MINI-REVIEW
ADVANCEMENTS OF MICROBIOLOGY
2025, 64, 3, 141-146
https://doi.org/10.2478/am-2025-0011

AKKERMANSIA MUCINIPHILA IS ASSOCIATED WITH HUMAN HEALTH: WHAT SHOULD WE KNOW?

Bartosz Ostrowski[1], Beata Krawczyk[1*]

[1] Gdańsk University of Technology, Department of Biotechnology and Microbiology, 80-233 Gdańsk, ul. G. Narutowicza 11/12, Poland

Submitted on 29 April 2025, accepted on 23 July 2025

Akkermansia muciniphila is a gut bacterium that has recently attracted considerable attention in microbiota research. Its presence in the gut is associated with improved metabolic health, enhanced gut barrier integrity, and modulation of the immune system. However, potential risks related to its abundance under certain pathological conditions have also been noted. As *A. muciniphila* emerges as a candidate for next-generation probiotics, evaluating whether current data support its therapeutic use is crucial. In this review, we analyze the available literature to outline the beneficial effects of *A. muciniphila* on the host and critically assess its potential as a probiotic.

Keywords: *Akkermansia muciniphila*, disease, microbiota, probiotics.

1. Introduction

Akkermansia muciniphila was first isolated from the faeces of a healthy adult Caucasian female in 2004 as the first known member of the *Akkermansia* genus and the only isolated member of the Verrucomicrobiota phylum (Derrien et al. 2004). The anaerobic, Gram-negative, non-motile, and non-spore-forming bacterium colonizes the intestines and nasopharynx of humans and other animals (Derrien et al. 2004). Other environments it inhabits include the appendix, the pancreas (in pathological conditions), human breast milk, and human blood samples (Geerlings et al. 2017). Since then, other members of the genus have been found inhabiting the human gut (Kobayashi et al. 2018). *Akkermansia* is a genus that has recently attracted much attention due to its probiotic effects and possible role in bowel disease treatment (approved by the European Food Safety Authority (EFSA).

2. *Akkermansia muciniphila* in the human population

A. muciniphila is an early colonizer of the human gut that reaches an abundance similar to or slightly lower than that in adults within the first year of life and then decreases in the elderly. The abundance appears to be higher in formula-fed than in breast-fed infants, and increases once breast-feeding stops (Azad et al. 2018). A Chinese study found a colonization rate of 51-74% in southern China and identified 22 strains within the studied population (Guo et al. 2016). Abundance and colonization rate can vary between countries, and the composition of the microbiota is influenced by diet and genetic factors (Grześkowiak et al. 2012). Nonetheless, the consensus is that *A. muciniphila* is a common and stable part of the human gut microbiota. *A. muciniphila* growth can be stimulated by diet, with one study demonstrating that dietary polyphenols from grapes can dramatically promote

* Corresponding author: Beata Krawczyk, Gdansk University of Technology, Department of Biotechnology and Microbiology, ul. G. Narutowicza 11/12, 80-233 Gdańsk, Poland, e-mail: beata.krawczyk@pg.edu.pl

Cite as:
Akkermansia muciniphila is associated with human health: What should we know? Ostrowski B and Krawczyk B., ADV MICROBIOL-NY, 2025, 64, 3, 141-146, https://doi.org/10.2478/am-2025-0011

its growth in mouse models (Roopchand et al. 2015). Another study demonstrated that fucoids from brown seaweed increased the abundance of *Akkermansia* in mice with metabolic syndrome induced by a high-fat diet (Qingsen et al. 2017).

3. *Akkermansia muciniphila* is a mucin specialist

One of the key characteristics of *A.muciniphila* is the ability to degrade mucins and use them as an energy source. Mucins are high-molecular-weight glycoproteins continuously secreted by goblet cells, which constitute a significant component of the intestinal mucus and form the protective mucus layer. Of the 21 different mucins identified, mucin 2 (MUC2) is the predominant component of the colonic mucus layer and acts as its structural skeleton (Song et al. 2023). The mucus layer serves as the first line of defense, protecting the epithelium from inflammation and infection. Disruption of the mucus layer is an important factor in the development of intestinal diseases, including inflammatory bowel disease (IBD) and colorectal cancer. The mucus barrier maintains homeostasis by stimulating the growth of appropriate microbiota and preventing pathogens from contacting the epithelium (Song et al. 2023).

Mucin-degrading bacteria produce glycosyl hydrolases (GHs), specialized enzymes that enable them to break down mucins. The *A. muciniphila* genome contains genes encoding nine different GH families (Glover et al. 2022). It can utilize different combinations to hydrolyze up to 85% of mucin structures, allowing it to use mucins as its sole carbon source (Glover et al. 2022). As a result, *A. muciniphila* is often considered one of the most important mucin degraders in the human microbiota. The metabolism of mucins by *A. muciniphila*, in addition to the action of other bacterial species, releases monosaccharides, oligosaccharides, and short-chain fatty acids into the intestinal environment, thereby contributing to the modulation of intestinal homeostasis (Belzer et al. 2012). Although *A. muciniphila* degrades mucin, it does so in a controlled and selective manner, which (1) stimulates the production of new, healthy mucus, (2) supports the regeneration of the mucus and epithelial barrier, and (3) reduces inflammation and strengthens mucosal immunity (Si et al. 2022). As such, its presence in the gut microbiota is associated with better metabolic, immune, and barrier health (Table 1).

Table 1. *Akkermansia muciniphila* is positively associated with improved metabolic profiles, enhanced mucosal immunity, and a robust epithelial barrier.

Mechanism	**Effect**	**Reference**
Mucin degradation + mucus stimulation	Promotes goblet cell proliferation and maintains mucus thickness	Si et al. (2022)
Barrier reinforcement	Enhances tight junctions (ZO1, occludin, claudins), and TER ↑	
Immune modulation	↓ proinflammatory cytokines, ↑ IL-10, and ↑ Tregs	

IL-10 – interleukin-10; TER – transepithelial electrical resistance; Tregs – regulatory T cells; ZO-1 – zonula occludin-1.

4. The protective role of *Akkermansia muciniphila* in diseases

The primary reported benefits of *A. muciniphila* are associated with alleviating symptoms or preventing gastrointestinal disease, with a primary focus on Inflammatory Bowel Disease IBD. IBD refers to a group of diseases that cause inflammation of the bowel, with the primary types being ulcerative colitis (UC) and Crohn's disease (CD). Symptoms may include diarrhea, abdominal pain, fatigue, nausea, and weight loss. Significant evidence suggests a correlation between *A. muciniphila* and the development of IBD, although its nature remains under discussion. In a mouse study,

treatment with *A. muciniphila* for five weeks reduced inflammation caused by chemically induced colitis (Yilmaz et al. 2024). Another mouse model found that *A. muciniphila* improved clinical parameters, including spleen weight, colon inflammation index, colon histological score, and regulation of pro-inflammatory cytokines, with varying activity levels among strains (Zhai et al. 2019). In addition, *A. muciniphila* supplementation reduced serum and tissue inflammatory cytokines and chemokines in mice, along with reduced weight loss, improved histological scores, and enhanced barrier function (Bian et al. 2019).

The role of *A. muciniphila* in the prevention of IBD can be inferred from its reduced presence in IBD patients, with UC and CD exhibiting lower colonization rates and abundance compared to healthy individuals, both of which increase significantly after washed microbiota transplantation (Qu et al. 2021). Additionally, *A. muciniphila* was lower in patients with active UC compared to those with quiescent UC and healthy individuals (Zhang et al. 2020). The same study identified a reduction of sulfated mucins in the mucus of IBD patients as a potential cause of *A. muciniphila* reduction (Zhang et al. 2020).

Investigations into the mechanisms underlying the anti-inflammatory effects of *A. muciniphila* are ongoing. Aside from the well-known anti-inflammatory effects of short-chain fatty acids (SCFA) produced by the human microbiota, there have been reports that one of the main surface proteins of *A. muciniphila* (Amuc_1100) could play a crucial role (Wu et al. 2019).

The anti-inflammatory effect of *A. muciniphila* might also be beneficial for patients with Parkinson's disease (PD). Indeed, an *A. muciniphila* treatment alleviated artificially induced PD in mice, including neuroinflammation and motor dysfunction, while promoting neurogenesis (Qiao et al. 2024). However, the evidence for the beneficial effects *of A. muciniphila* remains inconclusive, with some reports not aligning with the previously mentioned results. One such study detected an increase in *A. muciniphila* in patients with colorectal cancer (Weir et al. 2013), suggesting that the relationship between *A. muciniphila* and host health might be more complex.

5. The role of *Akkermansia muciniphila* in obesity prevention

Another area in which *A. muciniphila* is heavily investigated for its beneficial effects is obesity, with the bacterium's anti-obesity effects demonstrated in several studies. An analysis of data from the American Gut Project has found an association between a higher abundance of *A. muciniphila* and a lower risk of obesity (Zhou et al. 2020). A randomized controlled trial reported that *A. muciniphila* supplementation reduced obesity, though the effects appear to be limited to individuals with a low baseline abundance of the bacterium (Zhang et al. 2025). In this regard, the reduction of *A. muciniphila* was associated with the development of atherosclerosis induced by a high-fat Western diet in apolipoprotein E knock-out mice (Li et al. 2016). Meanwhile, daily administration of *A. muciniphila* has been shown to prevent weight gain, hyperphagia, and dysglycemia caused by the dietary emulsifiers carboxymethylcellulose and polysorbate (Daniel et al. 2023).

Investigations into the anti-obesity mechanisms of *A. muciniphila* demonstrated that the species can alleviate the negative effects of interferon gamma (IFNγ) on glucose tolerance (Greer et al. 2016). Another potential mechanism of action involves Amuc_1100, which has some of the same effects as the live bacterium when purified or applied as part of pasteurized *A. muciniphila* (Anhê et al. 2017). It is very likely that the effects of *A. muciniphila* on obesity are not centred on a single mechanism, but result from several separate effects in conjunction with other members of the human gut microbiota. Furthermore, many studies have involved mice fed a high-fat diet, so the impact on different sources of obesity should still be investigated.

6. *Akkermansia muciniphila* - potential as a probiotic

As described previously, *A. muciniphila* has several potential benefits for human health. However, it is worth discussing whether it can be used as a probiotic. Aside from providing health benefits to the host, a good probiotic should be considered safe for human consumption, and it should be able to survive long enough in storage and after consumption to reach the gut. A toxicological analysis of pasteurized *A. muciniphila* did not reveal any mutagenic, clastogenic, or aneugenic effects, nor did it reveal any adverse neurobehavioural or pathological effects that would undermine its use as a food additive (Druart et al. 2021). A comparative analysis of *A. muciniphila* and the commonly used probiotic bacterium *Lactobacillus rhamnosus* GG revealed comparable levels of auto-aggregation, co-aggregation,

hydrophobicity, and antimicrobial activity, but a higher level of antibiotic resistance in *A. muciniphila*. It is generally recommended that probiotic bacteria have a low level of antibiotic resistance to prevent potential horizontal gene transfer. However, the presence of resistance genes associated with transferable genetic elements has not been reported in *A. muciniphila* (Cozzolino et al. 2020).

Methods for cultivating *A. muciniphila* have improved since its initial discovery. Using mucin in growth medium is costly and inconvenient, so the use of alternatives has been investigated. One study identified glucose or N-acetylglucosamine (a component of mucins) as a good source of carbon, and tryptone as a reliable source of nitrogen (Wu et al. 2024). Another study identified galactose, sialic acid, lactose, and chitosan as factors significantly promoting *A. muciniphila* growth (Meng et al. 2024).

7. Conclusions

A. muciniphila supplementation provides significant benefits for patients suffering from IBD. Its relationship with obesity seems to be more complex, though studies agree that it alleviates symptoms associated with a high-fat diet, which is common in Western countries. As a natural member of the human microbiota, *A. muciniphila* is generally considered safe, which is supported by evidence, and has been approved by EFSA. There are also no technical obstacles to its use as a commercial probiotic. *A. muciniphila*'s general functions are summarised in Figure 1.

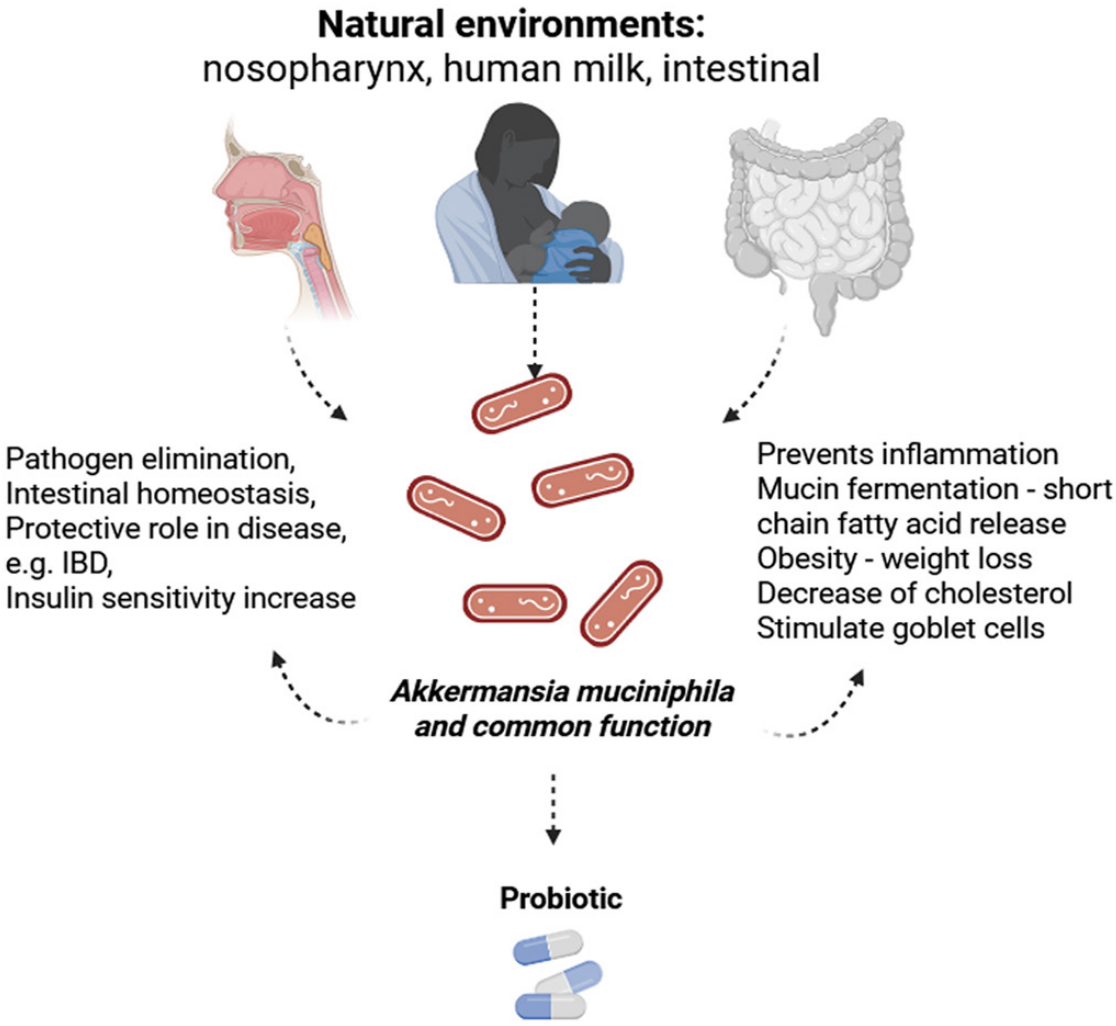

Figure1. Summary of the role of *A.muciniphila* in health and disease. Illustration created using Biorender (www.biorender.com). **Agreement number:** CA28PV7H2E

ORCID

Beata Krawczyk https://orcid.org/0000-0001-5528-8898

Conflict of interest

The authors do not report any financial or personal connections with other persons or organizations, which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

References

Anhê F, Marette A. A microbial protein that alleviates metabolic syndrome. Nat Med. 2017 Jan; 6:23(1):11-12. https://doi.org/10.1038/nm.4261

Azad MB, Kozyrskyj AL. CHILD Study Investigators. Gut microbiota of healthy Canadian infants: profiles by mode of delivery and infant diet at 4 months. CMAJ. 2013 Mar; 19:185(5):385-94. https://doi.org/10.1503/cmaj.121189

Belzer C, Chia LW, Aalvink S, Chamlagain B, Piironen V, Knol J, de Vos WM. Microbial metabolic networks at the mucus layer lead to diet-independent butyrate and vitamin B12 production by intestinal symbionts. *mBio*. 2017 Sep; 19:8(5):e00770-17. https://doi.org/10.1128/mBio.00770-17

Bian X, Wu W, Yang L, Lv L, Wang Q, Li Y, Ye J, Fang D, Wu J, Jiang X, et al. Administration of *Akkermansia muciniphila* ameliorates dextran sulfate sodium-induced ulcerative colitis in mice. Front Microbiol. 2019 Oct; 1:10:2259. https://doi.org/10.3389/fmicb.2019.02259

Cozzolino A, Vergalito F, Tremonte P, Iorizzo M, Lombardi SJ, Sorrentino E, Luongo D, Coppola R, Di Marco R. Succi M. Preliminary evaluation of the safety and probiotic potential of *Akkermansia muciniphila* DSM 22959 in comparison with *Lactobacillus rhamnosus* GG. Microorganisms. 2020 Jan; 30:8(2):189 https://doi.org/10.3390/microorganisms8020189

Daniel N, Gewirtz AT, Chassaing B. *Akkermansia muciniphila* counteracts the deleterious effects of dietary emulsifiers on microbiota and host metabolism. Gut. 2023 May; 72(5):906-917. https://doi.org/10.1136/gutjnl-2021-326835

Derrien M, Vaughan EE, Plugge CM, de Vos WM. *Akkermansia muciniphila* gen. nov., sp. nov., a human intestinal mucin-degrading bacterium. Int J Syst Evol Microbiol. 2004 Sep; 54(Pt 5):1469-1476. https://doi.org/10.1099/ijs.0.02873-0

Druart C, Plovier H, Van Hul M, Brient A, Phipps KR, de Vos WM, Cani PD. Toxicological safety evaluation of pasteurized *Akkermansia muciniphila*. J Appl Toxicol. 2021 Feb; 41(2):276-290. https://doi.org/10.1002/jat.4044

Earley H, Lennon G, Balfe Á, Coffey JC, Winter DC, O'Connell PR. The abundance of *Akkermansia muciniphila* and its relationship with sulphated colonic mucins in health and ulcerative colitis. Sci Rep. 2019 Oct; 30:9(1):15683. https://doi.org/10.1038/s41598-019-51878-3

Geerlings SY, Kostopoulos I, de Vos WM, Belzer C. *Akkermansia muciniphila* in the human gastrointestinal tract: when, where, and how? Microorganisms. 2018 Jul; 23:6(3):75. https://doi.org/10.3390/microorganisms6030075

Glover JS, Ticer TD, Engevik MA. Characterizing the mucin-degrading capacity of the human gut microbiota. Sci Rep. 2022 May; 19:12(1):8456. https://doi.org/10.1038/s41598-022-11819-z

Greer RL, Dong X, Moraes AC, Zielke RA, Fernandes GR, Peremyslova E, Vasquez-Perez S, Schoenborn AA, Gomes EP, Pereira AC, et al. *Akkermansia muciniphila* mediates negative effects of IFNγ on glucose metabolism. Nat Commun. 2016 Nov; 14:7:13329. https://doi.org/10.1038/ncomms13329

Grześkowiak Ł, Grönlund MM, Beckmann C, Salminen S, von Berg A, Isolauri E. The impact of perinatal probiotic intervention on gut microbiota: double-blind placebo-controlled trials in Finland and Germany. Anaerobe. 2012 Feb; 18(1):7-13. https://doi.org/10.1016/j.anaerobe.2011.09.006

Guo X, Zhang J, Wu F, Zhang M, Yi M, Peng Y. Different subtype strains of *Akkermansia muciniphila* abundantly colonize in southern China. J Appl Microbiol. 2016 Feb; 120(2):452-9. https://doi.org/10.1111/jam.13022

Kobayashi Y, Kawahara T, Inoue S, Kohda N. *Akkermansia biwaensis* sp. nov., an anaerobic mucin-degrading bacterium isolated from human faeces. Int J Syst Evol Microbiol. 2023 Feb; 73(1). https://doi.org/10.1099/ijsem.0.005697

Li J, Lin S, Vanhoutte PM, Woo CW, Xu A. *Akkermansia muciniphila* protects against atherosclerosis by preventing metabolic endotoxemia-induced inflammation in apoe-/- Mice. Circulation. 2016 Jun; 14:133(24):2434-46. https://doi.org/10.1161/CIRCULATIONAHA.115.019645

Meng X, Xv C, Lv J, Zhang S, Ma C, Pang X. Optimizing *Akkermansia muciniphila* Isolation and Cultivation: Insights into Gut Microbiota Composition and Potential Growth Promoters in a Chinese Cohort. Microorganisms. 2024 Apr; 28:12(5):881. https://doi.org/10.3390/microorganisms12050881

Zhang MX, Wu J, Zhao LP, Zhao WJ, Cui C, Shen YQ. *Akkermansia muciniphila* is beneficial to a mouse model of parkinson's disease, via alleviated neuroinflammation and promoted neurogenesis, with involvement of SCFAs. Brain Sci. 2024 Feb; 29:14(3):238. https://doi.org/10.3390/brainsci14030238

Qingsen S, Guanrui S, Meifang Z, Jingjing S, Cuiying X, Jiejie H, Guoyun L, Guangli Y. Dietary fucoidan improves metabolic syndrome in association with increased *Akkermansia* population in the gut microbiota of high-fat diet-fed mice. J Funct Foods. 2017 Nov; 28:136-146. https://doi.org/10.1016/j.jff.2016.11.002.

Qu S, Fan L, Qi Y, Xu C, Hu Y, Chen S, Liu W, Liu W, Si J. *Akkermansia muciniphila* alleviates dextran sulfate sodium (DSS)-induced acute colitis by NLRP3 activation. Microbiol Spectr. Microbiol Spectr. 2021 Oct; 31:9(2):e0073021.https://doi.org/10.1128/Spectrum.00730-21

Roopchand DE, Carmody RN, Kuhn P, Moskal K, Rojas-Silva P, Turnbaugh PJ, Raskin I. Dietary polyphenols promote growth of the gut bacterium *Akkermansia muciniphila* and attenuate high-fat diet-induced metabolic syndrome. Diabetes. 2015 Aug; 64(8):2847–2858. https://doi.org/10.2337/db14-1916

Si J, Kang H, You HJ, Ko G. Revisiting the role of *Akkermansia muciniphila* as a therapeutic bacterium. Gut Microbes. 2022 Jan-Dec; 14(1):2078619. https://doi.org/10.1080/19490976.2022.2078619

Song C, Chai Z, Chen S, Zhang H, Zhang X, Zhou Y. Intestinal mucus components and secretion mechanisms: what we do and do not know. Exp Mol Med. 2023 Apr; 55(4):681-691. https://doi.org/10.1038/s12276-023-00960-y

Weir TL, Manter DK, Sheflin AM, Barnett BA, Heuberger AL, Ryan EP. Stool microbiome and metabolome differences between col-

orectal cancer patients and healthy adults. PLoS One. 2013 Aug; 6:8(8):e70803.https://doi.org/10.1371/journal.pone.0070803

Wu H, Qi S, Yang R, Pan Q, Lu Y, Yao C, He N, Huang S, Ling X. Strategies for high cell density cultivation of *Akkermansia muciniphila* and its potential metabolism. Microbiol Spectr. 2024 Jan; 11:12(1):e0238623. https://doi.org/10.1128/spectrum.02386-23

Wu X, Yu D, Ma Y, Fang X, Sun P. Function and therapeutic potential of Amuc_1100, an outer membrane protein of *Akkermansia muciniphila*: A review. Int J Biol Macromol. 2025 May; 308(Pt 4):142442. https://doi.org/10.1016/j.ijbiomac.2025.142442

Yilmaz O, Okullu SO, Catakci M, Elmas MA, Pinheiro Y, Arbak S, Demir E, Schaefer KH, Kolgazi M. *Akkermansia muciniphila* improves chronic colitis-induced enteric neuroinflammation in mice. Neurogastroenterol Motil. 2024 Mar; 36(3):e14745. https://doi.org/10.1111/nmo.14745

Zhai R, Xue X, Zhang L, Yang X, Zhao L, Zhang C. Strain-specific anti-inflammatory properties of two *Akkermansia muciniphila* strains on chronic colitis in mice. Front Cell Infect Microbiol. 2019 Jul; 5:9:239. https://doi.org/10.3389/fcimb.2019.00239

Zhang T, Li P, Wu X, Lu G, Marcella C, Ji X, Ji G, Zhang F. Alterations of *Akkermansia muciniphila* in the inflammatory bowel disease patients with washed microbiota transplantation. Appl Microbiol Biotechnol. 2020 Dec; 104(23):10203-10215. https://doi.org/10.1007/s00253-020-10948-7

Zhang Y, Liu R, Chen Y, Cao Z, Liu C, Bao R, Wang Y, Huang S, Pan S, Qin L, et al. *Akkermansia muciniphila* supplementation in patients with overweight/obese type 2 diabetes: Efficacy depends on its baseline levels in the gut. Cell Metab. 2025 Mar; 4:37(3):592-605.e6. https://doi.org/10.1016/j.cmet.2024.12.010

Z**hou Q, Zhang Y, Wang X, Yang R, Zhu X, Zhang Y, Chen C, Yuan H, Yang Z, Sun L.** Gut bacteria *Akkermansia* is associated with reduced risk of obesity: evidence from the American Gut Project. Nutr Metab (Lond). 2020 Oct; 22:17:90. https://doi.org/10.1186/s12986-020-00516-1