

# Recent Studies and Publications on Probiotics and Health Benefits

## STUDIES

### 1. Probiotics For Dementia: A Systematic Review And Meta-Analysis Of Randomized Controlled Trials

A systematic review and meta-analysis was conducted to determine the effectiveness of probiotic and synbiotic supplementation on the cognitive function of individuals with dementia. Researchers included data from randomized clinical trials (RCTs) that addressed dementias and assessed the following outcomes: cognitive function; inflammatory, oxidative stress, and metabolic markers; nutritional status; and intestinal microbiota composition.

Data from 3 RCTs involving 161 individuals with Alzheimer's disease receiving *Lactobacillus* and *Bifidobacterium* strains showed no beneficial effect of probiotic supplementation on cognitive function (standardized mean difference, 0.56; 95%CI: -0.06 to 1.18), with very low certainty of evidence. However, probiotic supplementation improved plasma triglycerides, very-low-density lipoprotein cholesterol, insulin resistance, and plasma malondialdehyde. No RCTs included synbiotic supplementation or assessed microbiota composition.

The study concluded that current evidence regarding the use of probiotics and synbiotics for individuals with dementia is insufficient to support their clinical application.

Source: Krüger JF, Hillesheim E, Pereira ACSN, Camargo CQ, Rabitoiei. Probiotics For Dementia: A Systematic Review And Meta-Analysis Of Randomized Controlled Trials. *Nutrition Reviews*, Volume 79, Issue 2, February (2021), Pages 160–170. <https://doi.org/10.1093/nutrit/nuaa037>

### 2. Fewer Community-Acquired Colds With Daily Consumption Of *Lactiplantibacillus Plantarum* HEAL9 And *Lacticaseibacillus Paracasei* 8700:2. A Randomized, Placebo-Controlled Clinical Trial

This study concluded that Intake of *Lactiplantibacillus plantarum* HEAL9 and *Lacticaseibacillus paracasei* 8700:2 can be protective against multiple colds in adults prone to getting colds.

Source: Irimi Lazou Ahren, Probi AB, Lund, Sweden. Fewer Community-Acquired Colds With Daily Consumption Of *Lactiplantibacillus Plantarum* HEAL9 And *Lacticaseibacillus Paracasei* 8700:2. A Randomized, Placebo-Controlled Clinical Trial. *The Journal of Nutrition*, Volume 151, Issue 1, January (2021), Pages 214–222. <https://doi.org/10.1093/jn/nxaa353>

### 3. The International Scientific Association For Probiotics And Prebiotics (ISAPP) Consensus Statement On Fermented Foods

Although fermented foods have been consumed for thousands of years, they are receiving increased attention among biologists, nutritionists, technologists, clinicians and consumers. Despite this interest, inconsistencies related to the use of the term 'fermented' led the panel to define fermented foods and beverages as "foods made through desired microbial growth and enzymatic conversions of food components". This definition, encompassing the many varieties of fermented foods, is intended to clarify what is (and is not) a fermented food. The distinction between fermented foods and probiotics is further clarified.

The panel also addressed the current state of knowledge on the safety, risks and health benefits, including an assessment of the nutritional attributes and a mechanistic rationale for how fermented foods could improve gastrointestinal and general health. The latest advancements in the understanding of the microbial ecology and systems biology of these foods were discussed. Finally, the panel reviewed how fermented foods are regulated and discussed efforts to include them as a separate category in national dietary guidelines.

Source: Robert Hutkins, Department Of Food Science And Technology, University Of Nebraska - Lincoln, USA. The International Scientific Association For Probiotics And Prebiotics (ISAPP) Consensus Statement On Fermented Foods. *Nat Rev Gastroenterol Hepatol* 18, 196–208 (2021). <https://doi.org/10.1038/s41575-020-00390-5>

### 4. Effects Of *Lactobacillus Reuteri* Supplementation On The Gut Microbiota In Extremely Preterm Infants In A Randomized Placebo-Controlled Trial

Extremely low birth weight (ELBW) infants often develop an altered gut microbiota composition, which is related to clinical complications, such as necrotizing enterocolitis and sepsis. In a randomized, double-blind, placebo-controlled trial, Researchers have assessed the effect of *Lactobacillus reuteri* supplementation, from birth to post-menstrual week (PMW)36, on infant gut microbiota.

Probiotic supplementation results in increased bacterial diversity and increased *L. reuteri* abundance during the 1st month. At 1 week, probiotic supplementation also results in a lower abundance of Enterobacteriaceae and Staphylococcaceae. No effects were found at 2 years.

This study concluded that probiotics may exert benefits by modulating the gut microbiota composition during the 1st month in ELBW infants.

Source: Magali Martí, Department Of Biomedical And Clinical Sciences, Linköping University, Linköping, Sweden. Effects Of *Lactobacillus Reuteri* Supplementation On The Gut Microbiota In Extremely Preterm Infants In A Randomized Placebo-Controlled Trial. *Cell Reports Medicine*, Volume 2, Issue 3, 100206, March 16, (2021). <https://doi.org/10.1016/J.Xcrm.2021.100206>

## 5. Growth, Survival, And Metabolic Activities Of Probiotics *Lactobacillus Rhamnosus GG* And *Saccharomyces Cerevisiae* Var. *Boulardii CNCM-I745* In Fermented Coffee Brews

The main objective of the study was to enhance the viability of the probiotic bacteria, *Lactobacillus rhamnosus GG*, in coffee brews by co-culturing with the probiotic yeast, *Saccharomyces cerevisiae* var. *boulardii CNCM-I745*.

Study result shows that the yeast significantly enhanced the viability of *L. rhamnosus GG*, as bacterial populations beyond 7 Log CFU/mL were maintained throughout 14 weeks of storage at 4 and 25°C. In contrast, the single culture of *L. rhamnosus GG* suffered viability losses below 6 Log CFU/mL within 10 weeks at 4°C, and 3 weeks at 25°C. Growth and survival of *S. boulardii CNCM-I745* remained unaffected by the presence of *L. rhamnosus GG*. Volatile profiles of coffee brews were altered by probiotic metabolic activities, but co-culturing led to suppressed generation of *diacetyl* and *ethanol* compared to single cultures. Probiotic fermentation did not alter principal coffee bioactive compounds and antioxidant capacities; however, declines in peroxy radical scavenging capacities were observed after ambient storage.

Overall this study shows that yeasts are effective in enhancing probiotic bacterial viability in coffee brews, which may be useful in developing shelf stable probiotic food products.

Source: Shao-Quan Liu, Department Of Food Science & Technology, National University Of Singapore, Science Drive 2, Singapore And National University Of Singapore (Suzhou) Research Institute, No. 377 Linquan Street, Suzhou Industrial Park, Jiangsu, China. Growth, Survival, And Metabolic Activities Of Probiotics *Lactobacillus Rhamnosus GG* And *Saccharomyces Cerevisiae* Var. *Boulardii CNCM-I745* In Fermented Coffee Brews. International Journal Of Food Microbiology, Volume 350, 16 July (2021), 109229. <https://doi.org/10.1016/j.ijfoodmicro.2021.109229>

## 6. Untargeted LC-QTOF-MS/MS Based Metabolomics Approach For Revealing Bioactive Components In Probiotic Fermented Coffee Brews

The aim of this study was to discover postbiotics in coffee brews fermented with *L. rhamnosus GG* and/or *S. boulardii CNCM-I745*.

By using an untargeted LC-QTOF-MS/MS based metabolomics approach coupled with validated multivariate analyses, 37 differential metabolites between fermentation treatments were putatively annotated. These include the production of *postbiotics* such as *2-isopropylmalate* by *S. boulardii CNCM-I745*, and *aromatic amino acid catabolites* (*indole-3-lactate*, *p-hydroxyphenyllactate*, *3-phenyllactate*), and *hydroxydodecanoic acid* by *L. rhamnosus GG*.

Overall, LC-QTOF based untargeted metabolomics can be an effective approach to uncover postbiotics, which may substantiate additional potential functionalities of probiotic fermented foods compared to their non-fermented counterparts.

Source: Shao-Quan Liu, Department Of Food Science & Technology, National University Of Singapore, Science Drive 2, Singapore. Untargeted LC-QTOF-MS/MS Based Metabolomics Approach For Revealing Bioactive Components In Probiotic Fermented Coffee Brews. Food Research International, Volume 149, November (2021), 110656. <https://doi.org/10.1016/j.foodres.2021.110656>

## 7. Potential Beneficial Role Of Probiotics On The Outcome Of COVID-19 Patients: An Evolving Perspective

This review focuses on the current knowledge about the use of probiotics as adjuvant therapy for COVID-19 patients.

Researchers have found that most of the study data show good results demonstrating that probiotics can play a significant role in fighting SARS-CoV-2 infection, also compared with their use in the past for various diseases. Further, they seem effective in lowering inflammatory status, moreover in patients with chronic comorbidities such as cancer and diabetes, improving clinical outcomes.

Source: Ioannis Alexandros Charitos, Department Of Emergency And Urgency, National Poisoning Center, Riuniti University Hospital Of Foggia, Viale Luigi Pinto 1, Foggia, Italy. Potential Beneficial Role Of Probiotics On The Outcome Of COVID-19 Patients: An Evolving Perspective. Diabetes & Metabolic Syndrome: Clinical Research & Reviews, Volume 15, Issue 1, January–February (2021), Pages 295-301. <https://doi.org/10.1016/j.dsx.2020.12.040>

## 8. Probiotics May Be Beneficial In COVID-19 Treatment

This study present an overview of the experimental studies published in the last 10 years that provide a scientific basis for unexplored probiotics as a preventive approach to respiratory viral infections. Based on collated insights from these experimental data, researchers have identified promising microbial strains that may serve as lead prophylactic and immune-boosting probiotics in COVID-19 management.

Source: Alka Rao, CSIR-Institute Of Microbial Technology, Sector 39A, Chandigarh, India And Academy Of Scientific And Innovation Research (Acsir), Ghaziabad, Uttar Pradesh, India. Probiotics May Be Beneficial In COVID-19 Treatment. Nutrition Research, Volume 87, March (2021), Pages 1-12. <https://doi.org/10.1016/j.nutres.2020.12.014>

## **9. Effect Of Multi-Strain Probiotic Formulation On Students Facing Examination Stress: A Double-Blind, Placebo-Controlled Study**

In this placebo-controlled, double-blind clinical trial, researchers investigated the effect of multi-strain probiotic (Bacillus coagulans Unique IS2, Lactobacillus rhamnosus UBLR58, Bifidobacterium lactis UBBLa70, Lactobacillus plantarum UBLP40 (each of 2 billion CFU); Bifidobacterium breve UBBR01, Bifidobacterium infantis UBBI01 (each of 1 billion CFU)) capsule with glutamine (250 mg) on students facing examination stress.

The stress was analysed at the baseline and the at end of the treatment by using the perceived stress scale (PSS), depression anxiety stress scale (DASS), and state-trait anxiety inventory (STAI) questionnaire. The serum cortisol levels were also determined. The study showed that those students who consumed probiotic capsules showed a significant reduction in PSS, DASS, and STAI scores, and serum cortisol levels from the baseline as compared with placebo. No adverse events were reported during the study. The study concluded that the multi-strain probiotic is effective in reducing stress associated with examination.

**Source:** Jayesh J. Ahire, Centre For Research And Development, Unique Biotech Ltd., Plot No. 2, Phase II, Alexandria Knowledge Park, Hyderabad, Telangana, 500078, India. Effect Of Multi-Strain Probiotic Formulation On Students Facing Examination Stress: A Double-Blind, Placebo-Controlled Study. *Probiotics & Antimicro. Prot.* 13, 12–18 (2021). <https://doi.org/10.1007/s12602-020-09681-4>

## **10. Probiotic Stool Secretory Immunoglobulin A Modulation In Children With Gastroenteritis: A Randomized Clinical Trial**

The researchers associated with this study had previously conducted the Probiotic Regimen for Outpatient Gastroenteritis Utility of Treatment (PROGUT) study, which identified no improvements in children with acute gastroenteritis (AGE) administered a probiotic. However, the aforementioned study did not evaluate immunomodulatory benefits.

The objective of this study was to determine if stool secretory immunoglobulin A (sIgA) concentrations in children with acute gastroenteritis (AGE) increase more among participants administered a Lactobacillus rhamnosus/helveticus probiotic compared with those administered placebo. This study found no effect of an L. rhamnosus/helveticus probiotic, relative to placebo, on stool secretory immunoglobulin A (IgA) concentrations.

**Source:** Stephen B Freedman, Sections Of Pediatric Emergency Medicine And Gastroenterology, Department Of Pediatrics, Alberta Children's Hospital, Alberta Children's Hospital Research Institute, Cumming School Of Medicine And Department Of Emergency Medicine, Cumming School Of Medicine, University Of Calgary, Calgary, Canada. Probiotic Stool Secretory Immunoglobulin A Modulation In Children With Gastroenteritis: A Randomized Clinical Trial. *The American Journal Of Clinical Nutrition*, Volume 113, Issue 4, April (2021), Pages 905–914. <https://doi.org/10.1093/ajcn/nqaa369>

## **11. In Situ Biomanufacturing Of Small Molecules In The Mammalian Gut By Probiotic Saccharomyces Boulardii**

Saccharomyces boulardii is a probiotic yeast that exhibits rapid growth at 37 °C, is easy to transform, and can produce therapeutic proteins in the gut. Researchers have found that S. boulardii colonizes germ-free mice stably for over 30 days and competes for niche space with commensal microbes, exhibiting short (1–2 day) gut residence times in conventional and antibiotic-treated mice. Using these tools, scientists enabled  $\beta$ -carotene synthesis (194  $\mu$ g total) in the germ-free mouse gut over 14 days, estimating that the total mass of additional  $\beta$ -carotene recovered in feces was 56-fold higher than the  $\beta$ -carotene present in the initial probiotic dose. This work quantifies heterologous small molecule production titers by S. boulardii living in the mammalian gut and provides a set of tools for modulating these titers.

**Source:** Nathan Crook, Department Of Chemical And Biomolecular Engineering, North Carolina State University, Raleigh, North Carolina 27695, United States. In Situ Biomanufacturing Of Small Molecules In The Mammalian Gut By Probiotic Saccharomyces Boulardii. *CS Synth. Biol.* 2021, 10, 5, 1039–1052, April 12 (2021). <https://doi.org/10.1021/acssynbio.0c00562>

## **12. The Effect Of Lactiplantibacillus Plantarum 299v Together With A Low Dose Of Iron On Iron Status In Healthy Pregnant Women: A Randomized Clinical Trial**

The aim of this randomized, double-blind, placebo-controlled study was to evaluate the effect of Lactiplantibacillus plantarum 299v (Lp299v, 1010 colony forming units), 4.2 mg iron, 12 mg ascorbic acid and 30  $\mu$ g folic acid (Lp) on iron status in healthy, non-anemic, pregnant Swedish women.

Study result shows that intake of Lp attenuated the decrease in serum ferritin from baseline to week 28 and week 35. It also reduced prevalence of iron deficiency and iron deficiency anemia at week 35. Intake of Lp also resulted in beneficial effects on the soluble transferrin receptor and total body iron at week 35.

This study concluded that intake of Lp from early pregnancy was safe, attenuated the loss of iron stores and improved iron status in healthy pregnant women.

**Source:** Ulrika Axling, Probi AB, Ideongatan 1A, 223 70 Lund, Sweden. The Effect Of Lactiplantibacillus Plantarum 299v Together With A Low Dose Of Iron On Iron Status In Healthy Pregnant Women: A Randomized Clinical Trial. *Acta Obstetrica et Gynecologica Scandinavica*, 2021;100:1602–1610 21 April (2021). <https://doi.org/10.1111/aogs.14153>

### **13. Lactobacillus acidophilus Induces a Strain-specific and Toll-Like Receptor 2-Dependent Enhancement of Intestinal Epithelial Tight Junction Barrier and Protection Against Intestinal Inflammation**

Defective intestinal tight junction (TJ) barrier is an important pathogenic factor of inflammatory bowel disease. The purpose of this study was to identify probiotic bacterial species or strains that induce a rapid and sustained enhancement of intestinal TJ barrier and protect against the development of intestinal inflammation by targeting the TJ barrier.

Study result shows that after high-throughput screening of >20 Lactobacillus and other probiotic bacterial species or strains, a specific strain of Lactobacillus acidophilus, referred to as LA1, uniquely produced a marked enhancement of the intestinal TJ barrier. LA1 attached to the apical membrane surface of intestinal epithelial cells in a Toll-like receptor (TLR)-2-dependent manner and caused a rapid increase in enterocyte TLR-2 membrane expression and TLR-2/TLR-1 and TLR-2/TLR-6 hetero-complex-dependent enhancement in intestinal TJ barrier function. Further, oral administration of LA1 caused a rapid enhancement in mouse intestinal TJ barrier, protected against a dextran sodium sulfate (DSS) increase in intestinal permeability, and prevented the DSS-induced colitis in a TLR-2- and intestinal TJ barrier-dependent manner.

Researchers have concluded that a specific strain of LA causes a strain-specific enhancement of intestinal TJ barrier through a novel mechanism that involves the TLR-2 receptor complex and protects against the DSS-induced colitis by targeting the intestinal TJ barrier.

**Source:** Thomas Y. Ma, M.D., Ph.D., Or Rana Al-Sadi, Ph.D., Department Of Medicine, Penn State College Of Medicine, Penn State University, 500 University Dr., Hershey, PA, 17033. Regular Article Gastrointestinal, Hepatobiliary, And Pancreatic Pathology, Volume 191, Issue 5, P872-884, May 01 (2021). <https://doi.org/10.1016/j.ajpath.2021.02.003>

### **14. Shaping The Future Of Probiotics And Prebiotics**

In this review researchers have examined the recent, emerging, and anticipated trends in probiotic and prebiotic science, and create a vision for broad areas of developing influence in the field.

The wealth of research into *microbiome-targeted nutrition and therapeutics* has expanded the fields of probiotics and prebiotics as well as many related interventions. According to an article authored by an international team of scientists, both within and outside of the current definitions, new probiotics and prebiotics will emerge, challenging scientific as well as regulatory definitions.

Overlapping with, and adjacent to, the probiotic and prebiotic fields, new variants of microbiome-modulating interventions are developing, including synbiotics, postbiotics, microbial consortia, live biotherapeutic products, and genetically modified organisms, with renewed interest in polyphenols, fibres, and fermented foods.

Many substances will be derived from novel sources that meet economic and environmental needs to target a growing range of compositional and functional niches within the microbiome. Industry trends and consumer preferences will continue to drive demand for integration of probiotic, prebiotic, and other bioactive substances into a plethora of formats, supported by advancements in delivery technologies and quality assurance.

While the gut will likely remain as the heartland of these therapies, clinically proven applications will continue to expand in the respiratory system, immune system, urogenital tract, skin, nervous system, oral cavity, cardiometabolic system, and weight-management field. Emerging healthcare challenges will drive research into new areas of global health importance, and a growing body of evidence for key applications will guide increased implementation in healthcare policy and practice.

**Source:** Maria Cunningham, Department Of Science And Innovation, Metagenics, Virginia BC, Australia. Shaping The Future Of Probiotics And Prebiotics. Trends In Microbiology, Volume 29, Issue 8, August (2021), Pages 667-685. <https://doi.org/10.1016/j.tim.2021.01.003>

### **15. Generation Of Lactose- And Protease-Positive Probiotic Lactocaseibacillus Rhamnosus GG By Conjugation With Lactococcus Lactis NCDO 712**

Probiotic strain Lactocaseibacillus rhamnosus GG (LGG) is widely sold on the market as a probiotic or added as a supplement in dairy foods because of its benefits in human health. However, due to the deficiency of lactose and casein utilization, LGG does not grow well in milk. On the other hand, lactose intolerance and cow's milk protein allergy are the two major problems related to milk consumption.

The purpose of this study was to equip LGG with lactose/casein-hydrolyzing ability by bacterial conjugation. As a result, Researchers have generated a non-GMO LGG derivative with improved properties and better growth in milk.

**Source:** Per E. J. Saris, Department of Microbiology, University of Helsinki, Helsinki, Finland. Generation Of Lactose- And Protease-Positive Probiotic Lactocaseibacillus Rhamnosus GG By Conjugation With Lactococcus Lactis NCDO 712. Appl Environ Microbiol, (2021) Mar; 87(6): e02957-20. <https://doi.org/10.1128/AEM.02957-20>

## **16. Self-Tunable Engineered Yeast Probiotics For The Treatment Of Inflammatory Bowel Disease**

Inflammatory bowel disease (IBD) is a complex chronic inflammatory disorder of the gastrointestinal tract. Extracellular adenosine triphosphate (eATP) produced by the commensal microbiota and host cells activates purinergic signaling, promoting intestinal inflammation and pathology. Based on the role of eATP in intestinal inflammation, researchers have developed yeast-based engineered probiotics that express a human P2Y2 purinergic receptor with up to a 1,000-fold increase in eATP sensitivity.

Scientists have linked the activation of this engineered P2Y2 receptor to the secretion of the ATP-degrading enzyme apyrase, thus creating engineered yeast probiotics capable of sensing a pro-inflammatory molecule and generating a proportional self-regulated response aimed at its neutralization. These self-tunable yeast probiotics suppressed intestinal inflammation in mouse models of IBD, reducing intestinal fibrosis and dysbiosis with an efficacy similar to or higher than that of standard-of-care therapies usually associated with notable adverse events.

**Source:** Francisco J. Quintana, Ann Romney Center For Neurologic Diseases, Brigham And Women's Hospital, Harvard Medical School, Boston And Broad Institute Of MIT And Harvard, Cambridge, MA, USA. Self-Tunable Engineered Yeast Probiotics For The Treatment Of Inflammatory Bowel Disease. *Nat Med* 27, 1212-1222 (2021). <https://doi.org/10.1038/s41591-021-01390-x>

## **17. Role Of Probiotics, Prebiotics, And Synbiotics In The Elderly: Insights Into Their Applications**

Elderly people are an important part of the global population who suffer from the natural processes of senescence, which lead to changes in the gut microbiota composition.

The present review suggests that modifying the gut microbiota of the elderly population by the intake of functional food/supplements as probiotics, prebiotics, or synbiotics may be an effective and non-invasive strategy to counteract the natural consequences of aging which is due to the extended use of antibiotics and providing a better quality of life. Further, researchers have found that these functional products are suitable, affordable, and economical to most elderly people.

**Source:** Ana G. Binetti, Instituto De Lactología Industrial (CONICET-UNL), Facultad De Ingeniería Química (UNL), Santa Fe, Argentina. Role Of Probiotics, Prebiotics, And Synbiotics In The Elderly: Insights Into Their Applications. *Front. Microbiol.*, 28 January (2021). <https://doi.org/10.3389/fmicb.2021.631254>

## **18. Are Probiotics And Prebiotics Safe For Use During Pregnancy And Lactation? A Systematic Review And Meta-Analysis**

The objectives of this study were to evaluate the evidence on adverse effects of maternal probiotic, prebiotic, and/or synbiotic supplementation during pregnancy and lactation and interpret the findings to help inform clinical decision-making and care of this population.

The systematic review suggests that supplementation with probiotic and prebiotic products is relatively safe for use during and after pregnancy and during lactation and is not associated with any serious health outcomes in the mother or infant.

**Source:** Kristin L. Connor, Department Of Health Sciences, Carleton University, Ottawa, Canada. Are Probiotics And Prebiotics Safe For Use During Pregnancy And Lactation? A Systematic Review And Meta-Analysis. *Nutrients* (2021), 13(7), 2382. <https://doi.org/10.3390/nu13072382>

## **19. Probiotics As A Complementary Therapy For Management Of Obesity: A Systematic Review**

This study reviews the meta-analyses of the controlled trials and investigated the effects of probiotics on obesity. Researchers found that within 325 recorded studies, 20 studies met the inclusion criteria consisting of 16676 overweight/obese adults with different underlying disorders such as nonalcoholic fatty liver disease (NAFLD), or polycystic ovary syndrome (PCOS). Results of meta-analyses have shown a moderate effect of probiotics on body weight in overweight/obese adults: from -0.526 kg/m<sup>2</sup> to -0.25 kg/m<sup>2</sup>. Body mass index (BMI) was changed from -1.46 kg/m<sup>2</sup> to -1.08 kg/m<sup>2</sup> in NAFLD. Probiotics could reduce BMI from -0.36 kg/m<sup>2</sup> to -0.29 kg/m<sup>2</sup> in patients with polycystic ovary syndrome (PCOS). Hence, probiotic products have beneficial effects as an adjunct therapy for care and management of obesity when used in high dose.

**Source:** Hanieh-Sadat Ejtahed, Obesity And Eating Habits Research Center And Endocrinology And Metabolism Clinical Sciences Institute, Tehran University Of Medical Sciences Tehran, Iran. Probiotics As A Complementary Therapy For Management Of Obesity: A Systematic Review. Integrating Complementary and Alternative Medicines into Conventional Therapies for Metabolic Disorders Evid Based Complement Alternat Med, Volume (2021), Article ID 6688450. <https://doi.org/10.1155/2021/6688450>

## 20. A Probiotic Has Differential Effects On Allergic Airway Inflammation In A/J And C57BL/6 Mice And Is Correlated With The Gut Microbiome

This study investigated the probiotic effects on allergic inflammation in A/J and C57BL/6 mice.

Researchers have found that the use of the same probiotic induced different changes in gut microbiota of different mice, which correlated with the host gut microbiota, but these changes may not always have positive implications for health, and adverse effects may occur. Further, the microbiota composition was very relevant to the allergic airway inflammation phenotype. Therefore, the indiscriminate use of probiotics should be reconsidered because the effects of these products are dependent on host-related parameters, such as the resident gut microbiota.

**Source:** Caroline M. Ferreira, Department Of Pharmaceutics Sciences, Institute Of Environmental, Chemistry And Pharmaceutical Sciences, Universidade Federal De São Paulo, R. São Nicolau, 210, Diadema, Brazil. A Probiotic Has Differential Effects On Allergic Airway Inflammation In A/J And C57BL/6 Mice And Is Correlated With The Gut Microbiome. *Microbiome* 9, 134 (2021). <https://doi.org/10.1186/s40168-021-01081-2>

## 21. Oral Administration Of Latilactobacillus Sakei ADM14 Improves Lipid Metabolism And Fecal Microbiota Profile Associated With Metabolic Dysfunction In A High-Fat Diet Mouse Model

Effects of *Latilactobacillus sakei* ADM14 on changes in lipid metabolism and fecal microbiota composition were studied in high-fat diet (HFD) mouse model. The mice were divided into three groups: *normal diet (ND)*, *high-fat diet (HD)*, and *HFD plus L. sakei ADM14 (HDA)*.

Researchers have found that oral administration of *L. sakei* ADM14 daily for 10 weeks decreased body weight gain, fat tissue mass, and liver weight in mice and reduced the size of histologically stained liver adipocytes. In addition, serum total cholesterol, triglycerides, and blood glucose decreased significantly. *Latilactobacillus sakei* ADM14 regulated the expression of genes related to lipid metabolism in *epididymal adipose tissue* and liver and induced changes in the composition of fecal microbiota, thereby improving energy harvests and changing metabolic disorder-related taxa. A significant decrease ( $p < 0.05$ ) in the *Firmicutes* to *Bacteroidetes* ratio was found in the HDA group compared to the HD group, particularly due to the difference in the relative abundance of the *Bacteroidetes* between the two groups over 10 weeks. Differences in proportions of some taxa reported to have correlation with obesity were also found between HD and HDA groups.

Study results suggest that *L. sakei* ADM14 have a positive effect on metabolic disorders such as obesity and fatty liver through effective regulation of host lipid metabolism and gut microbiota.

**Source:** Jung-Hoon Yoon, Department Of Food Science And Biotechnology, Sungkyunkwan University, Suwon, South Korea. Oral Administration Of *Latilactobacillus Sakei* Adm14 Improves Lipid Metabolism And Fecal Microbiota Profile Associated With Metabolic Dysfunction In A High-Fat Diet Mouse Model. *Front. Microbiol.*, 06 October (2021). <https://doi.org/10.3389/fmicb.2021.746601>

## 22. Effect Of The Intake Of Probiotics Isolated From Human Milk In People With Gastritis And Irritable Bowel Syndrome

The objective of this study was to evaluate the effect of the intake of lactic bacteria isolated from human milk, in patients with gastritis problems and irritable colon syndrome.

Scientists have identified strain of *Salmonella spp.* in stool of the gastritis and irritable bowel syndrome groups. A diversity of bacteria was isolated in the stool, especially species of *Bacillus subtilis* and *Enterococcus faecium*. The intake of human milk probiotics favoured the health of sick patients by 85%. Further, there was decrease in inflammation of the intestines and an improvement in the general health of the patients was observed.

This study showed that *L. fermentum* LH01, *L. reuteri* LH03, and *L. plantarum* LH05 have significant probiotic potential to improve the problems, such as, the gastritis and irritable bowel syndrome.

**Source:** Blanca R. Aguilar Uscanga, Department Of Pharmacology, Industrial Microbiology Laboratory, Mexico. Effect Of The Intake Of Probiotics Isolated From Human Milk In People With Gastritis And Irritable Bowel Syndrome. *J Prob Health.* 9:228 (2021). Doi: 10.35248/2329-8901.21.9.228

## 23. Aflatoxin Reduction Mechanism Of Probiotics

The objective of this review was to see the effectiveness of the biological detoxification methods of aflatoxin, and reduction mechanisms.

This review concluded that Probiotic bacteria have many beneficial health effects, and one of them is their ability to bind aflatoxin. Evidence from in vitro, animal studies has supported the potential ability of probiotic bacteria as adsorbent of aflatoxin. The ability of aflatoxin reduction potentials of probiotics bacteria is different depending on the type of the bacteria, the concentrations of the bacteria, and the PH conditions. Further, researchers have recommended that it is important to study the chemical interactions between the cell wall of probiotic bacteria, and its related components with aflatoxin molecules that could be satisfied to provide further justification of probiotics as adsorbent of aflatoxin. The best way to prevent the aflatoxin prevalence in agricultural products is to make suitable conditions of harvesting and storage but if that could be impossible, then it would be better to eat fermented foods (yogurt or dairy drinks) or taking probiotics since they are available as capsules, tablets, packets, or powders to reduce the toxicity of the toxin.

**Source:** Masresha Minuye, Department Of Food Science And Nutrition, Ethiopian Institute Of Agricultural Science, Ethiopia. Aflatoxin Reduction Mechanism Of Probiotics. *J Prob Health.* 9:235 (2021). DOI: 10.35248/2329-8901.21.9.235

## 24. Relationship Between Probiotics And Overall Mental Health

Scientists have found that probiotics may actually aid in improving mood. They have also found that Probiotics is a good mechanism to fight anxiety or depression, or simply make one feel better.

Study result shows that those who consumed the probiotic supplements began to see improvements in their moods; they reported less reactivity to sad moods than those who took the placebos. These results provide the first evidence that the intake of probiotics may help reduce negative thoughts associated with sad mood. Further, more research is required in this area.

Source: Torres Economou, Felician University, 262 S Main Street Lodi, USA. Relationship Between Probiotics And Overall Mental Health. *J Prob Health*. 9:e13. 0 (2021). DOI: 10.35248/2329-8901.21.9.236

## 25. Probiotic And Antioxidant Properties Of Lactic Acid Bacteria Isolated From Indigenous Fermented Tea Leaves (Miang) Of North Thailand And Promising Application In Synbiotic Formulation

The results obtained from this study indicate that Miang, traditional fermented tea leaves, can serve as a beneficial source of potential probiotic candidates. Five selected LAB strains originally isolated from Miang samples clearly demonstrated survival under simulated gastrointestinal conditions, which indicates their beneficial capabilities and could be applied as probiotics. These selected LAB strains also showed specificity for being utilized in combinations of commercial prebiotics and tolerance against spray-drying process. Among the five strains, *L. pentosus A14-6* in particular had the most promising probiotic potential, with cellular antioxidative characteristics that support its feasibility for application in various food products or as targeted towards the development of synbiotic nutraceuticals. However, the safety and functional properties of these strains should be further evaluated.

Source: Chartchai Khanongnuch, Division Of Biotechnology, School Of Agro-Industry, Faculty Of Agro-Industry; Research Center For Multidisciplinary Approaches To Miang And Science And Technology Research Institute, Chiang Mai University, Chiang Mai, Thailand. Probiotic And Antioxidant Properties Of Lactic Acid Bacteria Isolated From Indigenous Fermented Tea Leaves (Miang) Of North Thailand And Promising Application In Synbiotic Formulation. *Journal Fermentation*, (2021), 7(3), 195. <https://doi.org/10.3390/fermentation7030195>

## 26. Nutritionally Enhanced Probioticated Whole Pineapple Juice

*This study concluded that a nutritionally enriched probioticated fermented beverage could be made using whole pineapple juice and the probiotic L. plantarum WU-P19.* The probioticated product and its mildly alcoholic variant were superior to whole pineapple juice in terms of all the sensory parameters. The fermented beverage proved to be an excellent purely vegetarian source of vitamin B12, an essential nutrient that is deficient in dairy-free vegan diets. The beverage contained nutritionally useful amounts of other vitamins, including vitamins C, B1, B2, B3 and B6. The probioticated beverages were stable at (4 °C) during refrigerated storage for the duration of their 21-day shelf-life. Within this shelf-life, the beverages could provide more than 1011 live cells of the probiotic for each 100 mL of the product consumed.

Source: Wilawan Palachum, Department Of Medical Technology, School Of Allied Health Sciences, Walailak University; Research Excellence Center For Innovation And Health Products, Walailak University And Center Of Excellence Research For Melioidosis, Walailak University, Tasala, Nakhon Si Thammarat 80161, Thailand. Nutritionally Enhanced Probioticated Whole Pineapple Juice. *Journal Fermentation*, (2021), 7(3), 178. <https://doi.org/10.3390/Fermentation7030178>

## 27. Hepatoprotective Effect Of Probiotic Lactic Acid Bacteria On Thioacetamide-Induced Liver Fibrosis In Rats

The aim of the present study was to investigate the hepatoprotective effects of probiotic lactic acid bacteria (mixture of *Lactobacillus paracasei*, *Lactobacillus casei*, and *Weissella confusa*) on *thioacetamide (TAA)*-induced liver fibrosis in rats.

Study result shows that TAA-treated rats receiving probiotics or silymarin had significantly lower serum enzyme levels, less inflammation, and less fibrosis. Liver damage was lower in the TAA + probiotics treated group. This study concluded that consumption of a mixture of probiotic lactic acid bacteria attenuates the development of liver fibrosis.

Source: Wisuit Pradidarcheep, Department Of Anatomy, Faculty Of Medicine, Srinakharinwirot University, Sukhumvit 23 Rd, Bangkok, 10110, Thailand. Hepatoprotective Effect Of Probiotic Lactic Acid Bacteria On Thioacetamide-Induced Liver Fibrosis In Rats. *Probiotics & Antimicro. Prot.* 13, 40-50 (2021). <https://doi.org/10.1007/s12602-020-09663-6>

## 28. The Antioxidant, Anti-Diabetic, And Anti-Adipogenesis Potential And Probiotic Properties Of Lactic Acid Bacteria Isolated From Human And Fermented Foods

In this study, lactic acid bacteria (LAB) strains derived from human and fermented food sources were examined to identify their properties related to obesity, as well as establish their safety and stability as probiotics.

Researchers have found that *LAB (Lactocaseibacillus rhamnosus MG4502, Lactobacillus gasseri MG4524, Limosilactobacillus reuteri MG5149, and Weissella cibaria MG5285)* exhibited antioxidant activity through DPPH (>26.1%) and ABTS (>40.1%) radical scavenging assays and  $\alpha$ -glucosidase inhibitory activities (>60.3%), respectively. The LAB strains promoted anti-adipogenesis by reducing lipid accumulation in 3T3-L1 cells by Oil Red O staining (>70.3%). In addition, scientists have also found that these LAB strains were resistant to simulated gastric and intestinal fluids (pH 3, 4, 7, and 8) and showed potential for health promotion, based on hemolysis, cell adhesion, antibiotic susceptibility, and enzyme production. Thus, LAB may be used as probiotic ingredients with beneficial effects.

Source: Chang-Ho Kang, MEDIOGEN, Co., Ltd., Biovalley 1-Ro, Jecheon-Si 27159, Korea. The Antioxidant, Anti-Diabetic, And Anti-Adipogenesis Potential And Probiotic Properties Of Lactic Acid Bacteria Isolated From Human And Fermented Foods. *Journal Fermentation*, (2021), 7(3), 123. <https://doi.org/10.3390/Fermentation7030123>

## 29. Heat-Killed Lactobacillus Reuteri GMNL-263 Inhibits Systemic Lupus Erythematosus-Induced Cardiomyopathy In NZB/W F1 Mice

In this study, scientists have investigated the anti-apoptotic effects of heat-killed *Lactobacillus reuteri* GMNL-263 on the cardiac tissue of NZB/W F1 mice.

Study result shows that prevention of enlarged interstitial spaces and abnormal myocardial structures in the hearts of NZB/W F1 mice with *L. reuteri* GMNL-263 feeding. Significant reduction in TUNEL-positive cells, Fas death receptor-related components, and apoptosis was also detected in the cardiac tissues of the NZB/W F1 mice after *L. reuteri* GMNL-263 feeding compared with the control group.

These findings are the first to reveal the protective effects of *L. reuteri* GMNL-263 against cardiac abnormalities in NZB/W F1 mice and suggest the potential clinical applications of *L. reuteri* GMNL-263 in the treatment of SLE-related cardiovascular diseases.

Source: Chih-Yang Huang, Graduate Institute Of Aging Medicine, China Medical University; Department Of Biotechnology, Asia University; And Department Of Medical Research, China Medical University Hospital, China Medical University, Taichung, Taiwan And Cardiovascular And Mitochondrial Related Disease Research Center, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Tzu Chi University Of Science And Technology, Hualien, Taiwan. Heat-Killed Lactobacillus Reuteri GMNL-263 Inhibits Systemic Lupus Erythematosus-Induced Cardiomyopathy In NZB/W F1 Mice. *Probiotics & Antimicro. Prot.* 13, 51-59 (2021). <https://doi.org/10.1007/s12602-020-09668-1>

## 30. Probiotic Potential And Wide-Spectrum Antimicrobial Activity Of Lactic Acid Bacteria Isolated From Infant Feces

The main objective of the study is to characterize *lactic acid bacteria* strains derived from infants' feces, to evaluate the probiotic potential and explore the wide-spectrum antimicrobial activity.

In this study the wide-spectrum antimicrobial activity analysis revealed that approximately all tested strains inhibited the ten pathogens, and four strains (ZX221, ZX633, ZX3131, and ZX3875) had good probiotic properties and survived after being exposed to simulated gastrointestinal tract conditions. Researchers have also found that four strains inhibited most pathogens at pH 4.5 and pH 5, whereas only ZX633 had an inhibitory effect on *Bacillus subtilis* ATCC 6633 and *Micrococcus luteus* ATCC 4698 at pH 5.5. Overall, *Lact. casei* ZX633 had wide-spectrum antimicrobial activity and could be considered a potential probiotic.

Source: Zhongfang Tan, Henan Key Laboratory Of Ion-Beam Bioengineering, School Of Agricultural Sciences, Zhengzhou University, Zhengzhou, China. Probiotic Potential And Wide-Spectrum Antimicrobial Activity Of Lactic Acid Bacteria Isolated From Infant Feces. *Probiotics & Antimicro. Prot.* 13, 90-101 (2021). <https://doi.org/10.1007/s12602-020-09658-3>

### 31. Criteria To Qualify Microorganisms As “Probiotic” In Foods And Dietary Supplements

This paper describes the minimum criteria that apply to a probiotic strain that will be used in foods and dietary supplements and similar criteria may be applicable to other uses of probiotics. Specifically, the strain must be identified using recognized scientific methods, named according to valid current nomenclature, and named with a retrievable strain designation. *Methods will vary depending on species of the probiotic and are likely to change as technologies evolve.* Also, scientists recommend that it should be deposited in an international culture collection.

Further, the strain must have demonstrated safety for its intended use and a demonstrated health benefit based on at least one study that meets generally accepted scientific standards or as per recommendations and provisions of local/national authorities when applicable. Sufficient levels of the probiotic strain(s) must be contained in the final product throughout the shelf life in order to be able to deliver the claimed (and evidence-based) health benefit. Products should be manufactured according to applicable good manufacturing requirements to assure safety, purity, and stability and should be labeled in a manner that communicates essential information on product contents (specific strains, level of live probiotic delivered at end of shelf life, and statements about health benefits as allowed) to the end-user.

Adherence to these principles will assure that the marketplace does not contain products that **misuse** the term “probiotic.” Some local regulatory contexts can define probiotics in a different manner, but it is the responsibility of the product manufacturer to produce and market probiotics that follow local rules and regulations and are in line with the above defined principles.

Source: Arthur C. Ouwehand, Global Health And Nutrition Sciences, DuPont Nutrition And Biosciences, Kantvik, Finland. Criteria To Qualify Microorganisms As “Probiotic” In Foods And Dietary Supplements. *Front. Microbiol.*, 24 July (2020). <https://doi.org/10.3389/fmicb.2020.01662>

### 32. Preclinical And Clinical Relevance Of Probiotics And Synbiotics In Colorectal Carcinogenesis: A Systematic Review

This systematic review investigated the role of probiotics and synbiotics in the prevention of colorectal cancer and specifies potential mechanisms involved. The results show positive effects of probiotics and synbiotics in preventing colorectal cancer. The main mechanisms identified were alterations in the composition and metabolic activity of the intestinal microbiota; reduction of inflammation; induction of apoptosis and inhibition of tumor growth; modulation of immune responses and cell proliferation; enhanced function of the intestinal barrier; production of compounds with anticarcinogenic activity; and modulation of oxidative stress.

This study concludes that probiotics or synbiotics may help prevent colorectal cancer, but additional studies in humans are required to better inform clinical practice.

Source: Bruna C S Cruz, Department Of Nutrition And Health, Nutritional Biochemistry Laboratory, Universidade Federal De Viçosa, Viçosa, Minas Gerais, Brazil. Preclinical And Clinical Relevance Of Probiotics And Synbiotics In Colorectal Carcinogenesis: A Systematic Review, *Nutrition Reviews*, Volume 78, Issue 8, August (2020), Pages 667–687, <https://doi.org/10.1093/Nutrit/Nuz087>

### 33. Therapeutic Responses To Roseomonas Mucosa In Atopic Dermatitis May Involve Lipid-Mediated TNF-Related Epithelial Repair

In this study researchers have examined the potential mechanism of action of *R. mucosa* treatment and its impact on children with atopic dermatitis (AD) less than 7 years of age, the most common age group for children with AD.

Study result shows that *R. mucosa* treatment was associated with amelioration of disease severity, improvement in epithelial barrier function, reduced *Staphylococcus aureus* burden on the skin, and a reduction in topical steroid requirements without severe adverse events. Skin improvements and colonization by *R. mucosa* persisted for up to 8 months after cessation of treatment. Also, the production of *sphingolipids* by *R. mucosa*, *cholinergic signaling*, and *flagellin expression* have contributed to therapeutic impact through induction of a *TNFR2-mediated epithelial-to-mesenchymal transition*.

*These results suggest that a randomized, placebo-controlled trial of R. mucosa treatment in individuals with AD is warranted and implicate commensals in the maintenance of the skin epithelial barrier.*

Source: Ian A. Myles, Epithelial Therapeutics Unit, National Institute Of Allergy And Infectious Disease, National Institutes Of Health And Laboratory Of Clinical Immunology And Microbiology, NIAID, NIH, Bethesda, MD, USA. Therapeutic Responses To Roseomonas Mucosa In Atopic Dermatitis May Involve Lipid-Mediated TNF-Related Epithelial Repair. *Science Translational Medicine*, 9 Sep (2020), Vol 12, Issue 560. DOI: 10.1126/Scitranslmed.Aaz8631.

### **34. Microbiota Supplementation With Bifidobacterium And Lactobacillus Modifies The Preterm Infant Gut Microbiota And Metabolome: An Observational Study**

Study result showed a predominance of Bifidobacterium and a lower abundance of pathobionts in the Bif/Lacto group. Moreover, metabolomic analysis showed higher fecal acetate and lactate and a lower fecal pH in the Bif/Lacto group. Further, fecal acetate positively correlated with relative abundance of Bifidobacterium, consistent with the ability of the supplemented Bifidobacterium strain to metabolize human milk oligosaccharides into acetate.

This study demonstrates that microbiota supplementation is associated with a Bifidobacterium-dominated preterm microbiota and gastrointestinal environment more closely resembling that of full-term infants.

**Source:** Lindsay J. Hall, Gut Microbes & Health, Quadram Institute Bioscience, Norwich Research Park; Norwich Medical School, University Of East Anglia, Norwich, UK; Chair Of Intestinal Microbiome, School Of Life Sciences, Technical University Of Munich, Freising, Germany And ZIEL – Institute For Food & Health, Technical University Of Munich, Freising, Germany. Microbiota Supplementation With Bifidobacterium And Lactobacillus Modifies The Preterm Infant Gut Microbiota And Metabolome: An Observational Study. Cell Reports Medicine, Volume 1, Issue 5, 100077, August 25 (2020). <https://doi.org/10.1016/j.xcrm.2020.100077>

### **35. Clinical Trials Of Probiotic Strains In Selected Disease Entities**

This paper provides a review of available information about the influence of probiotics on human health. It summarizes the current knowledge on the mechanism of action of probiotics as well as clinical trial results proving their efficacy in allergic, neurodegenerative, and cardiac diseases. It also discusses the data concerning the safety of probiotics in clinical treatment.

**Source:** Ruth Dudek Wicher, Department, Pharmaceutical Microbiology And Parasitology, Faculty Of Pharmacy, Medical University Of Silesian Piasts, Wroclaw, Poland. Clinical Trials Of Probiotic Strains In Selected Disease Entities. International Journal Of Microbiology, Vol. 2020, Article ID 8854119, 8 Pages, 2020. <https://doi.org/10.1155/2020/8854119>

### **36. The Potential Application Of Probiotics And Prebiotics For The Prevention And Treatment Of COVID-19**

Probiotics are live microorganisms that confer health benefits when consumed in adequate amounts, including enhanced immune activity and the clearance of respiratory tract infections. It is evident that probiotics can reduce the incidence and severity of diseases, suggesting their promise for treating or preventing COVID-19. Probiotics could help prevent COVID-19 by maintaining the human GI or lung microbiota because dysbiosis plays a major role in the susceptibility of people to infectious diseases. Further, In vitro and clinical studies are required to examine the potential preventive and curative effects of probiotics against SARS-CoV-2 infection.

**Source:** Amin N. Olaimat, Department Of Clinical Nutrition And Dietetics, Faculty Of Applied Medical Sciences, The Hashemite University, Jordan. The Potential Application Of Probiotics And Prebiotics For The Prevention And Treatment Of COVID-19. Npj Sci Food 4, 17 (2020). <https://doi.org/10.1038/s41538-020-00078-9>

### **37. Growth, Survival, And Metabolic Activities Of Probiotic Lactobacillus Spp. In Fermented Coffee Brews Supplemented With Glucose And Inactivated Yeast Derivatives**

The aim of this study was to develop a fermented coffee beverage rich in live probiotics, by supplementing nutrient-deficient coffee brews with glucose and inactivated yeast derivatives. This was followed by fermentation with single probiotic bacteria cultures (*Lactobacillus rhamnosus* GG, *L. paracasei* Lpc-37, *L. plantarum* 299v, and *L. acidophilus* NCFM), and subsequent storage at 4 and 25 °C.

This study demonstrated that nutrient supplementation was essential in supporting probiotic growth and survival in coffee brews, as viabilities above 7 Log CFU/mL could not be sustained longer than 2 weeks in non-supplemented coffees. In contrast, viabilities above 7 Log CFU/mL were maintained for 10 weeks by *L. rhamnosus* GG and *L. paracasei* Lpc-37 in supplemented coffees stored under refrigeration. Probiotic metabolic activities led to consumption of *glucose*, *glutamic acid*, and *alanine*, with simultaneous formation of *lactic acid*, *3-methylbutanoic acid*, and *diacetyl*. Nevertheless, endogenous coffee volatiles, bioactive components, and antioxidant capacities were retained.

Overall, this study illustrates the potential functionalities of probiotic fermented coffee brews, arising from high probiotic live counts and retention of major coffee bioactive components.

**Source:** Shao-Quan Liu, Department Of Food Science & Technology, National University Of Singapore, Science Drive 2, Singapore And National University Of Singapore (Suzhou) Research Institute, No. 377 Linquan Street, Suzhou Industrial Park, Jiangsu, China. Growth, Survival, And Metabolic Activities Of Probiotic Lactobacillus Spp. In Fermented Coffee Brews Supplemented With Glucose And Inactivated Yeast Derivatives. Food Research International, Volume 137, November (2020), 109746. <https://doi.org/10.1016/J.Foodres.2020.109746>

### **38. Recent Advances In Clinical Probiotic Research For Sport**

A review of the most up-to-date research on the effectiveness of probiotic supplementation for outcomes related to athletes and physical activity support the notion that certain probiotics could play important roles in maintaining normal physiology and energy production during exercise which may lead to performance-improvement and ant fatigue effects, improve exercise-induced gastrointestinal symptoms and permeability, stimulate/modulate of the immune system, and improve the ability to digest, absorb, and metabolize macro and micronutrients important to exercise performance and recovery/health status of those physically active.

Findings of the included clinical studies support the notion that certain probiotics could play important roles in maintaining normal physiology and energy production during exercise which may lead to performance-improvement and anti-fatigue effects, improve exercise-induced gastrointestinal symptoms and permeability, stimulate/modulate of the immune system, and improve the ability to digest, absorb, and metabolize macro and micronutrients important to exercise performance and recovery/health status of those physically active.

**Source: Jäger, Ralf, , Inrenovo LLC, Milwaukee, Wisconsin, USA. Recent Advances In Clinical Probiotic Research For Sport. Current Opinion in Clinical Nutrition and Metabolic Care: November (2020), Volume 23, Issue 6, Pages 428-436, Doi: 10.1097/MCO.0000000000000686**

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