# Recent Studies and Publications on Prebiotics

## STUDIES

### 1. Functional Proteins In Breast Milk And Their Correlation With The Development Of The Infant Gut Microbiota: A Study Of Mother-Infant Pairs

This study explored the correlation between functional proteins in breast milk and the infant gut microbiota.

The results indicate that the secretory immunoglobulin A (sIgA) content in breast milk is positively correlated with the abundance of ***Veillonella parvula***. The κ-casein content is positively correlated with the abundance of ***Clostridium butyricum***. The osteopontin (OPN) and lactalbumin contents were positively correlated with the abundance of ***Parabacteroides distasonis*** at 42 days.

Functional pathway analysis showed that the OPN and κ-casein contents in breast milk are significantly correlated with amino acid, pyruvate, propionic acid, linoleic acid, and alpha-linolenic acid metabolic pathways in early life. Hence this study suggests that specific proteins in breast milk can influence the abundance of certain gut microbes in infants, playing an important role in early immune and metabolic development.

***Source: Ai Zhao, Vanke School Of Public Health, Tsinghua University, Beijing, China. Functional Proteins In Breast Milk And Their Correlation With The Development Of The Infant Gut Microbiota: A Study Of Mother-Infant Pairs. Frontiers In Microbiology, 13 September 2023, Volume 14.***
***DOI: https://doi.org/10.3389/fmicb.2023.1239501.***

### 2. Impact Of Breastfeeding And Other Early-Life Factors On The Development Of The Oral Microbiome

In the present review, researchers drew data on the maternal, infant, and environmental factors linked to the composition of the infant oral microbiome, with a focus on early nutrition.

The review also explored potential mechanisms through which human milk components, including microbes, metabolites, oligosaccharides, and antimicrobial proteins, may interact with and shape the infant oral microbiome. Further it also highlights that infancy is a unique period for the oral microbiome.

***Source: Lisa F. Stinson, School Of Molecular Sciences, The University Of Western Australia, Perth, WA, Australia. Impact Of Breastfeeding And Other Early-Life Factors On The Development Of The Oral Microbiome. Frontiers In Microbiology, 07 September 2023, Volume 14, 2023.***
***DOI: https://doi.org/10.3389/fmicb.2023.1236601.***

### 3. Human Milk-Associated Bacterial Communities Associate With The Infant Gut Microbiome Over The First Year Of Life

Microbial communities inhabiting the human infant gut are important for immune system development and lifelong health. One critical exposure affecting the bacterial colonization of the infant gut is consumption of human milk, which contains diverse microbial communities and prebiotics. Scientists hypothesized that human milk-associated microbial profiles are associated with those of the infant gut. Maternal–infant dyads enrolled in the New Hampshire Birth Cohort Study (n = 189 dyads) contributed breast milk and infant stool samples collected approximately at 6 weeks, 4 months, 6 months, 9 months, and 12 months postpartum (n = 572 samples).

In this study researchers identified an association between the breast milk microbiome profile and the infant microbiome profile at 6-weeks through clustering analysis that was primarily observed in infants delivered by Cesarean section.

Scientists also found that specific microbial taxa in milk were correlated with those in the infant gut both in contemporaneously and longitudinally collected samples, occurring both between the same taxa in milk and infant stool as well as between different microbial taxa.

These results suggest that milk microbial communities have a long-term effect on the infant gut microbiome both through sharing of microbes and other molecular mechanisms.

***Source: Sara N. Lundgren, Department Of Epidemiology, Geisel School Of Medicine At Dartmouth, Lebanon, NH, United States. Human Milk-Associated Bacterial Communities Associate With The Infant Gut Microbiome Over The First Year Of Life. Frontiers In Microbiology, 2023 Apr 17:14:1164553.***
***DOI: https://doi.org/10.3389/fmicb.2023.1164553.***

## 4. Chemical Composition And Prebiotic Activity Of Baru (DipteryxAlataVog.) Pulp On Probiotic Strains And Human Colonic Microbiota

The baru (DipteryxalataVog.) pulpis is a by-product which is usually discarded by the agro-industry during the processing of baru fruit (Ber fruit).

This study shows that baru pulp has potential prebiotic properties to be explored in the formulation of new health-promoting foods.

***Source: Maria Margareth Veloso Naves, Laboratory Of Experimental Nutrition, School Of Nutrition, Federal University Of Goiás (UFG), Goiânia, Brazil. Chemical Composition And Prebiotic Activity Of Baru (DipteryxAlataVog.) Pulp On Probiotic Strains And Human Colonic Microbiota. Food Research International Volume 164, February 2023, 112366. DOI: https://doi.org/10.1016/j.foodres.2022.112366.***

## 5. Methodological Approaches For Studying The Human Milk Microbiome

Human milk contains a low-biomass, low-diversity microbiome, consisting largely of bacteria. This community is of great research interest in the context of infant health and maternal and mammary health. In this article researchers have discussed the technical challenges and analyzed the various methodological approaches used for studying the human milk microbiome.

Data was collected from studies in which breadths of methodological approaches were used. Recommendations for robust and reproducible analysis of the human milk microbiome are proposed. Such methods will ensure that high-quality data are produced in this field, ultimately supporting better research outcomes for mothers and infants.

***Source: Lisa F Stinson, School Of Molecular Sciences, The University Of Western Australia, Perth, Australia. Methodological Approaches For Studying The Human Milk Microbiome. Nutrition Reviews, Volume 81, Issue 6, June 2023, Pages 705–715. DOI: https://doi.org/10.1093/nutrit/nuac082.***

## 6. Modulating the Early-Life Gut Microbiota Using Pro-, Pre-, and Synbiotics to Improve Gut Health, Child Development and Growth

In children exposed to poor hygiene and sanitation, invasion of the gut by pathogenic microbes can result in a subclinical enteropathy termed “environmental enteric dysfunction” (EED) that contributes to undernutrition, growth faltering, and impaired organ development. EED may already be present by age 6–12 weeks; therefore, interventions that can be started early in life, and used alongside breastfeeding, are needed to prevent or ameliorate EED.

A healthy gut microbiota is critical for intestinal development and repair, nutrient digestion and absorption, and resisting colonization or overgrowth by pathogens. However, its development can be impaired by several environmental factors. Hence, dietary supplementation with pro-, pre-, or synbiotics is a safe and pragmatic approach to build gut microbiota resilience against adverse environmental factors and prevent future environmental enteric dysfunction.

***Source: Benjamin Momo Kadia, Department Of Clinical Sciences, Liverpool School Of Tropical Medicine, Liverpool, United Kingdom. Modulating the Early-Life Gut Microbiota Using Pro-, Pre-, and Synbiotics to Improve Gut Health, Child Development and Growth. Nutrition Reviews, 11 May 2023;, nuad050. DOI: https://doi.org/10.1093/nutrit/nuad050.***

## 7. Stability And Heterogeneity In The Antimicrobiota Reactivity Of Human Milk-Derived Immunoglobulin A

Immunoglobulin A (IgA) is secreted into breast milk and is critical for both protecting against enteric pathogens and shaping the infant intestinal microbiota. The efficacy of ***breast milk–derived maternal IgA (BrmIgA)*** is dependent upon its specificity; however, heterogeneity in BrmIgA binding ability to the infant microbiota is not known.

This study demonstrates that the antibacterial BrmIgA reactivity displays inter-individual heterogeneity but intra-individual stability. These findings have important implications for how breast milk shapes the development of the preterm infant microbiota and protects against necrotizing enterocolitis.

***Source: Timothy W. Hand, Pediatrics Department, Infectious Disease Section, R.K. Mellon Institute For Pediatric Research, UPMC Children’s Hospital Of Pittsburgh, School Of Medicine And Department Of Immunology, School Of Medicine, University Of Pittsburgh, Pittsburgh, PA, USA. Stability And Heterogeneity In The Antimicrobiota Reactivity Of Human Milk-Derived Immunoglobulin A. J Exp Med (2023) 220 (8): e20220839. DOI: https://doi.org/10.1084/jem.20220839.***

## 8. Prebiotics Improve Osteoporosis Indicators In A Preclinical Model: Systematic Review With Meta-Analysis

This study was conducted to determine the impact of supplementation with prebiotics in the basal diet of ovariectomized rats with induced osteoporosis as a preclinical model.

8 studies met the inclusion criteria. Rats (n = 206), were randomly divided between control and treatment groups. Weighted mean differences (WMDs) with the 95%CIs were used to estimate the combined effect size. Compared with the control group, dietary intake of prebiotics significantly increased bone density in the BMD subgroups, with WMDs as follows: 0.03 g/cm3, 95%CI, 0.01–0.05, P < 0.00001, n = 46; and 0.00 g/cm2, 95%CI, 0.00–0.02, P < 0.00001, n = 81; total BMD: WMD, 0.01, 95%CI, 0.01–0.02, P < 0.00001, n = 127; bone content in BMC: WMD, 0.02 g, 95%CI, 0.00–0.04, P = 0.05, n = 107; and the 3-point-bend test: WMD, 15.20 N, 95%CI, 5.92–24.47, P = 0.00001, n = 120.

This study shows that prebiotics improve the indicators of osteoporosis, bone Mineral Density (BMD), bone Mineral Content (BMC), and bone biomechanics in ovariectomized rats. More studies are required.

***Source: Hermann Bremer-Netodepartment Of Functional Sciences, Health Technology Assessment Nucleus Of The Medical School Of Presidente Prudente, Western Sao Paulo University, Presidente Prudente, São Paulo, Brazil. Prebiotics Improve Osteoporosis Indicators In A Preclinical Model: Systematic Review With Meta-Analysis. Nutrition Reviews, Volume 81, Issue 8, August 2023, Pages 891–903. DOI: https://doi.org/10.1093/nutrit/nuac097.***

## 9. Relationship Between Oat Consumption, Gut Microbiota Modulation, And Short-Chain Fatty Acid Synthesis: An Integrative Review

This integrative review summarizes the findings from studies on the relationship between oat consumption, the gut microbiota, and the metabolites, mainly short-chain fatty acids, it produces.

Current evidence suggests that oats can beneficially alter the composition of the gut microbiota and promote the synthesis of SCFAs. At present, most research has been conducted in animals and in vitro. These efforts suggest plausible mechanisms of action that demonstrates the need for future work in this area. Further, studies are required.

***Sources: Adriane Elisabete Costa Antunes, School Of Applied Sciences (FCA), State University Of Campinas, 1300 Pedro Zaccaria St., Limeira, SP, Brazil. Relationship Between Oat Consumption, Gut Microbiota Modulation, And Short-Chain Fatty Acid Synthesis: An Integrative Review. Nutrients 2023, 15(16), 3534. DOI: https://doi.org/10.3390/nu15163534.***

## 10. A Synbiotic Preparation (SIM01) For Post-Acute COVID-19 Syndrome In Hong Kong (RECOVERY): A Randomised, Double-Blind, Placebo-Controlled Trial

**This article assesses a synbiotic preparation (SIM01) for the alleviation of Post-acute COVID-19 syndrome (PACS) symptoms.**

In this study 463 patients were randomly assigned to receive SIM01 (n=232) or placebo (n=231). Researchers found that at 6 months, significantly higher proportions of the SIM01 group had alleviation of fatigue, memory loss, difficulty in concentration, gastrointestinal upset, and general unwellness compared with the placebo group. Adverse event rates were similar between groups during treatment. Treatment with SIM01, infection with omicron variants, vaccination before COVID-19, and mild acute COVID-19, were predictors of symptom alleviation.

***Source: Siew Chien Ng, Department Of Medicine And Therapeutics, Faculty Of Medicine, The Chinese University Of Hong Kong, Hong Kong Special Administrative Region, China. A Synbiotic Preparation (SIM01) For Post-Acute COVID-19 Syndrome In Hong Kong (RECOVERY): A Randomised, Double-Blind, Placebo-Controlled Trial. The LANCET Infectious Diseases, December 07, 2023. DOI: https://doi.org/10.1016/S1473-3099(23)00685-0.***

## 11. Resistant Starch Decreases Intrahepatic Triglycerides In Patients With NAFLD Via Gut Microbiome Alterations

This study investigated the effects of resistant starch (RS) as a microbiota-directed dietary supplement for Non-alcoholic fatty liver disease (NAFLD) treatment. This was a 4-month randomized placebo-controlled clinical trial in individuals with NAFLD (ChiCTR-IOR-15007519) with metagenomics and metabolomics analysis.

Study result shows that as compared to the control the RS intervention resulted in 9.08 % absolute reduction of intrahepatic triglyceride content (IHTC), which was 5.89% after adjusting for weight loss. Serum branched-chain amino acids (BCAAs) and gut microbial species, in particular ***Bacteroides stercoris***, significantly correlated with IHTC and liver enzymes and were reduced by RS.

Multi-omics integrative analyses revealed the interplay among gut microbiota changes, BCAA availability, and hepatic steatosis, with causality supported by fecal microbiota transplantation and monocolonization in mice. Thus***, RS dietary supplementation might be a strategy for managing NAFLD by altering gut microbiota composition and functionality.***

***Source: Weiping Jia, Shanghai Key Laboratory Of Diabetes Mellitus, Department Of Endocrinology And Metabolism, Shanghai Diabetes Institute, Shanghai Clinical Center For Diabetes, Shanghai Sixth People's Hospital Affiliated To Shanghai Jiao Tong University School Of Medicine, Shanghai, China. Resistant Starch Decreases Intrahepatic Triglycerides In Patients With NAFLD Via Gut Microbiome Alterations. Cell Metabolism, Clinical And Translational Report, Volume 35, Issue 9, P1530-1547.E8, September 05, 2023. DOI: https://doi.org/10.1016/j.cmet.2023.08.002.***

## 12. Prebiotic Diet Changes Neural Correlates Of Food Decision-Making In Overweight Adults: A Randomised Controlled Within-Subject Cross-Over Trial

Animal studies suggest that prebiotic, plant-derived nutrients could improve homoeostatic and hedonic brain functions through improvements in microbiome–gut–brain communication. This study explores the effects of high-dosed prebiotic fibre on reward-related food decision-making in a randomised controlled within-subject cross-over study and assayed potential microbial and metabolic markers.

Researcher found that on comparing with placebo, participant's showed decreased brain activation towards high-caloric wanted food stimuli in the ventral tegmental area and right orbitofrontal cortex after prebiotics ingestion.

While fasting blood levels remained largely unchanged, 16S-rRNA sequencing shows significant shifts in the microbiome towards increased occurrence of, among others, short chain fatty acids (SCFA)-producing ***Bifidobacteriaceae***, and changes in >60 predicted functional signalling pathways after prebiotic intake. Changes in brain activation correlated with changes in ***Actinobacteria*** microbial abundance and associated activity previously linked with SCFA production, such as ABC transporter metabolism.

This proof of concept study shows that a prebiotic intervention attenuated reward-related brain activation during food decision-making, paralleled by shifts in gut microbiota.

***Source: A Veronica Witte1, Department Of Neurology, Max Planck Institute For Human Cognitive And Brain Sciences And Cognitive Neurology, University Of Leipzig Medical Center, Leipzig, Germany. Prebiotic Diet Changes Neural Correlates Of Food Decision-Making In Overweight Adults: A Randomised Controlled Within-Subject Cross-Over Trial. Gut 2024;73:298-310. DOI: 10.1136/gutjnl-2023-330365.***

## 13. The Effects Of Prebiotic Partially Hydrolyzed Guar Gum On Skin Hydration: A Randomized, Open-Label, Parallel, Controlled Study In Healthy Humans

Dose-response of prebiotic partially hydrolyzed guar gum (PHGG) dietary fiber supports the gut microbiome abundance and improves gastrointestinal health, which is imperative for healthy skin.

In this 12 week of open-label randomized, paralleled, and controlled study, researchers investigated the role of PHGG on skin barrier function including the measurements of the stratum corneum hydration levels using the non-invasive electrical methods along with a questionnaire to determine near-surface hydration distribution, micro-topography and texture properties of the skin.

Study result indicates ingestion of 6 and 12 g/day PHGG dietary fiber helps maintain a constant moisture level in the surface skin stratum corneum (i.e. prevents drying skin conditions) during seasonal fluctuations. An amelioration of bowel movement reported in the study may show a link between improved gut environment and increased hydration level of the skin stratum corneum that prevents dryness, roughness, and textural disorder to the skin during winter conditions.

Hence , consumption of prebiotic PHGG dietary fiber could be pivotal to increased formation of bacterially produced metabolites that strengthen the skin integrity and regulate the moisture content of the skin stratum corneum.

***Source: Mahendra P. Kapoor, Taiyo Kagaku Co. Ltd., Nutrition Division, Takaramachi, Yokkaichi, , Japan. The Effects Of Prebiotic Partially Hydrolyzed Guar Gum On Skin Hydration: A Randomized, Open-Label, Parallel, Controlled Study In Healthy Humans. Journal of Functional Foods, Volume 103, April 2023, 105494 . DOI: https://doi.org/10.1016/j.jff.2023.105494.***

## 14. Structure, Health Benefits, Mechanisms, And Gut Microbiota Of Dendrobium Officinale Polysaccharides: A Review

***Dendrobium officinale polysaccharides (DOPs)*** are important active polysaccharides found in Dendrobium officinale, which is commonly used as a conventional food or herbal medicine and is well known in China. DOPs can influence the composition of the gut microbiota and the degradation capacity of these symbiotic bacteria, which in turn may determine the efficacy of dietary interventions.

In this review, researchers summarize the **extraction, structure, health benefits, and related mechanisms** of DOPs, construct the DOPs-host axis, and propose DOPs as potential prebiotics, mainly composed of 1,4-β-D-mannose, 1,4-β-D-glucose, and O-acetate groups, which induce an increase in the abundance of gut microbiota such as ***Lactobacillus, Bifidobacterium, Akkermansia, Bacteroides***, and ***Prevotella***. In addition, scientists found that when exposed to DOPs with different structural properties, the gut microbiota may exhibit different diversity and composition and provide health benefits, such as metabolism regulations, inflammation modulation, immunity moderation, and cancer intervention. This may contribute to facilitating the development of functional foods and health products to improve human health.

***Source: Xiaohui Guo, College Of Food Science And Nutritional Engineering, China Agricultural University, Beijing, China. Structure, Health Benefits, Mechanisms, And Gut Microbiota Of Dendrobium Officinale Polysaccharides: A Review. Nutrients 2023, 15(23), 4901. DOI: https://doi.org/10.3390/nu15234901.***

## 15. Modulating A Prebiotic Food Source Influences Inflammation And Immune-Regulating Gut Microbes And Metabolites: Insights From The BE GONE Trial

Accessible prebiotic foods hold strong potential to jointly target gut health and metabolic health in high-risk patients. **The BE GONE trial targeted the gut microbiota of obese surveillance patients with a history of colorectal neoplasia through a straightforward bean intervention.**

Out of the 55 patients, 87% completed the 16-week trial, demonstrating an increase on-intervention in diversity and shifts in multiple bacteria indicative of prebiotic efficacy, including increased ***Faecalibacterium, Eubacterium*** and ***Bifidobacterium***. The circulating metabolome showed parallel shifts in nutrient and microbiome-derived metabolites, including increased ***pipecolic acid*** and decreased ***indole*** that regressed upon returning to the usual diet. No significant changes were observed in circulating lipoproteins within 8 weeks; however, proteomic biomarkers of intestinal and systemic inflammatory response, fibroblast-growth factor-19 increased, and interleukin-10 receptor-α decreased.

These findings underscore the prebiotic and potential therapeutic role of beans to enhance the gut microbiome and to regulate host markers associated with metabolic obesity and colorectal cancer, while further emphasizing the need for consistent and sustainable dietary adjustments in high-risk patients.

***Source: Carrie R. Daniel, Division Of Cancer Prevention And Population Sciences, Department Of Epidemiology, The University Of Texas MD Anderson Cancer Center, 1515 Holcombe Blvd, Houston, USA. Modulating A Prebiotic Food Source Influences Inflammation And Immune-Regulating Gut Microbes And Metabolites: Insights From The BE GONE Trial. EBioMedicine. 2023 Dec:98:104873. DOI: https://doi.org/10.1016/j.ebiom.2023.104873.***

## 16. Effects Of Prebiotic Yeast Mannan On Gut Health And Sleep Quality In Healthy Adults: A Randomized, Double-Blind, Placebo-Controlled Study

The aim of Randomized, Double-Blind, Placebo-Controlled study was to evaluate the efficacy of yeast mannan (YM) in improving bowel habits and sleep quality, along with metabolomics in fecal samples. A total of 40 healthy adults (age range, 22–64 years) with discomfort in defecation were enrolled and randomly allocated to receive either YM (n = 20; 1.1 g/day) or placebo (n = 20) for four weeks.

Study result showed that the ***YM group significantly increased defecation frequency and stool volumes compared to the placebo group***. After 4 weeks of treatment, ***the non-REM sleep stage 3 ($N_3$) duration in the YM group was significantly higher than that in the placebo group***. YM ingestion significantly lengthened total time in bed (TIB) and significantly shortened $N_3$ latency compared to placebo intake during the trial. ***The metabolomics analysis found a total of 20 metabolite differences between the YM and placebo groups.*** As a result of stepwise linear regression, changes in ***fecal propionate and gamma-aminobutyric acid (GABA)*** levels were identified as the primary factors explaining changes in TIB and $N_3$ latency, respectively. ***The findings suggest that the prebiotic YM could be beneficial to gut health and sleep quality.***

***Source: Tatsuhiko Hirota ,Core Technology Laboratories, Asahi Quality And Innovations, Ltd., Japan. Nutrients 2024, 16(1), 141. Effects Of Prebiotic Yeast Mannan On Gut Health And Sleep Quality In Healthy Adults: A Randomized, Double-Blind, Placebo-Controlled Study. DOI: https://doi.org/10.3390/nu16010141.***

## 17. Identification Of Inulin-Responsive Bacteria In The Gut Microbiota Via Multi-Modal Activity-Based Sorting

Prebiotics are defined as non-digestible dietary components that promote the growth of beneficial gut microorganisms. In this study researchers developed a methodology for determining prebiotic-responsive bacteria using the popular dietary supplement inulin.

Scientists first identified microbes with a capacity to bind inulin using mesoporous silica nanoparticles functionalized with inulin. 16S rRNA gene amplicon sequencing of sorted cells revealed that the ability to bind inulin was widespread in the microbiota. They also evaluates which taxa are metabolically stimulated by inulin and found that diverse taxa from the phyla ***Firmicutes and Actinobacteria*** respond to inulin, and several isolates of these taxa can degrade inulin.

Further, Incubation with another prebiotic, ***xylooligosaccharides (XOS),*** in contrast, showed a more robust bifidogenic effect. Interestingly, the ***Coriobacteriia Eggerthella lenta and Gordonibacter urolithinfaciens*** are indirectly stimulated by the inulin degradation process, expanding the knowledge of inulin-responsive bacteria.

***Source: David Berry, Centre For Microbiology And Environmental Systems Science (Cemess) , University Of Vienna. Identification Of Inulin-Responsive Bacteria In The Gut Microbiota Via Multi-Modal Activity-Based Sorting. Nat Commun 14, 8210 (2023). DOI: https://doi.org/10.1038/s41467-023-43448-z.***

**Note: Only lead author's names and their affiliations are given. Please see the articles for full details.**
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