

For Healthcare Practitioners

We have compiled scientific reviews and original studies on key subject areas of probiotics and digestive health. Many studies are available on each subject—here we have focused on studies that provide the framework and concepts that define the current understanding of how different bacterial strains can act as probiotics to promote digestive health and provide a foundation for overall health.

These case reviews are helpful especially for those new to the understanding of probiotics, as each review article provides a summary and a list of more detailed original articles on a particular aspect of the topic in which you may be interested.

Research on the Probiotics found in Attune Products

Lactobacillus acidophilus, *Lactobacillus casei* and *bifidobacterium lactis* are the three probiotic strains found in Attune products, and they were chosen based on their ability to survive in the digestive tract using the proprietary encapsulation method developed by DSM to improve delivery and efficacy.(1) These particular bacteria are being studied in many different ways including looking at recovery from fatigue in athletes. Athletes were chosen as they represent a healthy population to study. The studies have been shown to demonstrate health benefits. (2-4) Also, these bacteria have been used to increase the safety of salami due to their ability to prevent growth of pathogenic bacteria. (5-8)

1. Su, P., A. Henriksson, J. E. Tandianus, J. H. Park, F. Foong, and N. W. Dunn. 2005. Detection and quantification of *Bifidobacterium lactis* LAFTI B94 in human faecal samples from a consumption trial. *FEMS Microbiol Lett* 244:99-103.
2. Clancy et al. Reversal in fatigued athletes of a defect in interferon gamma secretion after administration of *Lactobacillus acidophilus*. *Br J Sports Med*. 2006 Apr; 40(4): 351-354.
3. Welin et al. Survival of *L. Acidophilus* and *L. Casei* in the human GI tract, perceived benefits on health. *Nutrafoods* 2005; 4 (2/3): 9-14
4. Elahi et al. Enhanced clearance of *Candida albicans* from the oral cavities of mice following oral administration of *Lactobacillus acidophilus*. *Clin Exp Immunol*. 2005 Jul; 141(1): 29-36.
5. Mahoney, M., and A. Henriksson. 2003. The effect of processed meat and meat starter cultures on gastrointestinal colonization and virulence of *Listeria monocytogenes* in mice. *Int J Food Microbiol* 84:255-261.
6. Pidcock, K., G. M. Heard, and A. Henriksson. 2002. Application of nontraditional meat starter cultures in production of Hungarian salami. *Int J Food Microbiol* 76:75-81.
7. Crittenden, R. G., L. F. Morris, M. L. Harvey, L. T. Tran, H. L. Mitchell, and M. J. Playne. 2001. Selection of a *Bifidobacterium* strain to complement resistant starch in a synbiotic yoghurt. *J Appl Microbiol* 90:268-278.
8. Tuomola, E., R. Crittenden, M. Playne, E. Isolauri, and S. Salminen. 2001. Quality assurance criteria for probiotic bacteria. *Am J Clin Nutr* 73:393S-398S.

Other Studies on Attune Bacterial Strains

Lactobacillus acidophilus

This is the strain that is most abundant in Attune products, and in addition to the studies listed above completed by DSM, the probiotic manufacturer, these studies highlight how this strain might contribute to improving digestive health. (9-11)

9. Elahi, S., G. Pang, R. Ashman, and R. Clancy. 2005. Enhanced clearance of *Candida albicans* from the oral cavities of mice following oral administration of *Lactobacillus acidophilus*. *Clin Exp Immunol* 141:29-36.
10. Sullivan, A., L. Barkholt, and C. E. Nord. 2003. *Lactobacillus acidophilus*, *Bifidobacterium lactis* and *Lactobacillus F19* prevent antibiotic-associated ecological disturbances of *Bacteroides fragilis* in the intestine. *J Antimicrob Chemother* 52:308-311.
11. Liong, M. T., and N. P. Shah. 2005. Optimization of cholesterol removal, growth and fermentation patterns of *Lactobacillus acidophilus* ATCC 4962 in the presence of mannitol, fructo-oligosaccharide and inulin: a response surface methodology approach. *J Appl Microbiol* 98:1115-1126.

Lactobacillus casei

Again, these studies formed the basis for pursuing *L. casei* as a probiotic in Attune products (12-14).

12. Villena, J., S. Racedo, G. Aguero, E. Bru, M. Medina, and S. Alvarez. 2005. *Lactobacillus casei* improves resistance to pneumococcal respiratory infection in malnourished mice. *J Nutr* 135:1462-1469.
13. Tien, M. T., S. E. Girardin, B. Regnault, L. Le Bourhis, M. A. Dillies, J. Y. Coppee, R. Bourdet-Sicard, P. J. Sansonetti, and T. Pedron. 2006. Anti-inflammatory effect of *Lactobacillus casei* on *Shigella*-infected human intestinal epithelial cells. *J Immunol* 176:1228-1237.
14. Liong, M. T., and N. P. Shah. 2006. Effects of a *Lactobacillus casei* synbiotic on serum lipoprotein, intestinal microflora, and organic acids in rats. *J Dairy Sci* 89:1390-1399.

Bifidobacterium lactis

Part of the rationale for including this bacterial strain in our products is based on experiments completed around the world that have documented benefits of this strain in preventing childhood diarrhea, as well as documented that symbiotic combinations with this strain may have an anti-cancer effect. Research into the specific benefits of LAFTI B94 are being further explored (15-17).

15. Le Leu, R. K., I. L. Brown, Y. Hu, A. R. Bird, M. Jackson, A. Esterman, and G. P. Young. 2005. A synbiotic combination of resistant starch and *Bifidobacterium lactis* facilitates apoptotic deletion of carcinogen-damaged cells in rat colon. *J Nutr* 135:996-1001.
16. Ruiz, P. A., M. Hoffmann, S. Szcesny, M. Blaut, and D. Haller. 2005. Innate mechanisms for *Bifidobacterium lactis* to activate transient pro-inflammatory host responses in

intestinal epithelial cells after the colonization of germ-free rats. *Immunology* 115:441-450.

17. Correa, N. B., L. A. Peret Filho, F. J. Penna, F. M. Lima, and J. R. Nicoli. 2005. A randomized formula controlled trial of Bifidobacterium lactis and Streptococcus thermophilus for prevention of antibiotic-associated diarrhea in infants. *J Clin Gastroenterol* 39:385-389.

Prebiotics

It's been shown that prebiotics can play a role in supporting the growth of the naturally occurring intestinal bacteria in the digestive system and can also stimulate the growth of probiotics, acting symbiotically with them. These effects are being further explored (18, 19).

18. Schley, P. D., and C. J. Field. 2002. The immune-enhancing effects of dietary fibres and prebiotics. *Br J Nutr* 87 Suppl 2:S221-230.
19. Bengmark, S., and R. Martindale. 2005. Prebiotics and synbiotics in clinical medicine. *Nutr Clin Pract* 20:244-261.

General Information on Probiotics

These reviews discuss the state of the science behind probiotics (20, 21).

20. Walker, W. A., O. Goulet, L. Morelli, and J. M. Antoine. 2006. Progress in the science of probiotics: from cellular microbiology and applied immunology to clinical nutrition. *Eur J Nutr* 45 Suppl 9:1-18.
21. Saavedra, J. M., and A. Tschernia. 2002. Human studies with probiotics and prebiotics: clinical implications. *Br J Nutr* 87 Suppl 2:S241-246.

Benefits Beyond the Gut

The idea that probiotics can have effects on more than just gut health relates to the role of the immune system in the intestinal wall (70% of immune cells are found in the intestine) and has an ability to condition immune cells to protect other areas, such as the nasal cavity and lungs, which becomes important in flu season (19). There is a nice review that summarizes the concept that probiotics can have effects outside the gut (22-25).

22. Gluck, U., and J. O. Gebbers. 2003. Ingested probiotics reduce nasal colonization with pathogenic bacteria (Staphylococcus aureus, Streptococcus pneumoniae, and beta-hemolytic streptococci). *Am J Clin Nutr* 77:517-520.
23. Noverr, M. C., and G. B. Huffnagle. 2004. Does the microbiota regulate immune responses outside the gut? *Trends Microbiol* 12:562-568.
24. Bjorksten, B. 2005. Evidence of probiotics in prevention of allergy and asthma. *Curr Drug Targets Inflamm Allergy* 4:599-604.
25. de Vrese, M., P. Rautenberg, C. Laue, M. Koopmans, T. Herremans, and J. Schrezenmeier. 2005. Probiotic bacteria stimulate virus-specific neutralizing antibodies following a booster polio vaccination. *Eur J Nutr* 44:406-413.

Gut function and bacterial interactions

The concept that probiotics can aid in protecting from opportunistic infection comes from numerous studies. We have highlighted a few here. In a study that looked at the effects of probiotics on *Candida* showed that the short chain fatty acids that are a critical product made by the bacteria for use in the large intestine actually prevented the germination of the *Candida* (26-29).

26. Noverr, M. C., and G. B. Huffnagle. 2004. Regulation of *Candida albicans* morphogenesis by fatty acid metabolites. *Infect Immun* 72:6206-6210.
27. Lesniewska, V., I. Rowland, H. N. Laerke, G. Grant, and P. J. Naughton. 2006. Relationship between dietary-induced changes in intestinal commensal microflora and duodenojejunal myoelectric activity monitored by radiotelemetry in the rat in vivo. *Exp Physiol* 91:229-237.
28. Wong, J. M., R. de Souza, C. W. Kendall, A. Emam, and D. J. Jenkins. 2006. Colonic health: fermentation and short chain fatty acids. *J Clin Gastroenterol* 40:235-243.
29. Dock, D. B., M. Q. Latorraca, J. E. Aguilar-Nascimento, and M. H. Gomes-da-Silva. 2004. Probiotics enhance recovery from malnutrition and lessen colonic mucosal atrophy after short-term fasting in rats. *Nutrition* 20:473-476.

Understanding the Digestive System and Its Immune System

The journal *Science* dedicated an issue to understanding the digestive system titled, "The Inner Tube of Life," which provides an overview on how the digestive system works. Two articles from this issue are highlighted below. (30, 31). These articles provide general overviews of how the bacteria interact in our bodies, are a part of the immune response, and how they can contribute to our health (32-34)

30. Backhed, F., R. E. Ley, J. L. Sonnenburg, D. A. Peterson, and J. I. Gordon. 2005. Host-bacterial mutualism in the human intestine. *Science* 307:1915-1920.
31. Macdonald, T. T., and G. Monteleone. 2005. Immunity, inflammation, and allergy in the gut. *Science* 307:1920-1925.
32. Forchielli, M. L., and W. A. Walker. 2005. The role of gut-associated lymphoid tissues and mucosal defence. *Br J Nutr* 93 Suppl 1:S41-48.
33. Madsen, K. 2006. Probiotics and the immune response. *J Clin Gastroenterol* 40:232-234.
34. Cummings, J. H., J. M. Antoine, F. Azpiroz, R. Bourdet-Sicard, P. Brandtzaeg, P. C. Calder, G. R. Gibson, F. Guarner, E. Isolauri, D. Pannemans, C. Shortt, S. Tuijelaars, and B. Watzl. 2004. PASSCLAIM--gut health and immunity. *Eur J Nutr* 43 Suppl 2:II118-II173.