

Assessing the Efficacy of Postbiotics as a Chemopreventive Agent Against Colorectal Cancer: A Systematic Review

Rasika S ¹, Sindhu R ^{2*}, Gibbson Derick D ³, Lubna Fathima ⁴, Prabu D ⁵, Rajmohan M ⁶, Dinesh Dhamodhar ⁷

¹Undergraduate, SRM Dental College, Ramapuram, Bharathi Salai, Chennai, Tamil Nadu, India.

^{2*,4}MDS, Senior Lecturer, Department of Public Health Dentistry, SRM Dental College, Ramapuram, Bharathi Salai, Chennai, Tamil Nadu, India.

*Corresponding Author Email: researchphdsrm@gmail.com

³Postgraduate, Department of Public Health Dentistry, SRM Dental College, Ramapuram, Bharathi Salai, Chennai, Tamil Nadu, India.

⁵PhD, Head of the Department, Department of Public Health Dentistry, SRM Dental College, Ramapuram, Bharathi Salai, Chennai, Tamil Nadu, India.

^{6,7}MDS, Reader, Department of Public Health Dentistry, SRM Dental College, Ramapuram, Bharathi Salai, Chennai, Tamil Nadu, India.

*Corresponding Author: Dr. Sindhu R, MDS, Senior Lecturer, Department of Public Health Dentistry, SRM Dental College, Ramapuram, Bharathi Salai, Chennai, Tamil Nadu, India. Email: researchphdsrm@gmail.com

ABSTRACT

Background: The incidence of cancer has been rising rapidly in recent years, Postbiotics shows promising therapy in preventing colorectal cancer. It includes wide range of complex macromolecules such as inactivated microbial cells, cellular fractions or metabolites and provide various physiological health benefits to host. They exert anti-inflammatory, anti-proliferative and anti-cancer properties.

Aim: This systematic review was conducted to evaluate the efficacy of postbiotics against colorectal cancer in animal study and in vivo study.

Materials and methods: In this study, Data extraction were searched and analyzed with PRISMA flow chart. Total of five articles were included for the study based on the inclusion and exclusion criteria. Quality assessment was done using the RoB 2 second version of Cochrane's risk of bias tool.

Results: The results of the systematic review indicate that postbiotics provides immune-modulating effects anti-proliferative, anti-inflammatory, apoptosis induce properties may contribute as chemo preventive agent for prevention of colorectal cancer.

Conclusion: Postbiotics may provide efficacy in anti-cancer properties and can be used as adjuvant therapy but more research is needed to confirm its efficacy and optimal usage. Further research and clinical trials are required to assess its therapeutic roles and safety in developing the outcomes of radiotherapy in cancer patients.

Keywords: Postbiotic, colorectal cancer, anti-proliferative, anti-inflammatory, immune mediating.

How to cite this article: Rasika S, Sindhu R, Derick GD, Fathima L, Prabu D, Rajmohan M, Dhamodhar D. Assessing the efficacy of postbiotics as a chemopreventive agent against colorectal cancer: a systematic review. *Int J Drug Deliv Technol.* 2026;16(7s): 199-208; DOI: 10.25258/ijddt.16.7s.23

INTRODUCTION:

Colorectal cancer (CRC) contributed for 1 in every 10 cancer cases and nearly 1 in 10 cancer-related deaths in 2020, ranking as the third most common cancer, following lung cancer, which was responsible for 18% of cancer-related deaths¹. CRC is a complex disease influenced by combination of environmental, genetic, and lifestyle factors and the interactions among these elements.² Treatment for colorectal cancer includes surgery, chemotherapy, radiotherapy, molecular targeted therapy, immunotherapy, and other treatments. Present

chemotherapy regimens are frequently linked with significant side effects, including gastrointestinal toxicity, hematologic toxicity, neuropathy, and cardiac damage.³ Thus, there is an utmost need for novel treatment and prophylactic strategies. Researchers have begun focusing on the development of anticancer agents derived from natural products, which are believed to have a more favourable side effect profile. Such natural products are referred to as postbiotics.⁴ Postbiotics are produced by probiotics (food-grade microorganisms) through either active secretion or passive release after cell lysis. They can take various

Assessing The Efficacy Of Postbiotics As A Chemo Preventive Agent Against Colorectal Cancer: A Systematic Review

forms, including complex microbial cultures, food products, and intestinal contents.⁵ Postbiotics exert stronger modulatory effects on the gut microbiome than probiotics do. They possess anti-inflammatory, antimicrobial, antioxidant, immunomodulatory, and intestinal barrier-enhancing properties. In terms of cancer treatment, postbiotics offer several advantages, including immunomodulation and anticarcinogenic properties.⁶ Metabolites produced by strains of *Bifidobacterium*, *Lactobacillus plantarum*, *Lactobacillus acidophilus*, and other lactic acid bacteria have shown anticarcinogenic effects.⁷ Emerging evidence suggests that probiotics have potential anticancer properties, selectively targeting cancer cells and positioning postbiotics as a valuable adjunct to conventional cancer therapies.⁸ Various cancer types can receive a new therapeutic approach through the local and systemic effects of these metabolites on cancer cells.⁹ Postbiotics produce immunomodulatory effects in the host immune system through their interaction with microbial products, which occurs via postbiotic-mediated communication.¹⁰ Pattern recognition receptors (PRRs) detect microbe-associated molecular patterns (MAMPs) to initiate a signalling cascade that modifies the host immune system.¹¹ Scientific investigations shows that bacteriocins, exopolysaccharides, peptidoglycans and short-chain fatty acids (SCFAs) together plays vital role in triggering anticancer effects. Therefore, postbiotics have been developed as an innovative approach to manage gut microbiota and slow the advancement of colorectal cancer (CRC).¹² They present new opportunities for both the prevention and treatment of this disease. This review summarizes the effectiveness of postbiotics as chemo preventive agents for colorectal cancer.¹³ Consequently, postbiotics have emerged as a promising strategy for modulating the intestinal microbiota and inhibiting the progression of colorectal cancer (CRC).¹⁴ They present new opportunities for both the prevention and treatment of this disease. This review summarizes the effectiveness of postbiotics as chemo preventive agents for colorectal cancer.

MATERIALS AND METHODS:

Search strategies:

This systematic review shows Postbiotic effects in CRC, that collects information on major databases, including PubMed, Google Scholar, ScienceDirect, and ResearchGate, to collect relevant data.

Eligibility criteria:

Inclusion Criteria:

- Original in vitro, in vivo, or clinical studies assessing postbiotics in CRC.(2015-2025)
- Articles provides results such as tumour inhibition, apoptosis, immune modulation, in relation to postbiotics.

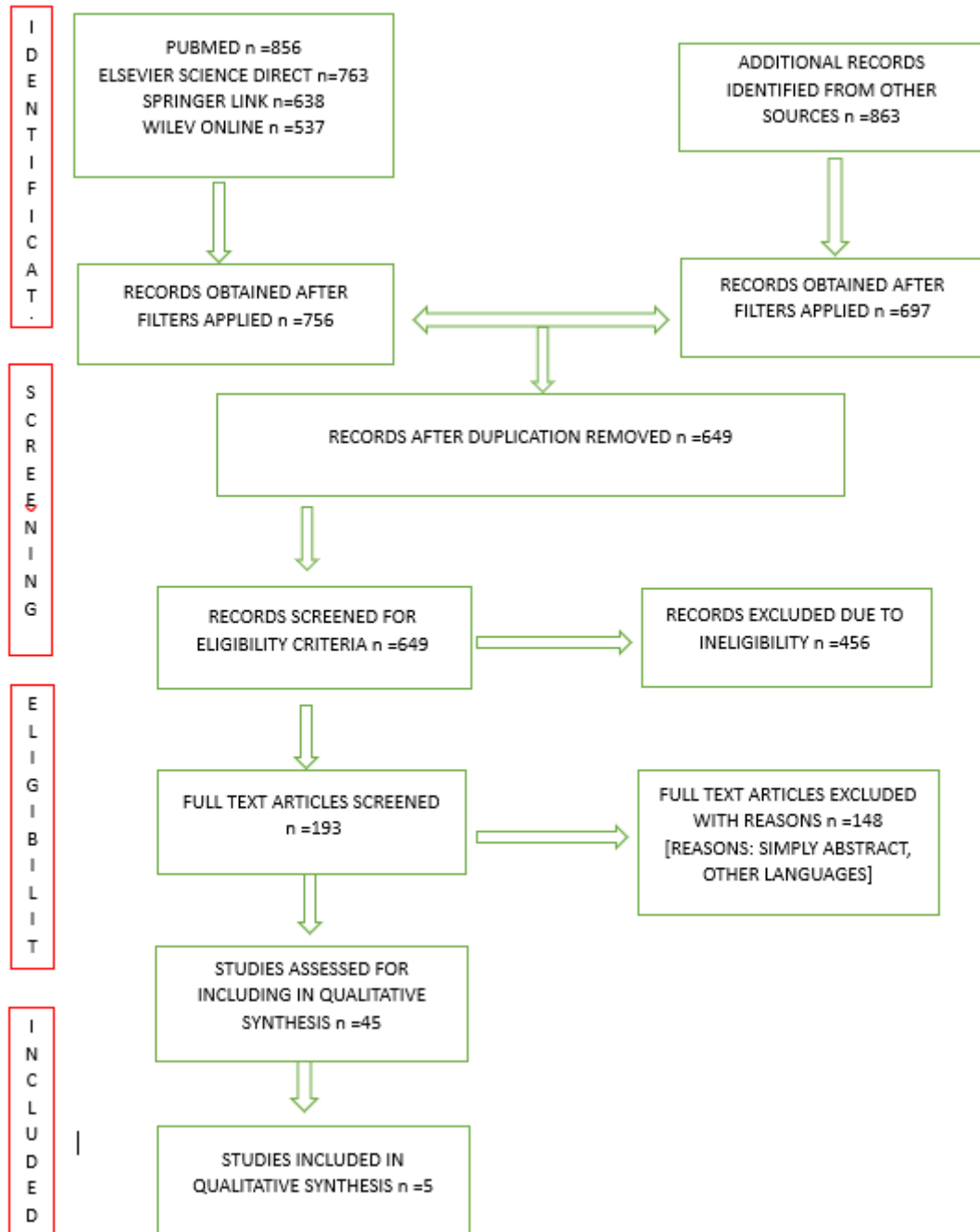
Exclusion Criteria:

- Reviews, editorials, case reports, abstracts only, or preprints.
- Studies published in language other than English.

FIGURE 1: PRISMA flow diagram for recently conducted systematic reviews that solely involved database and registration searches

Assessing The Efficacy Of Postbiotics As A Chemo Preventive Agent Against Colorectal Cancer: A Systematic Review

PRISMA DIAGRAM



RESULTS

TABLE 1: CHARACTERISTICS OF THE INTERVENTIONS IN THE INCLUDED STUDIES

ME	STUDY DESIGN	MODEL	SAMPLE SIZE	TIME PERIOD	INTERVENTION
	RESEARCH PAPER				
aladi et.al	Case control study	Animal model study	A total of 336 COBB 500 chicks, aged one day, were procured from a commercial hatchery and allocated randomly to eight dietary treatment groups, housed in a closed system facility.	35 days	The treatments included two control groups (T1: basal diet; T2: basal diet + 0.01% oxytetrisc) and six test groups, each receiving a different additive (postbiotics TL1, RS5, RI11,or paraprobiotics RG11,RG14,or RI11) at a concentration of 0.2% using 16S rRNA sequencing of colon mucosa.
anson et.al	Case control study	Animal model study	A total of 400 broiler chicks were used in this study, which were split into two replicates. Each replicates contains 200 chicks that were further divided into 8 floor pens lined with pine wood shaving.	21 days	Birds were weighed on days 1, 14and 21. On day 14 they were given a 10X dose of Coccivac B52 vaccine. Between day 1 and 19 three birds from negative control (Coccivac plus postbiotic) group were autopsied.The remaining birds were orally administered 1-3mL of C.perfringes broth culture,containing 10 ⁷ -10 ⁹ colony forming units(cfu)/mL once daily for three consecutive days (day17-19). On day 21 all birds were weighed and examined for necrotic enteritis lesion.
al [2024]	Research article	Animal model study	A total of 80 broiler chicks were used and divided into 4 groups each consists of 20 chicks.	42 days	Dietary treatments were based on basal diet which is supplemented with postbiotics at concentrations of 0.000%,0.015%, 0.030%, or 0.045%.
vy et.al	Research article	In vivo study model	A total of 3 SCFA salts were used in combination with Dex.	72 hours	(SCFA) salts mainly magnesium acetate (MgA), sodium propionate (NaP), and sodium butyrate (NaB) were combined with dexamethasone (Dex) with most active

Table 1 shows the

Assessing The Efficacy Of Postbiotics As A Chemo Preventive Agent Against Colorectal Cancer: A Systematic Review

characteristics of the interventions in the studies that are included. In all the above studies, some studies were postbiotics incorporated into broiler chicks and in other postbiotics were extracted and treated with various concentrations as shown in Table 2. Outcomes with CRC prevention that are given by many authors were taken and in which techniques it was performed was also mentioned.

TABLE 2: CHARACTERISTICS OF THE PRIMARY OUTCOME AND RESULTS OF THE STUDIES

S.NO	AUTHOR	FINDINGS	OUTCOME
1.	Yohanna Danladi et.al	The 16S rRNA gene sequencing of colon mucosa samples demonstrate clear changes in the composition of gut microbiota. Group that received paraprobiotic RI11 had low levels of proteobacteria compared with negative control group. Positive control group showed increase in Firmicutes. Additionally probiotic diet was included to reduction in Enterococcus population, whereas birds fed with the postbiotic TL1 diet had higher abundance of bacteriodes.	This study reveals that adding postbiotics to broiler feed enhances gut microbiota, promotes increase in beneficial bacteria like Firmicutes and decrease in harmful bacteria like Proteobacteria.
2.	Casey N. Johnson et.al	In both trials, postbiotic treatment noticeably lowered the number of <i>C. perfringes</i> colony forming unit (CFU) in the Jejunum the birds were challenged with <i>C. perfringes</i> , those given postbiotic had significantly fewer CFUs than the inoculated only groups (9.5 vs. 14.0×10^5 in Trail 1 and 2.3 vs 5.9×10^5 in Trail. Moreover, combining Coccivac with postbiotic further reduced CFU count compared to using Coccivac alone (1.7 vs 6.2×10^5 in Trail 1 and 0.5 vs 7.4×10^5 in Trail 2).	In this study it shows that adding postbiotics improves weight gain, reduced <i>C. perfringes</i> colonies and mortality rates in challenged birds. It had no effects on weight gain in healthy birds, due to its immune-modulating effects.

Assessing The Efficacy Of Postbiotics As A Chemo Preventive Agent Against Colorectal Cancer: A Systematic Review

3.	Desheng Li et.al	Broiler chicks are supplemented with 0.015% postbiotic effectively increases immunity, leading to improved growth performance and reduced mortality rates.	Results shows that Postbiotics from Bacillus subtilis ACCC 11025 provides improvement in growth rates and immune function, and skeletal health in broiler chicks.
4.	Radwa A Eladwy et.al	The studies found strong synergy between Dex and NaB at 2:8 ratio, exhibiting enhanced anti-AGS cell activity (CI<1) that exceeds individual treatment effects.	This study suggests that antiproliferative effects were observed in AGS cells treated with NaB, NaP, and MgA with NaB demonstrating the most pronounced dose-dependent response.
5.	Behnam Omid Sarajar et.al	Latilactobacillus sakei and Fresh (containing L.rhamnosus and L.paracasei) postbiotics able to decrease cell viability and proliferation and increase apoptosis in HCT-116 colorectal cancer cells. In addition, FreshQ postbiotics seemed more potent than Latilactobacillus sakei.	Postbiotics derived from Fresh (FQ) and Latilactobacillus sakei (L.sakei) inhibits the growth of HCT-116 colon cells and induced apoptosis and FQ shows greater potent than L.sakei.

Table 2 shows the outcome and results of postbiotics incorporated into broiler chicks; postbiotics extracted and treated with concentrations associated with CRC prevention in the studies that are mentioned above positive outcomes and findings were seen in the above studies showing antiproliferative properties, inducing

TABLE 3: RISK OF BIAS ASSESSMENT

S. No.	Author (Year)	Bias from Randomization Process	Bias due to Deviations from Intended Interventions	Bias due to Missing Outcome Data	Bias in Measurement of Outcome	Bias in Selection of the Reported Result	Overall Risk of Bias
1	Yohanna Danladi et al., 2022	Low Risk	Some concerns	Low Risk	Low Risk	Some concerns	Some concerns
2	Casey N. Johnson et al., 2019	Low Risk	Some concerns	Low Risk	Low Risk	Low Risk	Low Risk
3	Desheng Li, 2024	Some concerns	Low Risk	Low Risk	Low Risk	Some concerns	Some concerns
4	Radwa A. Eladwy et al., 2024	Low Risk	Some concerns	Low Risk	Low Risk	Low Risk	Low Risk

Assessing The Efficacy Of Postbiotics As A Chemo Preventive Agent Against Colorectal Cancer: A Systematic Review

S. No.	Author (Year)	Bias from Randomization Process	Bias due to Deviations from Intended Interventions	Bias due to Missing Outcome Data	Bias in Measurement of Outcome	Bias in Selection of the Reported Result	Overall Risk of Bias
5	Behnam Omidi Sarajar et al., 2022	● Some concerns	● Low Risk	● Low Risk	● Low Risk	● Some concerns	● Some concerns

Table 3 shows the bias analysis of all the included studies. It is categorized as Low risk; some concern; high risk. ● **green colour** indicates Low Risk for adequate methods and transparency bias unlikely to affect results; ● **yellow colour** indicates Some Concerns for uncertainty about risk of bias due to incomplete reporting or unclear procedures; ● **red colour** indicates high Risk for Clear flaws in design or reporting that may significantly affect results. Categorization was done according to the RoB 2 second version of Cochrane’s risk of bias

DISCUSSION:

This systematic review shows that postbiotics are substance produced by bacteria but not containing any live organisms may have the potential to help prevent CRC. These natural byproducts offer various health benefits and findings suggest that postbiotics can be effective method for preventing CRC. These bioactive compounds have significant features like anti-inflammatory, immunomodulatory, and antitumor effects across diverse models. Postbiotic supplements that are relevant for research especially in relation to CRC. Postbiotic supplements are absorbed through a combination of direct intestinal transport and targeted cell signalling, rather than the biological colonization required by live probiotics. Because they are already waste or byproduct, they do not need to survive the stomach to be active. No pharmaceutical-grade postbiotic tablet or injection is currently approved as a standalone drug for treating CRC. Most clinical use of postbiotics in CRC is as adjunctive supplement (eg, to improve gut health, reduce dysbiosis or support outcomes after surgery) rather than a primary anticancer medication. Commercial postbiotic supplements available as capsules and tablet form some of them are TULA postbiotic supplement(MRP₹1999)- 1capsule/day for gut health and digestive welfare. Swanson Postbiotic Epicor 500mg(MRP₹2796)- Postbiotic capsule with yeast

fermentate metabolites, often used for general immune and gut support. Thaenabiotic postbiotic supplement(30 capsules:\$499)- 1 capsule/day higher end postbiotic capsule formulation geared towards gut health. Epicor(MRP₹2500)- 500mg/day yeast derived postbiotic provides gut and immune support. There is no universal standard dosage for CRC. It also contains supplements to reduce postoperative complications. PoZibio(MRP is not listed in India)for postoperative dysbiosis which is delivered as chewable gummy that maintains healthy gut environment and balance between bacteria after colon cancer surgery. Butyrate supplementation evaluating 900mg of butyrate daily for 7days prior to CRC surgery to reduce postoperative complications by atleast 50%. There is no injection form of postbiotic drugs for colorectal cancer, would require drug level development, regulatory approval strong clinical evidence – none of which exists for postbiotic therapy. A key finding from Zhong et al. (2024) showed that Weizamannia coagulants MZY531 postbiotics notably reduced tumour burden in CT26 tumour-bearing mice by activation of apoptosis (programmed cell death) and autophagy (cellular cleanup process) pathways. These dual mechanisms are key to cancer suppression and provide therapeutic potential of microbial metabolites¹⁵. Similarly, Alizadeh et al. (2023) demonstrated that postbiotics produced from food based probiotic cultures that produce apoptosis and suppressed growth of HCT-116 colorectal cancer cells, highlighting their direct anticancer efficacy¹⁶. Notably, Eladwy et al. (2024) found that combining sodium butyrate, a postbiotic SCFA with dexamethasone produces stronger anticancer effects than either treatment alone. This suggests that combining postbiotics into chemotherapeutic regimens increases treatment effectiveness and simultaneously minimises drug toxicity¹⁷.

Further evidence from colitis models also supports the protective role of postbiotics. For example, Linli Bu et al. (2024) reported that Lacticaseibacillus rhamnosus

Assessing The Efficacy Of Postbiotics As A Chemo Preventive Agent Against Colorectal Cancer: A Systematic Review

postbiotics significantly reduced inflammation in mice with dextran sodium sulphate- induced colitis, a condition closely related to CRC progression¹⁸. Recent research by Li et al. (2024)¹⁹ and Danladi et al. (2022)²⁰, conducted in broiler models, shows the potential of postbiotic supplementation to boost immune function, skeletal health, and gut microbiota balance ultimately provide overall systemic health benefits. In addition, Aruna Senthilkumar sudharsan (2024)²¹. Jie Gao et al (2019) done research on *Lactobacillus rhammnosus* GG, with that he concluded that a LGG postbiotic HM0539 which exerts a protective effect on intestinal barrier function. It has potential to prevent dextran sulphate sodium (DSS)-induced colitis and LPS/D-galactosamine-induced bacterial translocation and liver injury²². Mager et al recently focused on microbiome derived metabolite, inosine which increases efficacy of cancer immunotherapy. He identified three bacterial species, *B.pseudolongum*, *L. Johnsonii*, and *Olsenella*, from immune checkpoint blockade (ICB) treated CRC mouse, ICB weakened intestinal barrier function, allowing inosine-postbiotic released by *B.pseudolongum*, enters bloodstream and promote antitumor T-cell immunity and enhanced immunotherapy response²³.

Based on the studies discussed in this review, researchers have begun to spot definite components of postbiotic that plays crucial role in producing health-modifying effects. However, more research is required to fill knowledge gaps and expand our understanding of how these health-modifying effects occurs²⁴. According to Linxi Ma et al (2023) provides absence of clear quality standards and universally accepted definitions for postbiotics contributes to these inconsistencies. Moreover, pharmacodynamics and long-term safety of postbiotics in human population remain poorly understood. This review process has certain limitations²⁵. According to Francesca et al (2023) *Lactobacillus rhamnosus* GG postbiotic on the alteration of autophagy and inflammation pathways induced by gliadin in intestinal models.²⁶ For example, A group receiving *L. acidophilus* with micronutrients obtains side effects involving dehydration, abdominal distension, and vomiting. Postbiotics therapies and potential are not fully understood²⁷. Compounds like gingerol and aloe vera shows anti-inflammatory and oxidative stress-reducing actions suggest potential relevance in limiting inflammation-driven colorectal tumor progression^{30,31}. These limitations reduced the range of evidence included and could affect how easily

the study can be repeated or verified. They also have important implications for future research, policy decisions, and clinical practices. Postbiotics are economical and safe adjuncts. These can be use along with standard colorectal cancer treatment to increase therapeutic outcomes and decrease toxicity. They have greater stability and longer shelf life compared to probiotics that provides further translational potential for their clinical practice¹³.

Future studies should concentrate on well-designed randomized controlled human trials, standardization of postbiotic formulations, and the utilize of technologies to explain molecular mechanisms and biomarker responses. In general, although the present research studies are encouraging, complete clinical verification and uniform regulatory guidelines are essential for applying postbiotic research to the successful prevention and treatment of colorectal cancer.

CONCLUSION:

This reviewed study collectively shows that postbiotic holds remarkable potential on emerging functional agents in animal research. They provide various benefits especially in, balancing microbiome, strengthening the immune system and therapeutic effects in cancer-related studies. Much of the existing research is based on short-term animal studies or lab-based experiments, which don't fully understand how these compounds interact within the human body Research have been going on for postbiotics usage on cancer treatment. Further studies need to work on randomised controlled trials to enhance this research.

REFERENCE:

- 1) Xi Y, Xu P. Global colorectal cancer burden in 2020 and projections to 2040. *Translational Oncology* [Internet]. 2021f Jul 6;14(10):101174. Available from: <https://doi.org/10.1016/j.tranon.2021.101174>
- 2) Rattray NJW, Charkoftaki G, Rattray Z, Hansen JE, Vasiliou V, Johnson CH. Environmental Influences in the Etiology of Colorectal Cancer: The Premise of Metabolomics. *Current Pharmacology Reports* [Internet]. 2017 Apr 7;3(3):114–25. Available from: <https://doi.org/10.1007/s40495-017-0088-z>
- 3) Duan B, Zhao Y, Bai J, Wang J, Duan X, Luo X, et al. Colorectal Cancer: an Overview. In: Exon Publications eBooks [Internet]. 2022. p. 1–12. Available from: <https://doi.org/10.36255/exon-publications-gastrointestinal-cancers-colorectal-cancer>

Assessing The Efficacy Of Postbiotics As A Chemo Preventive Agent Against Colorectal Cancer: A Systematic Review

- 4) Naeem A, Hu P, Yang M, Zhang J, Liu Y, Zhu W, et al. Natural products as anticancer agents: Current status and future perspectives. *Molecules* [Internet]. 2022 Nov 30;27(23):8367. Available from: <https://doi.org/10.3390/molecules27238367>
- 5) Kim S, Kim G-H, Cho H. Postbiotics for cancer prevention and treatment. *Korean J Microbiol.* 2022;57:142–53. doi:10.7845/kjm.2021.1067
- 6) Chuah LO, Foo HL, Loh TC, Alitheen NBM, Yeap SK, Mutalib NEA, et al. Postbiotic metabolites produced by *Lactobacillus plantarum* strains exert selective cytotoxicity effects on cancer cells. *BMC Complementary and Alternative Medicine* [Internet]. 2019 Jun 3;19(1). Available from: <https://doi.org/10.1186/s12906-019-2528-2>
- 7) Liu Y, Nawazish H, Farid MS, Qadoos KA, Habiba UE, Muzamil M, et al. Health-Promoting Effects of *Lactobacillus acidophilus* and Its Technological Applications in Fermented Food Products and Beverages. *Fermentation* [Internet]. 2024 Jul 25;10(8):380. Available from: <https://doi.org/10.3390/fermentation10080380>
- 8) Rad AH, Maleki LA, Kafil HS, Zavoshti HF, Abbasi A. Postbiotics as promising tools for cancer adjuvant therapy. *Advanced Pharmaceutical Bulletin* [Internet]. 2020 Nov 7;11(1):1–5. Available from: <https://doi.org/10.34172/apb.2021.007>
- 9) Anand U, Dey A, Chandel AKS, Sanyal R, Mishra A, Pandey DK, et al. Cancer chemotherapy and beyond: Current status, drug candidates, associated risks and progress in targeted therapeutics. *Genes & Diseases* [Internet]. 2022 Mar 18;10(4):1367–401. Available from: <https://doi.org/10.1016/j.gendis.2022.02.007>
- 10) Hijová E. Postbiotics as metabolites and their biotherapeutic potential. *International Journal of Molecular Sciences* [Internet]. 2024 May 16;25(10):5441. Available from: <https://doi.org/10.3390/ijms25105441>
- 11) Chen R, Zou J, Chen J, Zhong X, Kang R, Tang D. Pattern recognition receptors: function, regulation and therapeutic potential. *Signal Transduction and Targeted Therapy* [Internet]. 2025 Jul 10;10(1). Available from: <https://doi.org/10.1038/s41392-025-02264-1>
- 12) Song D, Wang X, Ma Y, Liu NN, Wang H. Beneficial insights into postbiotics against colorectal cancer. *Frontiers in Nutrition* [Internet]. 2023 Mar 10;10. Available from: <https://doi.org/10.3389/fnut.2023.1111872>
- 13) Kvakova M, Kamlarova A, Stofilova J, Benetinova V, Bertkova I. Probiotics and postbiotics in colorectal cancer: Prevention and complementary therapy. *World Journal of Gastroenterology* [Internet]. 2022 Jul 14;28(27):3370–82. Available from: <https://doi.org/10.3748/wjg.v28.i27.3370>
- 14) Fong W, Li Q, Yu J. Gut microbiota modulation: a novel strategy for prevention and treatment of colorectal cancer. *Oncogene* [Internet]. 2020 Jun 8;39(26):4925–43. Available from: <https://doi.org/10.1038/s41388-020-1341-1>
- 15) Zhong B, Zhao Y, Gao L, Yang G, Gao Y, Li F, et al. Anticancer Effects of *Weizmannia coagulans* MZY531 Postbiotics in CT26 Colorectal Tumor-Bearing Mice by Regulating Apoptosis and Autophagy. *Life* [Internet]. 2024 Oct 19;14(10):1334. Available from: <https://doi.org/10.3390/life14101334>
- 16) Omidi Sarajar B, Alizadeh A, Moradi M, Shafiei Irannejad V. Effects of postbiotics from food probiotic and protective cultures on proliferation and apoptosis in HCT-116 colorectal cancer cells. *Appl Food Biotechnol.* 2023;10(2):85–101. doi:10.22037/afb.v10i2.39745
- 17) Eladwy RA, Alsherbiny MA, Chang D, Fares M, Li CG, Bhuyan DJ. The postbiotic sodium butyrate synergizes the antiproliferative effects of dexamethasone against the AGS gastric adenocarcinoma cells. *Frontiers in Nutrition* [Internet]. 2024 Mar 12;11. Available from: <https://doi.org/10.3389/fnut.2024.1372982>
- 18) Bu L, Li Y, Wang C, Jiang Y, Suo H. Preventive effect of *Lactocaseibacillus rhamnosus* 2016SWU.05.0601 and its postbiotic elements on dextran sodium sulfate-induced colitis in mice. *Frontiers in Microbiology* [Internet]. 2024 Feb 5;15. Available from: <https://doi.org/10.3389/fmicb.2024.1342705>
- 19) Li D, Fang S, He F, Fan X, Wang T, Chen Z, et al. Postbiotic derived from *Bacillus subtilis* ACCC 11025 improves growth performance, mortality rate, immunity, and tibia health in broiler chicks. *Frontiers in Veterinary Science* [Internet]. 2024 Jul 19;11. Available from: <https://doi.org/10.3389/fvets.2024.1414767>
- 20) Danladi Y, Loh TC, Foo HL, Akit H, Tamrin NAM, Naeem AM. Impact of Feeding Postbiotics and Paraprobiotics Produced From *Lactiplantibacillus plantarum* on Colon Mucosa Microbiota in Broiler Chickens. *Frontiers in Veterinary Science* [Internet]. 2022 Mar 29;9. Available from: <https://doi.org/10.3389/fvets.2022.859284>
- 21) Sudaarsan ASK, Ghosh AR. Appraisal of postbiotics in cancer therapy. *Frontiers in*

Assessing The Efficacy Of Postbiotics As A Chemo Preventive Agent Against Colorectal Cancer: A Systematic Review

- Pharmacology [Internet]. 2024 Sep 20;15. Available from: <https://doi.org/10.3389/fphar.2024.1436021>
- 22) Gao J, Li Y, Wan Y, Hu T, Liu L, Yang S, et al. A Novel Postbiotic From *Lactobacillus rhamnosus* GG With a Beneficial Effect on Intestinal Barrier Function. *Frontiers in Microbiology* [Internet]. 2019 Mar 14;10. Available from: <https://doi.org/10.3389/fmicb.2019.00477>
- 23) Mager LF, Burkhard R, Pett N, Cooke NCA, Brown K, Ramay H, et al. Microbiome-derived inosine modulates response to checkpoint inhibitor immunotherapy. *Science* [Internet]. 2020 Aug 13;369(6510):1481–9. Available from: <https://doi.org/10.1126/science.abc3421>
- 24) Liang B, Xing D. The current and future perspectives of postbiotics. *Probiotics and Antimicrobial Proteins* [Internet]. 2023 Feb 10;15(6):1626–43. Available from: <https://doi.org/10.1007/s12602-023-10045-x>
- 25) Ma L, Tu H, Chen T. Postbiotics in Human Health: A Narrative review. *Nutrients* [Internet]. 2023 Jan 6;15(2):291. Available from: <https://doi.org/10.3390/nu15020291>
- 26) Furone F, Bellomo C, Carpinelli M, Nicoletti M, Hewa-Munasinghe FN, Mordaa M, et al. The protective role of *Lactobacillus rhamnosus* GG postbiotic on the alteration of autophagy and inflammation pathways induced by gliadin in intestinal models. *Frontiers in Medicine* [Internet]. 2023 May 4;10. Available from: <https://doi.org/10.3389/fmed.2023.1085578>
- 27) Malagón-Rojas JN, Mantziari A, Salminen S, Szajewska H. Postbiotics for Preventing and Treating common Infectious Diseases in Children: a Systematic review. *Nutrients* [Internet]. 2020 Jan 31;12(2):389. Available from: <https://doi.org/10.3390/nu12020389>
- 28) Johnson CN, Kogut MH, Genovese K, He H, Kazemi S, Arsenault RJ. Administration of a postbiotic causes immunomodulatory responses in broiler gut and reduces disease pathogenesis following challenge. *Microorganisms* [Internet]. 2019 Aug 17;7(8):268. Available from: <https://doi.org/10.3390/microorganisms7080268>
- 29) Aggarwal S, Sabharwal V, Kaushik P, Joshi A, Aayushi A, Suri M. Postbiotics: From emerging concept to application. *Frontiers in Sustainable Food Systems* [Internet]. 2022 Sep 21;6. Available from: <https://doi.org/10.3389/fsufs.2022.887642>
- 30) Cimini D, D'ambrosio S, Stellavato A, Fusco A, Corsaro MM, Dabous A, et al. Optimization of growth of *Levilactobacillus brevis* SP 48 and in vitro evaluation of the effect of viable cells and high molecular weight potential postbiotics on *Helicobacter pylori*. *Frontiers in Bioengineering and Biotechnology* [Internet]. 2022 Oct 31;10. Available from: <https://doi.org/10.3389/fbioe.2022.1007004>
- 31) Sreenu B, Sindhu R, Banu Jothi A, Fathima L, Prabu D, Rajmohan M, et al. A systematic review of Aloe vera in chemotherapy- and radiotherapy-induced inflammation in cancer patients: unraveling antiproliferative and proapoptotic effects. *Cuest Fisioter.* 2025;54(4):50–56.
- 32) Noor JJ, Sindhu R, Jothi AB, Prabu D, Mohan MR, Dhamodhar D, et al. Modulatory effects of gingerol in cancer cell growth through activation and suppression of signaling pathways: a systematic review. *J Pharm Bioallied Sci.* 2024;16(Suppl 5):S4314–S4319. doi:10.4103/jpbs.jpbs_1001_24.