Case Report

BIOMEDICAL Journal of Scientific & Technical Research

ISSN: 2574 -1241

DOI: 10.26717/BJSTR.2026.65.010143

Gastrointestinal Functional Testing-Informed Protocol Associated with Improvement in Gastrointestinal and Joint Symptoms: A Case Report

Constance Karstens[1]*, Chaana Rosenthal[2], Sara Wilson[3] and Oscar Coetzee[4]

[1]*Hawthorn University, Whitethorn, CA, Clinical Herbalist and Holistic Nutrition Educator and Practitioner, The Lamb Shoppe & Wellness Center, Hutchinson, MN, USA*

[2]*Functional Medicine Practitioner, My Wellness Consultant, Los Angeles, CA, USA*

[3]*Nutrition Consultant, Independent, San Diego, CA, USA*

[4]*Professor, Notre Dame of Maryland University, Baltimore, MD. Clinical Director, Functional Medicine, Natural Healthcare Center, Long Branch, NJ, USA*

***Corresponding author:** Constance Karstens, MS, Hawthorn University, Whitethorn, CA. Clinical Herbalist and Holistic Nutrition Educator and Practitioner, The Lamb Shoppe & Wellness Center, Hutchinson, MN, USA

ARTICLE INFO

Received: March 06, 2026

Published: March 20, 2026

Citation: Constance Karstens, Chaana Rosenthal, Sara Wilson and Oscar Coetzee. Gastrointestinal Functional Testing-Informed Protocol Associated with Improvement in Gastrointestinal and Joint Symptoms: A Case Report. Biomed J Sci & Tech Res 65(1)-2026. BJSTR. MS.ID.010143.

ABSTRACT

A female adult patient presented with a constellation of gastrointestinal and systemic symptoms including bloating, altered bowel function, fatigue, cognitive complaints, and progressive musculoskeletal discomfort. Given the patient's history of prior unresolved gastrointestinal issues and the absence of a unifying conventional diagnosis, a functional medicine-informed evaluation was pursued. Baseline symptom burden was assessed using the Medical Symptom Questionnaire (MSQ) and the Gastrointestinal Symptom Rating Scale (GSRS), the latter used with formal permission granted by AstraZeneca. A comprehensive stool analysis (GI Spotlight™ stool test) was obtained and used to help inform dietary and nutraceutical intervention strategies targeting digestive function, microbial balance, and intestinal barrier support. The patient underwent a personalized gut-focused intervention consisting of dietary modification and a targeted nutraceutical protocol designed to support digestive function, microbial balance, intestinal barrier integrity, and inflammation modulation. Symptom outcomes were tracked over approximately ten weeks with follow up assessments at five and ten weeks. Compared with baseline, total MSQ scores improved by 58.7% at the first follow-up and 82.7% by the final assessment. Improvements were observed across multiple domains, including digestive, musculoskeletal, energy, cognitive, and weight-related symptom categories.

GSRS domain scores demonstrated parallel reductions in gastrointestinal symptom severity over the same period. No adverse effects were reported. This case report highlights the potential for symptom improvement across gastrointestinal and extraintestinal domains following a comprehensive, gut-focused intervention. While causality cannot be established, the findings underscore the interconnected nature of gastrointestinal and systemic symptoms and support further investigation into individualized, microbiome-informed approaches.

Introduction

Chronic musculoskeletal pain and digestive complaints are commonly reported in clinical practice and are often managed as separate conditions. [1,2] In recent years, increasing attention has been given to the relationship between gastrointestinal health and systemic manifestations, including symptoms affecting bones, joints, muscles, tendons, and nerves. Emerging research suggests that alterations in the gut microbiota may influence musculoskeletal health through pathways involving intestinal barrier integrity, immune activation, and systemic inflammation. [3] The gut microbiome, composed of trillions of microorganisms residing within the gastrointestinal tract, plays a critical role in immune regulation, nutrient metabolism, and maintenance of mucosal integrity. [4] Disruption of this microbial ecosystem, commonly referred to as dysbiosis, has been associated

not only with gastrointestinal disorders but also with extraintestinal conditions, including metabolic disease, mood disorders, and musculoskeletal pain. [3,5-7] Diet is recognized as a major modifiable factor influencing gut microbial composition and intestinal permeability and may therefore contribute to systemic inflammatory processes that affect musculoskeletal tissues. [7,8] Among dietary factors implicated in gut-related symptomatology, gluten has been identified as a potential trigger in susceptible individuals.

In non-celiac gluten sensitivity, gluten exposure has been associated with increased intestinal permeability, immune activation, and both gastrointestinal and extraintestinal symptoms, including musculoskeletal complaints. [9,10] Symptom improvement following gluten elimination has been reported in this population, supporting a potential clinical link between dietary gluten, gut barrier function, and systemic symptom burden. This case report describes a 35-year-old female presenting with chronic gastrointestinal symptoms and diffuse musculoskeletal pain, and outlines clinical outcomes observed following implementation of a personalized nutraceutical protocol combined with a gluten-free diet. Changes in gastrointestinal and musculoskeletal symptoms were assessed longitudinally using patient-reported outcome measures.

Narrative

A 35-year-old female presented with a longstanding history of gastrointestinal complaints, including intermittent diarrhea, bloating, abdominal discomfort, and reflux symptoms. She also reported diffuse musculoskeletal pain involving multiple joint and muscle groups, described as persistent and impacting daily activities. These symptoms had been present for several years and were managed as separate clinical concerns. Prior to presentation, the patient had pursued various conservative approaches, including dietary modifications, chiropractic care, and over-the-counter supplements, with limited and inconsistent relief. She denied a history of inflammatory bowel disease, autoimmune disease, or diagnosed celiac disease. There was no report of recent infection, trauma, or significant changes in physical activity preceding symptom onset. At baseline, gastrointestinal symptoms were assessed using the Gastrointestinal Symptom Rating Scale (GSRS), a validated patient-reported outcome measure. Formal permission to use the GSRS tool for clinical assessment and reporting was granted by AstraZeneca. Broader symptom patterns, including musculoskeletal complaints, were assessed using the Medical Symptom Questionnaire (MSQ), a commonly used clinical symptom inventory. Baseline GSRS domain scores for diarrhea, indigestion, constipation, abdominal pain, and reflux are summarized in Table 1. Baseline MSQ domain scores, including musculoskeletal domains, are presented in Table 2.

Table 1: Medical Questionnaire (MSQ).

	Baseline 4/16/2025	5/19/2025	6/24/2025
Head	1	1	1
Eyes	1	0	0
Ears	1	0	0
Nose	2	0	0
Mouth/Throat	1	1	0
Skin	5	1	0
Heart	1	0	0
Lungs	0	0	0
Digestive tract	14	8	5
Joints/Muscles	10	3	1
Weight	11	3	0
Energy/Activity	12	2	3
Mind	14	8	2
Emotions	0	1	1
Other	0	3	0
Total	75	31	13
% Improvement from baseline		58.7%	82.7%

Table 2: Gastrointestinal Symptom Rating Scale.

DOMAIN	Diarrhea Syndrome	Indigestion Syndrome	Constipation Syndrome	Abdominal Pain Syndrome	Reflux Syndrome
Baseline 4/16/2025	3.6	4	3	1.3	1
5/19/2025	2.6	1.25	2.3	1.3	1
% Improvement from baseline	27.8%	68.8%	23.3%	0%	0%
6/24/2025	1.6	2.25	2.6	1	1
% Improvement from baseline	55.6%	43.8%	13.3%	23.1%	0%

The change in total MSQ score from baseline through follow-up visits is shown in Figure 1. Initial assessment also included a comprehensive stool analysis using the Designs for Health GI Spotlight™ test to further characterize gastrointestinal function. Findings demonstrated patterns consistent with digestive insufficiency and altered microbial balance, along with markers suggestive of intestinal barrier disruption, including elevated zonulin, and an increased anti-gliadin IgA, an immune response to gliadin in the intestines. Results further indicated reduced digestive capacity, features of dysbiosis, and markers consistent with increased intestinal permeability and low-grade inflammatory signaling. Based on clinical presentation and assessment findings, a personalized nutraceutical protocol targeting digestive function, intestinal barrier support, and microbial balance was initiated, along with a gluten-free diet. For symptomatic support of musculoskeletal pain, the patient also used a topical CBD cream during the intervention period. The intervention was selected to address gastrointestinal symptoms and provide systemic support, while musculoskeletal symptom changes were tracked longitudinally. Follow-up assessments were conducted at approximately one and two months following initiation of the intervention.

Gastrointestinal symptoms were reassessed using the GSRS, and changes in musculoskeletal symptoms were documented using the MSQ over the same period. Follow-up GSRS domain scores are presented in Table 1, and changes in MSQ domains are summarized in Table 2.

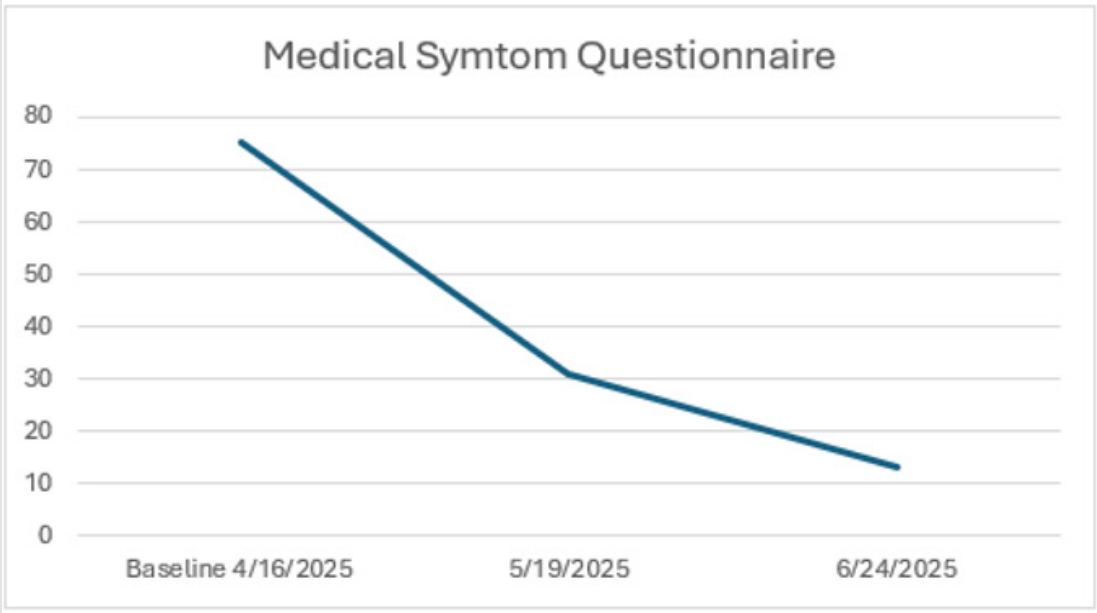

Figure 1: Improvements in the Medical Symptom Questionnaire.

Discussion

In this section, the scientific relevance of the dietary strategy and supplement ingredients used during the three-month intervention will be discussed in relation to the patient's presenting symptoms and observed outcomes. This discussion is intended to contextualize the clinical rationale, biological plausibility, and hypothesized mechanisms underlying the improvements noted, while acknowledging that causality cannot be established in a single-patient case report.

Gluten-Free Diet

At baseline, the patient reported chronic gastrointestinal symptoms including abdominal pain, bloating, gas, constipation, and reflux, along with extraintestinal symptoms such as joint pain and fatigue. Based on this symptom pattern and assessment findings suggestive of intestinal barrier dysfunction, a gluten-free dietary intervention was implemented. Gliadin, a component of gluten, has been shown to increase intestinal permeability in individuals with non-celiac gluten sensitivity through stimulation of zonulin release, a regulator of intestinal tight junction integrity. [11] Increased zonulin activity leads to loosening of tight junctions between enterocytes, which may promote immune activation and symptom development. Adherence to a gluten-free diet has been shown to improve gut barrier integrity in susceptible individuals, including those without celiac disease. [12] In addition to gastrointestinal symptoms, arthralgia and other musculoskeletal complaints have been commonly reported in individuals with non-celiac gluten sensitivity and may resolve following gluten elimination. [13] Given the patient's concurrent digestive and joint pain complaints, alongside her elevated anti-gliadin IgA, removal of gluten was selected as a foundational intervention to support both intestinal and systemic inflammatory balance.

Nacher CBD 500 mg

The patient reported persistent joint pain that affected daily comfort and physical activity. As part of the intervention, a topical cannabidiol preparation was used to provide localized musculoskeletal support. A randomized controlled trial in humans demonstrated that topical cannabidiol applied twice daily resulted in statistically significant improvements in patient-reported pain and disability in individuals with thumb basal joint arthritis compared to placebo. [14] Cannabidiol is thought to exert analgesic and anti-inflammatory effects through modulation of endocannabinoid signaling, transient receptor potential channels, and inflammatory mediators. In this case, topical CBD was used as an adjunctive, non-systemic approach to support joint comfort while broader gut-focused interventions were implemented.

OmegAvail TG1000™

Given the patient's gastrointestinal symptoms, inflammatory burden, and joint pain, omega-3 fatty acid supplementation was incorporated to support intestinal barrier integrity and inflammatory balance. Omega-3 fatty acids are incorporated into intestinal epithelial cell membranes and have been shown to support epithelial permeability, inhibit pro-inflammatory cytokine production, and promote synthesis of specialized pro-resolving mediators. [15] Omega-3 supplementation has also been shown to modulate the gut microbiota, increasing beneficial taxa and enhancing short-chain fatty acid production, including butyrate, which further supports mucosal integrity and immune regulation. [16,17] Clinical and translational studies in conditions such as irritable bowel syndrome and inflammatory bowel disease have associated higher omega-3 status with improvements in markers of intestinal permeability, including zonulin. [18,19] Additionally, attenuation of arthritic symptoms has been associated with improved gut barrier integrity following omega-3 supplementation. [20] From a musculoskeletal perspective, a randomized placebo-controlled trial demonstrated that krill oil supplementation at 4 g per day over six months significantly improved knee pain, stiffness, and physical function in adults with mild to moderate knee osteoarthritis. [21] A systematic review and meta-analysis further reported clinically meaningful reductions in chronic pain with omega-3 supplementation, with benefits observed as early as one month and sustained through six months [22].

GI Revive®

The patient's baseline presentation suggested compromised digestive capacity, altered microbial balance, and possible intestinal barrier disruption. To address these findings, a multi-ingredient gut support formula was incorporated. L-glutamine, a primary fuel source for intestinal epithelial cells, plays a central role in maintaining gut barrier integrity and regulating inflammatory signaling. In a randomized controlled trial involving patients with post-infectious irritable bowel syndrome with diarrhea, glutamine supplementation resulted in significant improvements in intestinal permeability, stool form, bowel movement frequency, and abdominal symptoms compared with controls. [23-25] N-acetyl-D-glucosamine is an amino sugar involved in the synthesis of glycoproteins and glycosaminoglycans that contribute to epithelial structure and mucosal defense. Experimental and translational data suggest that N-acetyl-D-glucosamine may support tight junction integrity and promote a healthy intestinal barrier and microbial environment. [26-30] When combined with mucin, as in GI Revive®, these components may further support mucosal protection, lubrication, and microbial interactions. [27,30-35] Additional support for mucosal integrity is provided by zinc carnosine, which has been shown to stabilize gastric and intestinal mucosa, support antioxidant status, and promote healthy inflammatory responses. [36-38] The inclusion of mucilaginous botanicals such as licorice, aloe, marshmallow, chamomile, and okra may further support mucosal soothing, tissue repair processes, and barrier function. [39-54] Beyond barrier support, several components of GI Revive® may contribute to immune and inflammatory modulation. Glutamine has been shown to reduce pro-inflammatory cytokines and support immune function in inflammatory bowel conditions. [23-25,55]

N-acetyl-D-glucosamine has shown potential benefit in inflammatory gastrointestinal conditions, including inflammatory bowel disease. [26,29,31,33,56] Additional compounds such as methylsulfonylmethane and quercetin support antioxidant capacity and inflammatory signaling balance through modulation of NF-κB, COX-2, and mast cell activity. [57-59] GI Revive® also contains prune powder, which has been shown to assist in improving bowel regularity and stool consistency in multiple randomized controlled trials. While the amount of prune material in a single serving of GI Revive® is lower than doses studied in isolation, these ingredients may contribute synergistically to improved stool frequency and form [60-63].

Tri-Butyrin Supreme™

Given evidence of intestinal barrier disruption and inflammatory signaling, a butyrate-based postbiotic was included to support epithelial health. Butyrate serves as the primary energy source for colonocytes and supports tight junction integrity, mucin production, and epithelial repair. Tributyrin supplementation has been shown to downregulate serum zonulin, lipopolysaccharide, and inflammasome-related markers while upregulating tight junction proteins in models of intestinal injury. [64] Additional studies have demonstrated increased regulatory T-cell activity, reduced pro-inflammatory cytokines, and improved oxidative stress markers following tributyrin supplementation. [65] A double-blind clinical trial in patients with knee osteoarthritis demonstrated that butyrate supplementation significantly reduced markers of intestinal permeability and systemic inflammation, while improving physical function measures, including grip strength, walking speed, and balance. [66] These findings support the hypothesis that improvements in gut barrier function may be associated with downstream benefits in joint pain and physical performance, although causality cannot be established in this case.

ProbioMed™ 100

Given the patient's gastrointestinal symptoms, evidence of immune activation, and concurrent musculoskeletal pain, a multi-strain probiotic formulation was included to support microbial balance, immune regulation, and systemic inflammatory control. The included *Lactobacillus* and *Bifidobacterium* strains have demonstrated strain-specific benefits related to immune modulation, intestinal barrier support, short-chain fatty acid production, and symptom reduction in gastrointestinal conditions such as irritable bowel syndrome, colitis, and constipation. [67-80] Collectively, these strains have been shown to modulate cytokine production, enhance immunoglobulin responses, support gut motility, and promote resilience of the intestinal microbiota following stressors such as antibiotic exposure. [67-70,73,76,81-85] In addition to gastrointestinal effects, several strains contained in the formulation have demonstrated reproducible systemic anti-inflammatory activity. *Lactobacillus acidophilus* La-14, *Bifidobacterium lactis* HN019, *Lactobacillus rhamnosus* GG, and *Bifidobacterium longum* have been shown in experimental and clinical studies to downregulate pro-inflammatory cytokines including tumor necrosis factor alpha and interleukin-6, while upregulating anti-inflammatory mediators such as interleukin-10. [67-70,76,82,86,87] These established immunomodulatory effects support the inclusion of a multi-strain probiotic to address inflammatory balance in this patient, although strain-specific contributions to observed gastrointestinal or musculoskeletal symptom changes cannot be isolated in a single-patient case report.

PaleoFiber® RS

Resistant starch supplementation was included to increase the abundance of beneficial microbes in the gut and encourage the production of short-chain fatty acids. Resistant starch has been shown to increase the abundance of beneficial gut microbes and increase the production of colonic short-chain fatty acids, particularly butyrate, which plays a key role in epithelial energy metabolism and barrier maintenance. [88] Clinical trials have demonstrated reductions in markers of intestinal permeability and endotoxemia following resistant starch supplementation, supporting its role in epithelial barrier function [89-91].

Patient Perspective

05/19/2025

I could feel that things were off in my body. I felt drained of energy. I had gut issues in the past, and no doctor was ever able to provide an answer for me. Now, as an adult, I could feel my health slipping and knew I needed to find help. I was exhausted. I had gained weight, especially in my mid-section. My face grew puffy. My stomach was swollen and bloated. Brain fog left me stuttering, grasping for words I couldn't remember. I also developed joint pain in my knees and elbows. The Spotlight test showed I was reacting to gluten, and after two weeks of a gluten-free diet and being on supplements, my puffy face slimmed out to my old self! I saw the change instantly. The bloating in my mid-section flattened out. My eyes brightened. The joint pain was gone. My energy increased. I no longer felt exhausted. This means the world to me. I sought treatment for an array of different symptoms and got the help and insight that I needed to regain my health.

06/24/2025

My energy continues to improve. I wake up early without an alarm and feel refreshed. Also, I don't need as much sleep as I did before, so that is a plus! I had a slip-up with gluten this past week, which accounts for the points I added for GI symptoms like bloating and gas. So, I know how to fix that.

Conclusion

This case report describes changes in gastrointestinal and musculoskeletal symptoms observed in a patient following a gut-focused intervention that included dietary modification and targeted nutraceutical support. Over the course of the intervention, patient-reported outcomes demonstrated improvement across multiple symptom

domains as measured by the Medical Symptoms Questionnaire (MSQ) and the Gastrointestinal Symptom Rating Scale (GSRS). From baseline to the final assessment, the patient's total MSQ score improved from 75 to 13, representing an 82.7% reduction in overall symptom burden. Improvements were observed across multiple MSQ domains, including the digestive tract, joints/muscles, weight, energy/activity, and cognitive symptoms. In parallel, GSRS scores demonstrated reductions across all measured gastrointestinal domains, including a 55.6% improvement in diarrhea symptoms, a 43.8% improvement in indigestion symptoms, and a 13.3% improvement in constipation symptoms, with abdominal pain and reflux scores remaining stable. These gastrointestinal improvements occurred alongside reported resolution of joint pain by the final follow-up visit. The intervention was comprehensive and multifactorial, incorporating a gluten-free diet and a nutraceutical protocol intended to support digestive function, intestinal barrier integrity, immune regulation, and inflammatory balance.

While the temporal association between the intervention and symptom improvement is notable, causality cannot be established in a single-patient case report. Nonetheless, this case supports the biological plausibility that gut-directed interventions may be associated with concurrent improvements in gastrointestinal and extraintestinal symptoms. Further controlled studies are warranted to better characterize the relationship between gut-focused strategies, gastrointestinal symptom burden, and musculoskeletal outcomes, as well as to clarify the contribution of individual components within personalized interventions.

Author Disclosure Statement

The authors declare that they have no competing interests.

References

1. Feldman DE, Carlesso LC, Nahin RL (2020) Management of patients with a musculoskeletal pain condition that is likely chronic: results from a national cross sectional survey. J Pain 21(7-8): 869-880.
2. Almario CV, Ballal ML, Chey WD, Nordstrom C, Khanna D, et al. (2018) Burden of gastrointestinal symptoms in the United States: results of a nationally representative survey of over 71,000 Americans. Am J Gastroenterol 113(11): 1701-1710.
3. Jeyaraman N, Jeyaraman M, Dhanpal P, Swaminathan Ramasubramanian, Arulkumar Nallakumarasamy, et al. (2025) Integrative review of the gut microbiome's role in pain management for orthopaedic conditions. World J Exp Med 15(2): 102969.
4. Salvadori M, Rosso G (2024) Update on the gut microbiome in health and diseases. World J Methodol 14(1): 89196.
5. Wang Y, Li Y, Bo L, Enyuan Zhou, Yanyan Chen, et al. (2023) Progress of linking gut microbiota and musculoskeletal health: casualty, mechanisms, and translational values. Gut Microbes 15(2): 2263207.
6. Randeni N, Bordiga M, Xu BA (2024) Comprehensive review of the triangular relationship among diet-gut microbiota-inflammation. IJMS 25(17): 9366.
7. Boer CG, Radjabzadeh D, Medina Gomez C, Sanzhima Garmaeva, Dieuwke Schiphof, et al. (2019) Intestinal microbiome composition and its relation to joint pain and inflammation. Nat Commun 10(1): 4881.
8. Mendonça C, Noll M, Castro M, Silveira E (2020) Effects of nutritional interventions in the control of musculoskeletal pain: an integrative review. Nutrients 12(10): 3075.
9. Barbaro MR, Cremon C, Wrona D, Daniele Fuschi, Giovanni Marasco, et al. (2020) Non-celiac gluten sensitivity in the context of functional gastrointestinal disorders. Nutrients 12(12): 3735.
10. Di Sabatino A, Volta U, Salvatore C, Paolo Biancheri, Giacomo Caio, et al. (2015) Small amounts of gluten in subjects with suspected nonceliac gluten sensitivity: a randomized, double-blind, placebo-controlled, crossover trial. Clin Gastroenterol Hepatol 13(9): 1604-1612.
11. Hollon J, Puppa E, Greenwald B, Goldberg E, Guerrerio A, et al. (2015) Effect of gliadin on permeability of intestinal biopsy explants from celiac disease patients and patients with non-celiac gluten sensitivity. Nutrients 7(3): 1565-1576.
12. Barbaro MR, Cremon C, Morselli Labate AM, Antonio Di Sabatino, Paolo Giuffrida, et al. (2020) Serum zonulin and its diagnostic performance in non-coeliac gluten sensitivity. Gut 69(11): 1966-1974.
13. Leonard MM, Sapone A, Catassi C, Fasano A (2017) Celiac disease and nonceliac gluten sensitivity: a review. JAMA 318(7): 647.
14. Heineman JT, Forster GL, Stephens KL, Cottler PS, Timko MP, et al. (2022) A randomized controlled trial of topical cannabidiol for the treatment of thumb basal joint arthritis. J Hand Surgery Am 47(7): 611-620.
15. Durkin LA, Childs CE, Calder PC (2021) Omega-3 polyunsaturated fatty acids and the intestinal epithelium - a review. Foods 10(1): 199.
16. Costantini L, Molinari R, Farinon B, Merendino N (2017) Impact of Omega-3 fatty acids on the gut microbiota. IJMS 18(12): 2645.
17. Chai Z, Zhang H, Ji X, Xinyi Hu, Yannan He, et al. (2024) The disparate effects of omega-3 PUFAs on intestinal microbial homeostasis in experimental rodents under physiological condition. Prostaglandins Leukot Essent Fatty Acids 203: 102643.
18. Linsalata M, Ignazzi A, D'Attoma B, Giuseppe Riezzo, Domenica Mallardi, et al. (2024) Relationship between markers of gut barrier function and erythrocyte membrane PUFAs in diarrhea-predominant IBS patients undergoing a low-FODMAP diet. Nutrients 16(16): 2706.
19. Marton LT, Goulart RDA, Carvalho ACAD, Barbalho SM (2019) Omega fatty acids and inflammatory bowel diseases: an overview. IJMS 20(19): 4851.
20. Tajik N, Frech M, Schulz O, Fabian Schälter, Sébastien Lucas, et al. (2020) Targeting zonulin and intestinal epithelial barrier function to prevent onset of arthritis. Nat Commun 11(1): 1995.
21. Stonehouse W, Benassi Evans B, Bednarz J, Vincent AD, Hall S, et al. (2022) Krill oil improved osteoarthritic knee pain in adults with mild to moderate knee osteoarthritis: a 6-month multicenter, randomized, double-blind, placebo-controlled trial. Am J Clin Nutr 116(3): 672-685.
22. Xie L, Wang X, Chu J, Xinyao He, Jingting Bao, et al. (2025) Effects of omega-3 fatty acids on chronic pain: a systematic review and meta-analysis. Front Med 12: 1654661.
23. Kim MH, Kim H (2017) The roles of glutamine in the intestine and its implication in intestinal diseases. IJMS 18(5): 1051.
24. Perna S, Alalwan TA, Alaali Z, Tahera Alnashaba, Clara Gasparri, et al. (2019) The role of glutamine in the complex interaction between gut microbiota and health: a narrative review. IJMS 20(20): 5232.

25. Zhou Q, Verne ML, Fields JZ, John J Lefante, Sarpreet Basra, et al. (2019) Randomised placebo-controlled trial of dietary glutamine supplements for postinfectious irritable bowel syndrome. Gut 68(6): 996-1002.

26. Chen JK, Shen CR, Liu CL (2010) N-acetylglucosamine: production and applications. Mar Drugs 8(9): 2493-2516.

27. Abo H, Muraki A, Harusato A, Tetsuya Imura, Maki Suzuki, et al. (2023) N-acetylglucosamine-6-O sulfation on intestinal mucins prevents obesity and intestinal inflammation by regulating gut microbiota. JCI Insight 8(16): e165944.

28. Aleman RS, Paz D, Cedillos R, Tabora M, Olson DW, et al. (2023) Attributes of culture bacteria as influenced by ingredients that help treat leaky gut. Microorganisms 11(4): 893.

29. Choi SI, Shin YC, Lee JS, Yoon YC, Kim JM, et al. (2023) N -acetylglucosamine and its dimer ameliorate inflammation in murine colitis by strengthening the gut barrier function. Food Funct 14(18): 8533-8544.

30. Qu D, Wang G, Yu L, Tian F, Chen W, et al. (2021) The effects of diet and gut microbiota on the regulation of intestinal mucin glycosylation. Carbohydr Polym 258: 117651.

31. Salvatore S, Heuschkel R, Tomlin S, S E Davies, S Edwards, et al. (2000) A pilot study of N-acetyl glucosamine, a nutritional substrate for glycosaminoglycan synthesis, in paediatric chronic inflammatory bowel disease. Aliment Pharmacol Ther 14(12): 1567-1579.

32. Sicard JF, Vogeleer P, Le Bihan G, Yaindrys Rodriguez Olivera, Francis Beaudry, et al. (2018) N-acetyl-glucosamine influences the biofilm formation of *Escherichia coli*. Gut Pathog 10(1): 26.

33. Zhu A, Patel I, Hidalgo M, Gandhi V (2015) N-acetylglucosamine for treatment of inflammatory bowel disease: a real-world pragmatic clinical trial. Nat Med J 7(4).

34. Corfield AP (2015) Mucins: a biologically relevant glycan barrier in mucosal protection. Biochim Biophys Acta 1850(1): 236-252.

35. Kim YS, Ho SB (2010) Intestinal goblet cells and mucins in health and disease: recent insights and progress. Curr Gastroenterol Rep 12(5): 319-330.

36. Hewlings S, Kalman D (2020) A review of zinc-l-carnosine and its positive effects on oral mucositis, taste disorders, and gastrointestinal disorders. Nutrients 12(3): 665.

37. Mahmood A, FitzGerald AJ, Marchbank T, E Ntatsaki, D Murray, et al. (2007) Zinc carnosine, a health food supplement that stabilises small bowel integrity and stimulates gut repair processes. Gut 56(2): 168-175.

38. Efthymakis K, Neri M (2022) The role of Zinc L-carnosine in the prevention and treatment of gastrointestinal mucosal disease in humans: a review. Clin Res Hepatol Gastroenterol 46(7): 101954.

39. Yang R, Yuan BC, Ma YS, Zhou S, Liu Y (2017) The anti-inflammatory activity of licorice, a widely used Chinese herb. Pharm Biol 55(1): 5-18.

40. Peterson CT, Sharma V, Uchitel S, Kate Denniston, Deepak Chopra, et al. (2018) Prebiotic potential of herbal medicines used in digestive health and disease. J Altern Complement Med 24(7): 656-665.

41. Ahluwalia B, Magnusson MK, Böhn L, Stine Störsrud, Fredrik Larsson, et al. (2020) Randomized clinical trial: effects of *Aloe barbadensis* Mill. extract on symptoms, fecal microbiota and fecal metabolite profiles in patients with irritable bowel syndrome. Neurogastroenterol Motil 32(8): e13860.

42. Deters A, Zippel J, Hellenbrand N, Pappai D, Possemeyer C, et al. (2010) Aqueous extracts and polysaccharides from marshmallow roots (*Althea officinalis* L.): cellular internalisation and stimulation of cell physiology of human epithelial cells *in vitro*. J Ethnopharmacol 127(1): 62-69.

43. Miraj S, Alesaeidi S (2016) A systematic review study of therapeutic effects of *Matricaria recuitta chamomile* (chamomile). Electron Physician 8(9): 3024-3031.

44. Ortaç D, Cemek M, Karaca T, Mehmet E Büyükokuroğlu, Zafer Ö Özdemir, et al. (2018) *In vivo* anti-ulcerogenic effect of okra (*Abelmoschus esculentus*) on ethanol-induced acute gastric mucosal lesions. Pharm Biol 56(1): 165-175.

45. Murray MT (2020) *Glycyrrhiza glabra* (Licorice). In: Pizzorno JE, Murray MT, (Eds.)., Textbook of Natural Medicine. (5th Edn.,), Elsevier, pp. 641-647. e3.

46. Raveendra KR, Jayachandra, Srinivasa V, Kadur Raveendra Sushma, Joseph Joshua Allan, et al. (2012) An extract of *Glycyrrhiza glabra* (GutGard) alleviates symptoms of functional dyspepsia: a randomized, double-blind, placebo-controlled study. Evid Based Complement Alternat Med 2012: 1-9.

47. Puram S, Suh HC, Kim SU, Bharathi Bethapudi, Joshua Allan Joseph, et al. (2013) Effect of GutGard in the management of *Helicobacter pylori:* a randomized double blind placebo controlled study. Evid Based Complement Alternat Med 2013: 1-8.

48. Zaghlool S, Shehata B, Abo Seif A, Abd El Latif H (2015) Protective effects of ginger and marshmallow extracts on indomethacin-induced peptic ulcer in rats. J Nat Sc Biol Med 6(2): 421.

49. Jabri MA, Aissani N, Tounsi H, Sakly M, Marzouki L, et al. (2017) Protective effect of chamomile (*Matricaria recutita L.*) decoction extract against alcohol-induced injury in rat gastric mucosa. Pathophysiology 24(1): 1-8.

50. Sah A, Naseef PP, Kuruniyan MS, Jain GK, Zakir F, et al. (2022) A comprehensive study of therapeutic applications of chamomile. Pharmaceuticals (Basel) 15(10): 1284.

51. Malek Mahdavi A, Javadivala Z, Ahmadian E (2022) Effects of okra (*Abelmoschus esculentus* L) on inflammatory mediators: a systematic review of preclinical studies. Food Funct 13(6): 3159-3169.

52. Wu J, Cao M, Hu M, Yu Gong, Jianming Xue, et al. (2022) Intervention effects of okra extract on brain-gut peptides and intestinal microorganisms in sleep deprivation rats. Evid Based Complement Alternat Med 2022: 1-13.

53. Messing J, Thöle C, Niehues M, Anna Shevtsova, Erik Glocker, et al. (2014) Antiadhesive properties of *Abelmoschus esculentus* (okra) immature fruit extract against *Helicobacter pylori* adhesion. PLoS One 9(1): e84836.

54. Khan S, Rafi Z, Baker A, Ambreen Shoaib, Ali G Alkhathami, et al. (2022) Phytochemical screening, nutritional value, anti-diabetic, anti-cancer, and anti-bacterial assessment of aqueous extract from *Abelmoschus esculentus* pods. Processes 10(2): 183.

55. De Oliveira Santos R, Da Silva Cardoso G, Da Costa Lima L, Mickael Laudrup de Sousa Cavalcante, Mariana Sousa Silva, et al. (2021) L-glutamine and physical exercise prevent intestinal inflammation and oxidative stress without improving gastric dysmotility in rats with ulcerative colitis. Inflammation 44(2): 617-632.

56. Dias AM, Correia A, Pereira MS, Catarina R Almeida, Inês Alves, et al. (2018) Metabolic control of T cell immune response through glycans in inflammatory bowel disease. Proc Natl Acad Sci U S A 115(20): E4651-E4660.

57. Shaik Y, Caraffa A, Ronconi G, Lessiani G, Conti P (2018) Impact of polyphenols on mast cells with special emphasis on the effect of quercetin and luteolin. Cent Eur J Immunol 43(4): 476-481.

58. Kim JE, Lee MR, Park JJ, Jun Young Choi, Bo Ram Song, et al. (2018) Quercetin promotes gastrointestinal motility and mucin secretion in loperamide-induced constipation of SD rats through regulation of the mAChRs downstream signal. Pharm Biol 56(1): 309-317.

59. Butawan M, Benjamin R, Bloomer R (2017) Methylsulfonylmethane: applications and safety of a novel dietary supplement. Nutrients 9(3): 290.

60. Koyama T, Nagata N, Nishiura K, Miura N, Kawai T, et al. (2022) Prune juice containing sorbitol, pectin, and polyphenol ameliorates subjective complaints and hard feces while normalizing stool in chronic constipation: a randomized placebo-controlled trial. Am J Gastroenterol 117(10): 1714-1717.

61. Lever E, Scott SM, Louis P, Emery PW, Whelan K (2019) The effect of prunes on stool output, gut transit time and gastrointestinal microbiota: a randomised controlled trial. Clin Nutr 38(1): 165-173.

62. Simpson AMR, De Souza MJ, Damani J, Connie Rogers, Nancy I Williams, et al. (2022) Prune supplementation for 12 months alters the gut microbiome in postmenopausal women. Food Funct 13(23): 12316-12329.

63. Stacewicz Sapuntzakis M, Bowen PE, Hussain EA, Damayanti Wood BI, Farnsworth NR (2001) Chemical composition and potential health effects of prunes: a functional food? Crit Rev Food Sci Nutr 41(4): 251-286.

64. Yang N, Lan T, Han Y, Haifeng Zhao, Chuhui Wang, et al. (2023) Tributyrin alleviates gut microbiota dysbiosis to repair intestinal damage in antibiotic-treated mice. PLoS One 18(7): e0289364.

65. Leonel AJ, Teixeira LG, Oliveira RP, Andrezza F Santiago, Nathália V Batista, et al. (2013) Antioxidative and immunomodulatory effects of tributyrin supplementation on experimental colitis. Br J Nutr 109(8): 1396-1407.

66. Karim A, Khan HA, Ahmad F, Qaisar R (2025) Butyrate (short-chain fatty acid) alleviates lipopolysaccharide-binding proteins and improves physical function in knee osteoarthritis patients. Int J Biol Macromol 307: 142017.

67. Park JS, Choi JW, Jhun J, Ji Ye Kwon, Bo In Lee, et al. (2018) *Lactobacillus acidophilus* improves intestinal inflammation in an acute colitis mouse model by regulation of Th17 and Treg cell balance and fibrosis development. J Med Food 21(3): 215-224.

68. Deng S, Pei C, Cai K, Wenyi Huang, Xiaoyi Xiao, et al. (2024) *Lactobacillus acidophilus* and its metabolite ursodeoxycholic acid ameliorate ulcerative colitis by promoting Treg differentiation and inhibiting M1 macrophage polarization. Front Microbiol 15: 1302998.

69. Donkor ON, Ravikumar M, Proudfoot O, S L Day, V Apostolopoulos, et al. (2012) Cytokine profile and induction of T helper type 17 and regulatory T cells by human peripheral mononuclear cells after microbial exposure. Clin Exp Immunol 167(2): 282-295.

70. Ashraf R, Vasiljevic T, Smith SC, Donkor ON (2014) Effect of cell-surface components and metabolites of lactic acid bacteria and probiotic organisms on cytokine production and induction of CD25 expression in human peripheral mononuclear cells. J Dairy Sci 97(5): 2542-2558.

71. De Roock S, Van Elk M, Van Dijk MEA, H M Timmerman, G T Rijkers, et al. (2010) Lactic acid bacteria differ in their ability to induce functional regulatory T cells in humans. Clin Experimental Allergy 40(1): 103-110.

72. Ala Jaakkola R, Forssten SD, Cheng J, Flavie Griffon, Isabelle Metreau, et al. (2025) Effect of an 8-week *Bifidobacterium lactis* HN019 supplementation on functional constipation: a multi-center, triple-blind, randomized, placebo-controlled trial. Mol Nutr Food Res 69(17): e70081.

73. Su GL, Ko CW, Bercik P, Yngve Falck Ytter, Shahnaz Sultan, et al. (2020) AGA clinical practice guidelines on the role of probiotics in the management of gastrointestinal disorders. Gastroenterology 159(2): 697-705.

74. Bengoa AA, Zavala L, Carasi P, Paula Carasi, Sebastián Alejandro Trejo, et al. (2018) Simulated gastrointestinal conditions increase adhesion ability of *Lactobacillus paracasei* strains isolated from kefir to Caco-2 cells and mucin. Food Res Int 103: 462-467.

75. Vergalito F, Bagnoli D, Maiuro L, Gianfranco Pannella, Valentino Palombo, et al. (2024) *Akkermansia muciniphila*: new insights into resistance to gastrointestinal stress, adhesion, and protein interaction with human mucins through optimised *in vitro* trials and bioinformatics tools. Front Microbiol 15: 1462220.

76. Dalziel JE, Anderson RC, Peters JS, Amy T Lynch, Nick J Spencer, et al. (2017) Promotility action of the probiotic *Bifidobacterium lactis* HN019 extract compared with prucalopride in isolated rat large intestine. Front Neurosci 11:20.

77. Hojsak I (2018) Probiotics in functional gastrointestinal disorders. In: Guandalini S, Indrio F, (Eds.,), *Probiotics and Child Gastrointestinal Health*. Advances in Experimental Medicine and Biology. Springer 1125: 121-137.

78. Martoni CJ, Srivastava S, Damholt A, Leyer GJ (2023) Efficacy and dose response of *Lactiplantibacillus plantarum* in diarrhea-predominant irritable bowel syndrome. World J Gastroenterol 29(28): 4451-4465.

79. Yao Q, Zhang W, Wang Y, Le Shi, Yixiao Zhao, et al. (2025) *Lactobacillus plantarum* and galacto-oligosaccharides synbiotic relieve irritable bowel syndrome by reshaping gut microbiota and attenuating mast cell hyperactivation. Nutrients 17(10): 1670.

80. Xia B, Lin T, Li Z, Jialin Wang, Yuwei Sun, et al. (2024) *Lactiplantibacillus plantarum* regulates intestinal physiology and enteric neurons in IBS through microbial tryptophan metabolites. J Agric Food Chem 72(32): 17989-18002.

81. Ayyash MM, Abdalla AK, AlKalbani NS, Mohd Affan Baig, Mark S Turner, et al. (2021) Invited review: characterization of new probiotics from dairy and nondairy products - insights into acid tolerance, bile metabolism and tolerance, and adhesion capability. J Dairy Sci 104(8): 8363-8379.

82. Rodenes Gavidia A, Lamelas A, Bloor S, Anthony Hobson, Sam Treadway, et al. (2023) An insight into the functional alterations in the gut microbiome of healthy adults in response to a multi-strain probiotic intake: a single arm open label trial. Front Cell Infect Microbiol 13: 1240267.

83. Ibarra A, Latreille Barbier M, Donazzolo Y, Pelletier X, Ouwehand AC (2018) Effects of 28-day *Bifidobacterium animalis* subsp. lactis HN019 supplementation on colonic transit time and gastrointestinal symptoms in adults with functional constipation: a double-blind, randomized, placebo-controlled, and dose-ranging trial. Gut Microbes 9(3): 236-251.

84. Qu Z, Wu Y, Jiang Y, Jiajia Fan, Li Cao, et al. (2025) Effects of two compound probiotic formulations on gastrointestinal symptoms and gut microbiota: a 4-week randomized, double-blind intervention trial. Nutrients 17(17): 2886.

85. Goya Jorge E, Gonza I, Bondue P, Germain Druart, Mohamed Al Chihab, et al. (2024) Unveiling the influence of a probiotic combination of *Heyndrickxia coagulans* and *Lacticaseibacillus casei* on healthy human gut microbiota using the TripleSHIME® system. Microbiol Res 285: 127778.

86. Capurso L (2019) Thirty years of *Lactobacillus rhamnosus* GG: a review. J Clin Gastroenterol 53(Supplement 1): S1-S41.

87. Yu DY, Oh SH, Kim IS, Gwang Il Kim, Jeong A Kim, et al. (2023) Effects of lactic acid bacteria fermented feed and three types of lactic acid bacteria (*L. plantarum, L. acidophilus, B. animalis*) on intestinal microbiota and T cell polarization (Th1, Th2, Th17, Treg) in the intestinal lymph nodes and spleens of rats. Anim Biosci 36(1): 156-166.

88. Wen JJ, Li MZ, Hu JL, Tan HZ, Nie SP (2022) Resistant starches and gut microbiota. Food Chem 387: 132895.

89. Cao S, Shaw EL, Quarles WR, Geoffrey Y Sasaki, Priyankar Dey, et al. (2022) Daily inclusion of resistant starch-containing potatoes in a Dietary Guidelines for Americans dietary pattern does not adversely affect cardiometabolic risk or intestinal permeability in adults with metabolic syndrome: a randomized controlled trial. Nutrients 14(8): 1545.

90. DeMartino P, Johnston EA, Petersen KS, Kris Etherton PM, Cockburn DW (2022) Additional resistant starch from one potato side dish per day alters the gut microbiota but not fecal short-chain fatty acid concentrations. Nutrients 14(3): 721.

91. Bush JR, Han J, Deehan EC, Scott V Harding, Madhura Maiya, et al. (2023) Resistant potato starch supplementation reduces serum histamine levels in healthy adults with links to attenuated intestinal permeability. J Funct Foods 108: 105740.

ISSN: 2574-1241

DOI: 10.26717/BJSTR.2026.65.010143

Constance Karstens. Biomed J Sci & Tech Res

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