DBN Review N° 26

A resource about dairy-based nutrition
A product of the Consumer Education Project of Milk SA
www.rediscoverdairy.co.za

A publication for health professionals

This review briefly summarises current thinking about the pre- and probiotic effects of dairy foods and their contribution to a healthy gut microbiome.

Health effects of dairy foods on the gut microbiome

Current scientific opinion agrees that milk and milk product intake improves dietary quality and can be linked to a reduced risk of obesity and chronic metabolic conditions.[1-3] Although several mechanisms may underlie the health benefits of dairy foods, the recent emphasis on the structure and function of the human gut microbiome has focused attention on the potential role of probiotics and prebiotics in dairy foods in promoting human health.[4]

The gut microbiome

The gut microbiome refers to the intestinal community of microbes that contribute to maintaining and influencing health.[5,6] This community includes trillions of microbes from more than a thousand bacterial species.[7]

A large body of evidence confirms that lower bacterial diversity in the gut is associated with chronic and inflammatory diseases,[4,5,8] with different disease states being characterised by unique microbiota profiles.[7] Bacterial diversity is therefore an indicator of gut health, and certain conditions, such as obesity and metabolic complications, are closely associated with low microbial diversity and dysbiosis.[9-11] Composition of the gut microbiome is fairly stable in a healthy person, but microbial dynamics are influenced by host lifestyle and diet, with dietary components shaping the microbiome to a considerable extent.[4,8,12] What people eat directly influences the gut microbiota, which, in turn, affects metabolism, immunity and neurobehavioural traits and so ultimately impacts on well-being and disease risk.[5,8,13-16] It is not only the microbes themselves that impact on health but also the products of their metabolism. Fermentation supports the growth of specialist microbes that produce short-chain fatty acids (SCFAs) and gases closely linked to specific beneficial metabolic effects,[8] with important health implications.

Effects of dairy as a prebiotic

Fermentable fibres and prebiotics have the potential to shape the diversity of the microbiome by stimulating the growth of specific genera of the gut microbiota. In addition to the prebiotic lactose, milk also contains oligosaccharides, which provide nutrients to intestinal bacteria.[17]

Lactase is produced in the intestinal mucosa of most mammals and full-term infants generally have sufficient lactase activity to digest milk. However, lactase activity declines after weaning in most humans (lactase non-persistence), especially those from East Asian and African heritage,[18] resulting in different degrees of lactose maldigestion.[19-22] Most people who are lactose intolerant can eat small amounts of dairy foods without experiencing discomfort.[23]

In persons with lactase non-persistence, lactose is not fully digested and thus proceeds to the colon. In lactase-persistent persons, most lactose is digested in the small intestine, but a small amount may reach the large intestine.[23] Lactose and oligosaccharides in milk are considered to be bioactive ingredients with bifidogenic effects,[19,24] serving as a substrate for the growth of the beneficial *Bifidobacteria* and *Lactobacillus* bacteria. In inflammatory bowel disease, the bifidogenic effects of prebiotics such as lactose may prevent the growth of potential pathogens.[25]

Colonic microbiota ferment the lactose and oligosaccharides in dairy foods in the colon, producing metabolites such as SCFAs (primarily acetate, propionate and butyrate) and gases.[8,26] These SCFAs are metabolised by the colonocytes; promote colon motility; reduce inflammation; and inhibit tumour cell progression. Furthermore, SCFAs have been shown to protect against diet-induced obesity, probably through an effect on gut hormones that reduce appetite and food intake.[19,27] Moreover, fermentation of lactose in the colon has a positive effect on the absorption of minerals, particularly calcium and magnesium, owing to increased mineral solubility or enhanced osmotic pressure.[28]

With regard to immune function, lactose may have beneficial effects on gut immunity in both children and adults through interactions with other carbohydrates or SCFAs.[29] In the presence of undigested lactose, enzymes that metabolise sugars are stimulated, leading to a decrease in harmful bacterial metabolites such as hydrogen and ammonia.[30] Hirahatake et al.[24] have shown that the intestinal production of glucagon-like peptide (GLP-1) is influenced by components in foods that provide a substrate for colonic microbiota. In particular, prebiotics and probiotics from dairy may influence gut microbiota in such a way that insulin sensitivity and the action of GLP-1 are positively affected.[31,32] The low glycaemic index of lactose also contributes to improved glycaemic control.[33]

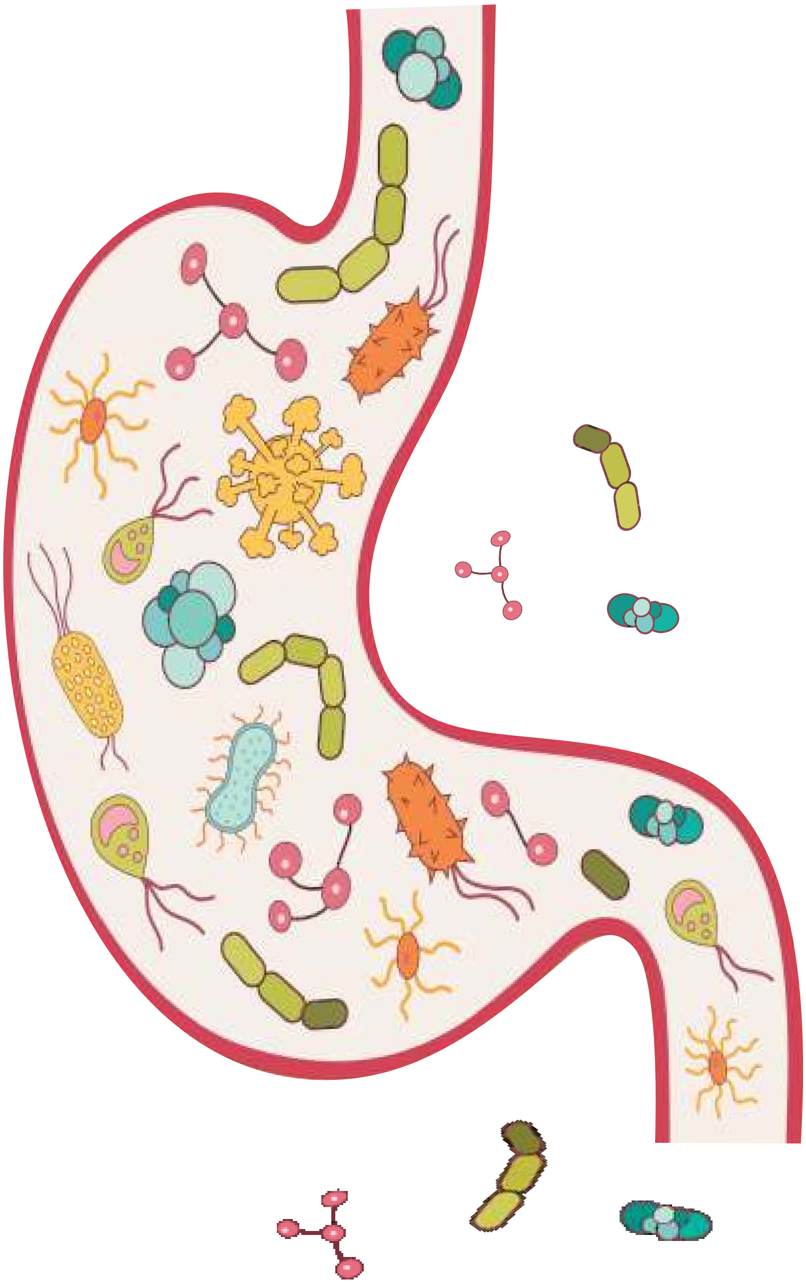
Probiotic effects of fermented dairy foods

In addition to beneficial fatty acids, micronutrients and bioactive peptides, fermented foods also contain live microbes (probiotics) that can influence the diversity and composition of the gut microbiota favourably.[34-36]

How fermented foods are manufactured, processed and stored determine the types and number of microbes that are present.[37] Cultured dairy products and cheese are commonly made using starter cultures chosen for specific performance characteristics. Lactic acid bacteria are preferred for milk fermentation as they do not affect the taste and nutritional value of dairy. The growth of these bacteria is furthermore enhanced by the vitamins, amino acids and nucleotides present in milk.[34] According to Marco et al.,[38] the food matrix of dairy can protect bacteria during their transit through the gut, improving the delivery of viable bacteria.

Although probiotics consumed in microbe-containing foods are transient components of the microbiome (they seldom persevere for more than a few days),[39,40] they have numerous beneficial effects on the diversity, structure and function of the gut microbiota, especially when they are habitually consumed.[40] A recent study by González et al.[10] assessed the association between the consumption of fermented dairy foods, microbial diversity and biomarkers of health in an observational cohort. The authors found that study participants who consumed natural yoghurt had higher levels of the beneficial *Akkermansia* bacteria and lower levels of inflammation than those who did not consume natural yoghurt. These findings have been confirmed in probiotic yoghurt intervention studies,[41,42] suggesting that fermented dairy products may protect against chronic low-grade inflammation common in many chronic conditions, such as metabolic syndrome.[11,34,43] Proposed mechanisms include the possible induction of anti-inflammatory cytokines such as IL-10,[44,45] and an increase in total serum IgA to potentiate the humoral immune response.[4]

Other health benefits of fermented dairy products include improved lactose tolerance and alleviation of gastrointestinal intolerance symptoms,[34,46] accelerated intestinal transit time, inhibition of pathogen adhesion to the intestinal mucosa,[39,47] prophylactic prevention of traveller's diarrhoea[4] and improved glucose metabolism.[43] Cheese consumption is associated with increased *Bifidobacteria* counts and decreased *Bacteroides* and *Clostridium* counts (some strains are associated with intestinal infections), providing potential protection against pathogens through increased production of SCFAs and decreased production of trimethylamine oxide.[16]



Conclusion

There is substantial evidence that a balanced diet has a positive impact on the microbiome, decreasing the risk of developing metabolic and inflammatory diseases. Milk and fermented dairy foods contain microbial, nutritive and bioactive components that benefit the gut microbiome and, consequently, general health. Research related to the potential lasting impact of habitual dairy intake on the microbiome and the potential to promote shifts in microbiota species is, however, needed. This is especially important in poverty-stricken communities, where the risk for gastrointestinal infections is high.

Please visit our website for more evidence-based reviews on dairy nutrition and health.
www.rediscoverdairy.co.za

References

1. Rafey MF, et al. 2020. Diabetes Metab Syndr Obes. 13:197-205.
2. Mozaffarian D. 2019. Adv Nutr. 10(5):917S-923S.
3. Kongerslev Thorning T, et al. 2016. Food Nutr Res. 60:32527.
4. Singh RK, et al. 2017. J Transl Med. 15:73.
5. Hills RD Jr, et al. 2019. Nutrients. 11(7):1613.
6. Velasquez-Manoff M. 2019. Nautilus. 30.
7. Duvallet C, et al. 2017. Nat Commun. 8:1784.
8. Valdes AM. 2018. BMJ. 361:k2179.
9. Cerdó T, et al. 2019. Nutrients. 11(3):635.
10. González S, et al. 2019. Front Microbiol. 10:1046.
11. Baothman OA, et al. 2016. Lipids Health Dis. 15:108.
12. Wilson AS, et al. 2020. Dig Dis Sci. 65(3):723-740.
13. Fernández-Navarro T, et al. 2018. Eur J Nutr. 57:487-497.
14. Rothschild D, et al. 2018. Nature. 555:210-215.
15. Levy M, et al. 2017. Nat Rev Immunol. 17:219-232.
16. Zhang H, et al. 2015. ISMEJ. 9:770-781.
17. Pereira PC. 2014. Nutrition. 30:619-627.
18. Deng Y, et al. 2015. Nutrients. 7:8020–8035.
19. Vandenplas Y. 2015. Asia Pac J Clin Nutr. 24(1):S9-S13.
20. Heaney RP. 2013. Adv Nutr. 4:151-156.
21. Mattar R, et al. 2012. Clin Exp Gastroenterol. 5:113-121.
22. Brown-Esters O, et al. 2012. Int Dairy J. 22:98-103.
23. Bailey RK, et al. 2013. J Natl Med Assoc. 105(2):112-127.
24. Hirahatake KM, et al. 2014. Metabolism. 63:618-627.
25. Szilagyi A. 2002. Aliment Pharmacol Ther. 16(9):1591-1602.
26. Venema K. 2012. Int Dairy J. 22:123-140.
27. Vulevic J, et al. 2015. Br J Nutr. 114:586-595.
28. Romero-Velarde E, et al. 2019. Nutrients. 11(11):2737.
29. Wahlqvist ML. 2015. Asia Pac J Clin Nutr. 24(1):S21-S25.
30. Cederlund A, et al. 2013. PLoS One. 8(1):e53876.
31. Flint HJ, et al. 2012. Nat Rev Gastroenterol Hepatol. 9(10):577-589.
32. Zivkovic AM, Barile D. 2011. Adv Nutr. 2:284-289.
33. Wolever TM. 2017. J Nutr. 147(7):1462S-1467S.
34. Ghosh T, et al. 2019. Front Microbiol. 10:502.
35. Severyn CJ, Bhatt AS. 2018. Cell Host Microbe. 24:334-336.
36. Panahi S, et al. 2018. Eur J Nutr. 57:1591-1603.
37. Rezac S, et al. 2018. Front Microbiol. 9:1785.
38. Marco ML, et al. 2017. Curr Opin Biotechnol. 44:94-102.
39. Derrien M, et al. 2014. Trends Microbiol. 23:354-366.
40. Zhang C, et al. 2016. ISMEJ. 10:2235-2245.
41. Burton KJ, et al. 2017. Br J Nutr. 117:1312-1322.
42. Mohamadshahi M, et al. 2014. Bioimpacts. 4:83-88.
43. Salas-Salvadó J, et al. 2017. J Nutr. 147(7):1452S-1461S.
44. Pandey KR, et al. 2015. J Food Sci Technol. 52:7577-7587.
45. Wang S, et al. 2012. J Dairy Sci. 95:4813-4822.
46. Savaiano DA. 2014. Am J Clin Nutr. 5 Suppl:1251S-1255S.
47. Rajkumar H, et al. 2014. Mediators Inflamm. 2014:348959.