Original Research Article

Homologous postbiotic-synergized tri-strain composition for immune-response modulation and intestinal barrier restoration

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Abstract: We investigated a tri-strain composition for immune-response modulation and intestinal barrier restoration built around Lactobacillus acidophilus LA-06, Lactobacillus plantarum LPL28, and Bifidobacterium longum BL21, each paired with a homologous postbiotic fraction. The platform used a fixed live-bacteria-to-postbiotic mass ratio of 1:2 and batch-matched fermentation supernatant as the sole protectant for the live fraction. In the dextran sulfate sodium colitis dataset, the three implementation examples reduced aggregate serum inflammatory mediators by 68.2%, 65.7%, and 67.4%, while increasing colonic tight-junction protein expression by 42.6%, 40.1%, and 41.8%; the live-bacteria-only comparator achieved 32.5% and 18.3%. Published evidence aligns with this direction, supporting barrier reinforcement, cytokine suppression, and the growing relevance of postbiotic preparations. The composition is therefore best understood as a barrier-centered platform in which strain complementarity, homologous postbiotic synergy, additive minimization, and reproducible anti-inflammatory performance define its scientific value.
Keywords: lactobacillus acidophilus; lactobacillus plantarum; bifidobacterium longum; postbiotics; immune modulation; intestinal barrier

1. Introduction

Immune dysregulation and intestinal barrier impairment form a reciprocally reinforcing axis in inflammatory bowel disease and related inflammatory states. When epithelial tight junctions are disrupted, antigen flux and cytokine amplification increase; when barrier integrity is restored, inflammatory load often declines in parallel. Many probiotic products still rely on simple live-bacteria blending without a coordinated strategy for immediate activity, process continuity, and strain-level complementarity.

Here we evaluate a tri-strain composition in which each live strain is paired with its homologous postbiotic fraction. The design assigns complementary roles to L. acidophilus LA-06, L. plantarum LPL28, and B. longum BL21 while using same-batch fermentation supernatant as the only protectant for the live fraction.

2. Materials and methods

The invention dataset comprised three implementation examples and one live-bacteria-only comparator. The live fraction contained L. acidophilus LA-06, L. plantarum LPL28, and B. longum BL21, and each strain was paired with its homologous postbiotic fraction. The overall live-bacteria-to-postbiotic mass ratio was fixed at 1:2, with an internal strain ratio of 2:3:5 in both fractions.

Each strain underwent independent fermentation. One-third of each batch was directed to the live-bacteria lyophilized fraction and two-thirds to the postbiotic fraction. The live fraction was freeze-dried using five-fold concentrated sterile supernatant from the same fermentation batch as the sole protectant; the postbiotic fraction was thermally inactivated at 65 degrees C for 30 minutes, sterility verified, and then freeze-dried.

Preclinical verification used a dextran sulfate sodium acute colitis model in male BALB/c mice with six groups: Blank control, model control, Example 1, Example 2, Example 3, and comparative example. Animals received 10 mg composition per 10 g body weight per day by gavage for 7 days. Main readouts were disease activity index, colon length, serum TNF-alpha, IL-6, IL-1beta, and colonic occludin and ZO-1 expression.

Table 1. Core formulation parameters and preclinical outcomes.

Group	Core composition	Live: Postbiotics	Protectant	Inflammatory-factor reduction	Tight-junction increase
Example 1	3 live strains + homologous postbiotics	1:2	Batch-matched supernatant	68.2%	42.6%
Example 2	3 live strains + homologous postbiotics	1:2	Batch-matched supernatant	65.7%	40.1%
Example 3	3 live strains + homologous postbiotics	1:2	Batch-matched supernatant	67.4%	41.8%
Comparative	3 live strains only	—	10% skim-milk solution	32.5%	18.3%

3. Results

The three examples consistently outperformed the live-bacteria-only comparator. Aggregate serum inflammatory-factor reduction reached 68.2% in Example 1, 65.7% in Example 2, and 67.4% in Example 3, compared with 32.5% in the comparative group. Colonic tight-junction protein expression increased by 42.6%, 40.1%, and 41.8% in Examples 1-3, whereas the comparator produced an 18.3% increase. The narrow spread among the three examples indicates that the operating range remained stable rather than depending on a single fragile optimization point.

These findings support a coordinated mechanism in which live bacteria provide colonization-oriented and strain-specific signaling, while homologous postbiotics contribute rapid anti-inflammatory activity, process stability, and barrier-supportive bioactivity.

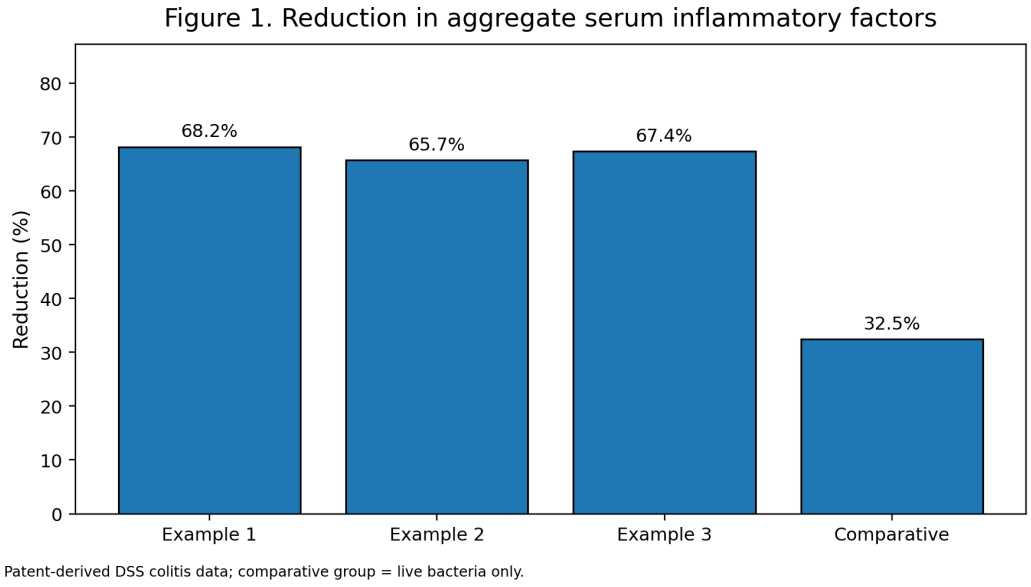

Figure 1. Aggregate reduction in serum inflammatory mediators across the three implementation examples and the live-bacteria-only comparator.

4. Evidence context

Published evidence supports the platform. Strain-specific Lactobacillus acidophilus models enhance intestinal tight-junction barrier function, protect against DSS colitis, and inhibit TNF-alpha-induced permeability. Lactobacillus plantarum studies report preservation of occludin and ZO-1, lower IL-1beta, IL-6, and TNF-alpha, and improved colitis severity. Bifidobacterium longum strains likewise improve barrier function and colitis-related outcomes in DSS models.

The postbiotic arm is also supported. The ISAPP consensus framework defines postbiotics as preparations of inanimate microorganisms and/or their components that confer a health benefit on the

host. Recent work further showed that both viable probiotic and heat-inactivated postbiotic interventions can ameliorate DSS colitis, reduce pro-inflammatory mediators, and restore key tight-junction proteins. Updated evidence syntheses also suggest that multi-strain probiotics show the most favorable signal for ulcerative colitis remission support and relapse reduction among probiotic strategies, despite persistent heterogeneity.

5. Discussion

The main strength of the composition lies in whole-platform architecture rather than in any single ingredient. Homologous postbiotic pairing links immediate activity to colonization-oriented support, while the same-batch protectant strategy tightens process continuity and reduces dependence on generic additive systems.

The preclinical dataset and the external literature point in the same direction: A barrier-centered, anti-inflammatory multi-strain system can be made more coherent when live organisms and their homologous postbiotic fractions are developed together. Although the present results do not replace independent clinical validation, they provide a strong translational basis for further study with prespecified inflammatory, barrier, and remission-related endpoints.

6. Conclusion

In conclusion, this tri-strain composition integrates Lactobacillus acidophilus LA-06, Lactobacillus plantarum LPL28, and Bifidobacterium longum BL21 with homologous postbiotic fractions in a single barrier-oriented platform. Across three implementation examples, the composition consistently exceeded the live-bacteria-only comparator in both inflammatory-factor reduction and tight-junction restoration. The strongest claim for the platform is therefore its technical coherence: Strain complementarity, postbiotic synergy, additive minimization, and reproducible preclinical performance converge within one formulation logic.

About the author

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