Fullscript® | Pendulum®

The gut-metabolism connection

Metabolic disorders like type 2 diabetes, obesity, and osteoporosis are becoming increasingly common. [8] It's estimated that a third of the world's population has a higher weight or obesity. [6][8] In 2021, diabetes was the eighth-leading cause of death in the United States, and approximately 11.6% of adults had the condition. [13]

An imbalance in gut bacteria and impaired function of the mucosa layer of the gut lining has been associated with obesity and insulin resistance. [5][12] Recent studies have evaluated the efficacy of certain probiotic strains and their potential benefits to both digestive and metabolic health. These innovative probiotics support the integrity of the gut lining, create an optimal ecosystem of favorable bacteria, and produce hormones and beneficial metabolites such as short-chain fatty acids (SCFAs). [12]

SCFAs like butyrate help improve insulin sensitivity and glucose metabolism and modulate the secretion of glucagon-like peptide-1 (GLP-1). GLP-1 is a peptide hormone that helps balance blood sugar levels, affects insulin secretion and appetite regulation, and slows gastric emptying. [3][12][17][20]

Probiotics for metabolic health

The following probiotic strains are being recognized for their potential benefits to both digestive and metabolic health:

- *Akkermansia muciniphila (A. muciniphila)*
- *Anaerobutyricum hallii (A. hallii)*
- *Bifidobacterium infantis (B. infantis)*
- *Clostridium butyricum (C. butyricum)*
- *Clostridium beijerinckii* (*C. beijerinckii*)

Akkermansia muciniphila WB-STR-0001

A. muciniphila is an anaerobic species of bacteria present in the mucus layer of the human gut. When *A. muciniphila* consumes mucin, it produces acetic acid and SCFAs that supply energy to goblet cells, promoting mucus secretion and playing an important role in maintaining the integrity of the intestinal barrier. *A. muciniphila* may also increase GLP-1 levels and positively affect human metabolic responses by supporting energy metabolism and contributing to improved insulin sensitivity. [3][12][20]

Health benefits

A. muciniphila may help:

- Increase GLP-1 levels
- Produce beneficial metabolites such as acetic acid
- Promote mucus secretion in the mucus layer of the gut
- Support glucose and lipid metabolism
- Support the integrity of the intestinal barrier

Anaerobutyricum hallii WB-STR-0008

A. hallii is an anaerobic species of bacteria found in the human gut. It utilizes glucose to produce beneficial metabolites such as butyrate, providing energy to the cells lining the gut. *A. hallii* helps support the integrity of the gut mucosa, has anti-inflammatory effects, and may increase GLP-1 levels. [2]

Studies suggest that *A. hallii* may be less abundant in individuals with type 2 diabetes and insulin resistance compared to healthy individuals. [18]

Health benefits

A. hallii may:

- Support the integrity of the gut mucosa layer
- Increase GLP-1 levels
- Produce beneficial metabolites such as butyrate
- Provide anti-inflammatory effects
- Improve insulin sensitivity

Bifidobacterium infantis Bi-26

B. infantis is a species of bacteria passed down from the birthing person to their infant and is especially abundant in breastfed infants. Through the metabolism of human milk oligosaccharides (HMOs) and the production of beneficial metabolites such as acetate, butyrate, and lactate, *B. infantis* may support the maturation of the immune system, suppress inflammation, improve intestinal barrier function, and affect appetite regulation. [1][4][7][11][19]

Adults may also benefit from consuming *B. infantis.* A meta-analysis of studies looking at the benefits of *B. infantis* in individuals with irritable bowel syndrome (IBS) determined that, in combination with other probiotics, *B. infantis* may benefit adults with gastrointestinal conditions such as IBS by reducing abdominal pain and distention. [21]

In another study, 10 billion CFU per day of *B. infantis* for six to eight weeks was shown to reduce systemic pro-inflammatory biomarkers in adults with ulcerative colitis (UC), chronic fatigue syndrome (CFS), and psoriasis. Plasma CRP levels were reduced in all three disorders compared with placebo. Additionally, tumor necrosis factor alpha (TNF-α) was reduced in individuals with CFS and psoriasis, while interleukin 6 (IL-6) was reduced in individuals UC and CFS. These results suggest that *B. infantis* may support the systemic immune system and benefit adults with non-gastrointestinal conditions. [9]

Health benefits

B. infantis may:

- Improve intestinal barrier function
- Positively affect appetite regulation
- Produce beneficial metabolites such as SCFAs
- Provide anti-inflammatory effects
- Support the immune system

Clostridium butyricum WB-STR-0006

C. butyricum is an anaerobic species of bacteria found in the intestines of humans and animals as well as in soil and water. *C. butyricum* supports metabolic health by producing SCFAs such as butyrate through the fermentation of carbohydrates, providing energy to gut-lining cells and supporting immune and intestinal mucosa health. *C. butyricum* may also increase GLP-1 levels in the body. [10]

Health benefits

C. butyricum may help:

- Increase GLP-1 levels
- Improve insulin sensitivity
- Produce beneficial metabolites such as butyrate
- Support immune function
- Support the health of the gut mucosa layer

Clostridium beijerinckii WB-STR-0005

C. beijerinckii is an anaerobic spore-forming species of bacteria found in the intestines of humans and animals as well as in soil and water. Much like *C. butyricum*, *C. beijerinckii* supports metabolic health by producing SCFAs such as butyrate through the fermentation of carbohydrates. It may also increase GLP-1 levels in the body. [15]

Health benefits

C. beijerinckii may:

- Increase GLP-1 levels
- Improve insulin sensitivity
- Produce beneficial metabolites such as butyrate
- Support immune function

Dosing and adverse effects

The majority of studies covering the metabolic effects of *A. muciniphila*, *A. hallii*, *C. beijerinckii*, *C. butyricum*, and *B. infantis* are conducted in vitro, in animals, or in human infants.

In a human study of adult participants with type 2 diabetes, a multi-strain probiotic (WBF-0011) including live *A. muciniphila*, *A. hallii*, *C. beijerinckii*, *C. butyricum*, and *B. infantis* was administered daily for 12 weeks. It was safe and well tolerated. The probiotic combination included the following five strains:

- 16 billion CFU of *C. beijerinckii*
- 3 billion 300 million CFU of *C. butyricum*
- 2 billion CFU of *B. infantis*
- 1 billion 200 million CFU of *A. muciniphila*
- 900 million CFU of *A. hallii.* [14]

The WBF-0011 probiotic combination provided beneficial metabolic effects and improved postprandial glucose control. It significantly improved:

- Glucose total area under the curve (AUC): -36.1 mg/dL/180 min
- Glycated hemoglobin (A1c): -0.6
- Glucose incremental-AUC: -28.6 mg/dL/180 min [14]

Human studies examining the metabolic effects of live *A. muciniphila*, *A. hallii*, *C. beijerinckii*, *C. butyricum*, and *B. infantis* on their own are limited, and further research in human subjects is needed to validate these findings and establish safe and effective dosing for each individual strain.

The metabolic benefits: A summary

This table summarizes the potential metabolic benefits of the probiotic bacteria strains *A. muciniphila*, *A. hallii*, *C. beijerinckii*, *C. butyricum*, and *B. infantis*.

	Akkermansia muciniphila	*Anaerobutyricum hallii*	*Bifidobacterium infantis*	*Clostridium butyricum*	*Clostridium beijerinckii*
Supports lipid and glucose metabolism	✓	✓	✓	✓	✓
Supports insulin sensitivity	✓	✓	—	✓	✓
Supports GLP-1 production	✓	✓	—	✓	✓
Supports gut barrier integrity	✓	✓	✓	✓	—
Supports a healthy weight	✓	✓	✓	✓	✓
Supports butyrate production	—	✓	✓	✓	✓
Supports SCFA production	✓	✓	✓	✓	✓

*These statements have not been evaluated by the Food and Drug Administration. These products are not intended to diagnose, treat, cure, or prevent any disease.

References

1. Bergmann, K. R., Liu, S. X., Tian, R., Kushnir, A., Turner, J. R., Li, H. L., Chou, P. M., Weber, C. R., & De Plaen, I. G. (2013). *The American Journal of Pathology, 182*(5), 1595–1606. https://pubmed.ncbi.nlm.nih.gov/23470164/
2. Bunešová, V., Lacroix, C., & Schwab, C. (2017). *Microbial Ecology, 75*(1), 228–238. https://pubmed.ncbi.nlm.nih.gov/28721502/
3. Cani, P. D., & Knauf, C. (2021). *Cell Metabolism, 33*(6), 1073–1075. https://pubmed.ncbi.nlm.nih.gov/34077715/
4. Chichlowski, M., De Lartigue, G., German, J. B., Raybould, H. E., & Mills, D. A. (2012). *Journal of Pediatric Gastroenterology and Nutrition, 55*(3), 321–327. https://pubmed.ncbi.nlm.nih.gov/22383026/
5. Chichlowski, M., Shah, N., Wampler, J. L., Wu, S. S., & Vanderhoof, J. A. (2020). *Nutrients, 12*(6), 1581. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7352178/
6. Chooi, Y. C., Ding, C., & Magkos, F. (2019). *Metabolism, 92*, 6–10. https://pubmed.ncbi.nlm.nih.gov/30253139/
7. Frost, G., Sleeth, M., Sahuri-Arisoylu, M., Lizarbe, B., Cerdán, S., Brody, L., Anastasovska, J., Ghourab, S., Hankir, M. K., Zhang, S., Carling, D., Swann, J. R., Gibson, G. R., Viardot, A., Morrison, D. J., Thomas, E. L., & Bell, J. D. (2014). *Nature Communications, 5*(1). https://pubmed.ncbi.nlm.nih.gov/24781306/
8. Garus-Pakowska, A. (2023). *International Journal of Environmental Research and Public Health, 20*(18), 6789. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10530887/
9. Groeger, D., O'Mahony, L., Murphy, E. F., Bourke, J., Dinan, T. G., Kiely, B., Shanahan, F., & Quigley, E. M. (2013). *Gut Microbes, 4*(4), 325–339. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3744517/
10. Ishikawa, K., Hasegawa, R., Shibutani, K., Mikami, Y., Kawai, F., Matsuo, T., Uehara, Y., & Mori, N. (2023). *Anaerobe, 83,* 102770. https://www.sciencedirect.com/science/article/abs/pii/S1075996423000793
11. Koh, A., De Vadder, F., Kovatcheva-Datchary, P., & Bäckhed, F. (2016). *Cell, 165*(6), 1332–1345. https://pubmed.ncbi.nlm.nih.gov/27259147/
12. Naito, Y., Uchiyama, K., & Takagi, T. (2018). *Journal of Clinical Biochemistry and Nutrition, 63*(1), 33–35. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6064808/
13. *National diabetes statistics report.* (2021). Center for Disease Control and Prevention. https://www.cdc.gov/diabetes/data/statistics-report/
14. Perraudeau, F., McMurdie, P. J., Bullard, J., Cheng, A., Cutcliffe, C., Deo, A., Eid, J., Gines, J., Iyer, M. S., Justice, N. J., Loo, W. T., Nemchek, M., Schicklberger, M., Souza, M., Stoneburner, B., Tyagi, S., & Kolterman, O. G. (2020). BMJ *Open Diabetes Research & Care, 8*(1), e001319. https://drc.bmj.com/content/8/1/e001319
15. Sedlář, K., Nykrýnová, M., Bezdíček, M., Branská, B., Lengerová, M., Patáková, P., & Škutková, H. (2021). *Processes, 9*(7), 1196. https://www.mdpi.com/2227-9717/9/7/1196
16. Singh, A., Prasad, S., & Singh, G. (2023). In *Elsevier eBooks* (pp. 443–475). https://www.sciencedirect.com/science/article/abs/pii/B9780323993364000185?via%3Dihub
17. Tilg, H., & Moschen, A. R. (2014). *Gut, 63*(9), 1513–1521. https://pubmed.ncbi.nlm.nih.gov/24833634/
18. Udayappan, S. D., Manneråas-Holm, L., Chaplin, A., Belzer, C., Herrema, H., Dallinga-Thie, G. M., Duncan, S. H., Stroes, E. S., Groen, A. K., Flint, H. J., Bäckhed, F., De Vos, W. M., & Nieuwdorp, M. (2016). *Npj Biofilms and Microbiomes, 2*(1). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5515273/
19. Underwood, M. A., German, J. B., Lebrilla, C. B., & Mills, D. A. (2014). *Pediatric Research, 77*(1–2), 229–235. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4350908/
20. Yoon, H., Cho, C. H., Yun, M. S., Jang, S. J., You, H. J., Kim, J. H., Han, D., Hyun, K., Moon, S. J., Lee, K., Kim, Y. J., Lee, S. J., Nam, T. W., & Ko, G. P. (2021). *Nature Microbiology, 6*(5), 563–573. https://www.nature.com/articles/s41564-021-00880-5
21. Yuan, F., Ni, H., Asche, C. V., Kim, M., Walayat, S., & Ren, J. (2017). *Current Medical Research and Opinion, 33*(7), 1191–1197. https://pubmed.ncbi.nlm.nih.gov/28166427/