calcium absorption mainly in girls with lower calcium absorption. Nutrition Research, [S.L.], v. 23, n. 7, p. 901-909, Jul. 2003. Elsevier BV.

PROMITOR®
Soluble Fibre

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

Tate & Lyle • 5450 Prairie Stone Parkway, Hoffman Estates, IL 60192 • 1.800.526.5728

TATE & LYLE

Nutrition Centre