

Food-Derived Probiotics and Breast Cancer: A Narrative Review of Mechanisms, Clinical Evidence, and Practical Considerations (2020–2025)

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Abstract

This review (2020–2025) examines the growing link between gut health and breast cancer (BC), focusing on probiotics from fermented foods such as yogurt, kimchi, and sauerkraut. Strains like *Lactiplantibacillus plantarum*, *Lacticaseibacillus rhamnosus*, and *Bifidobacterium animalis* subsp. *lactis* demonstrate supportive potential through multiple mechanisms: enhancing immune activity (e.g., Th1/NK cells), reinforcing gut barriers, generating anti-inflammatory short-chain fatty acids via cross-feeding, and modulating estrogen metabolism.

Clinically, multi-strain probiotics show particular promise, with randomized trials indicating benefits such as reduced chemotherapy-related cognitive decline and gastrointestinal toxicity. Low baseline gut diversity may predict poorer treatment tolerance, underscoring the potential of microbiome-focused strategies. Although generally safe, caution is advised in immunocompromised patients due to rare infection risks.

In conclusion, food-sourced probiotics are a safe and biologically plausible adjunct for BC supportive care. Integrating them into a fiber-rich diet before chemotherapy may improve treatment tolerance. However, further rigorous trials are essential to identify optimal strains, clarify interactions with therapies like immunotherapy, and enable personalized applications.

Keywords: breast cancer, probiotics, fermented foods, *Lactobacillus*, *Bifidobacterium*; microbiome, estrobolome, chemotherapy, symbiotic, postbiotics

Introduction

Breast cancer (BC) care increasingly recognizes the gut–immune–endocrine axis as a modifiable determinant of treatment tolerance and quality of life. Probiotics are defined as “live microorganisms that, when administered in adequate amounts, confer a health benefit on the host,” as consolidated by ISAPP consensus statements. Fermented foods are a predominant source of candidate probiotic taxa. Common food-derived strains include *Lactiplantibacillus plantarum* (kimchi, sauerkraut, olives), *Lacticaseibacillus rhamnosus* and *L. casei* group (dairy/

vegetables), *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* (yogurt starters), and *Bifidobacterium animalis* subsp. *lactis* (fermented milk/yogurt). Converging evidence suggests these microbes and their metabolites can regulate inflammation, epithelial integrity, and estrogen metabolism, all relevant to BC biology and to toxicities from chemotherapy and targeted therapies. This review updates the field with emphasis on food-derived probiotics and practical considerations for clinicians and researchers, while outlining safety, knowledge gaps, and research priorities.

Search Strategy and Scope

We conducted targeted searches (January 2020–August 17, 2025) in PubMed/Medline, Web of Science, and Google Scholar using combinations of: “breast cancer,” “probiotic*,” “fermented food,” “yogurt,” “kimchi,” “kefir,” “Lactobacillus,” “Bifidobacterium,” “synbiotic,” “postbiotic,” “chemotherapy,” “immunotherapy,” and “cognitive impairment.” Inclusion prioritized RCTs in BC and high-quality clinical or mechanistic studies involving food-derived taxa or fermented foods. We excluded honey-derived microorganisms. Given heterogeneity of designs and endpoints, this is a narrative review.

The Gut–Mammary Axis, Estrobolome, and Treatment Tolerance

The gut microbiome communicates with the mammary gland via immune, endocrine, and metabolic routes. Cross-sectional and longitudinal studies indicate that BC and its treatments are associated with reduced alpha diversity and altered community composition, including depletion of SCFA-producing taxa, which correlates with symptom burden and treatment side effects. In a 2024 prospective study, lower pre-chemotherapy alpha diversity predicted greater chemotherapy-induced gastrointestinal symptoms in women with BC, suggesting candidates for microbiome-directed preventive strategies. The “estrobolome”, microbial genes involved in estrogen metabolism, may influence enterohepatic recycling of estrogens via microbial β -glucuronidases; modulation of this axis is a putative pathway linking probiotics and BC risk or course.

Food-Derived Probiotic Taxa and Dietary Sources

Yogurt starters: *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* the canonical starters with symbiotic growth in milk, remain the backbone of most yogurts. Many commercial yogurts additionally include *Bifidobacterium animalis* subsp. *lactis* (e.g., BB-12–type strains).

Fermented vegetables: Kimchi, sauerkraut, olives, and pickles often harbor *Lactiplantibacillus plantarum*, *L. brevis*, *Leuconostoc* spp., and *Weissella* spp.; human feeding studies show fecal increases of food-associated lactobacilli after intake. Kefir and cultured dairy: Kefir grains yield communities enriched in lactobacilli (e.g., *L. kefir*), lactococci, *Leuconostoc*, acetic-acid

bacteria, and yeasts; some strains exhibit immunomodulatory properties in preclinical BC models. These microbial taxa are not interchangeable, as their health effects depend on specific strains and dosages. In addition, fermented foods provide postbiotic compounds—such as organic acids, bacteriocins, and exopolysaccharides that may exert biological activity even in the absence of live cells.

Mechanistic Plausibility for BC Prevention and Supportive Care (Table 1)

Immune modulation and anti-tumor responses

Preclinical studies show that oral *Lactobacillus casei* (including CRL431 and BL23) and *L. acidophilus* can enhance Th1-skewing (IL-12, IFN- γ), improve NK cell activity, and delay breast tumor growth and metastasis in murine models. Milk fermented with *L. casei* CRL431 reduced tumor vascularity and lung metastasis, consistent with immunomodulation.

Barrier integrity and inflammation

Food-derived lactobacilli and bifidobacteria support epithelial tight junctions and reduce endotoxin translocation. Clinically, lower baseline microbiome diversity and loss of SCFA producers track with more severe chemotherapy-related GI symptoms; mechanistically, SCFAs (notably butyrate) promote epithelial health and anti-inflammatory signaling.

Metabolites and cross-feeding

The gut bacteria *Lactobacilli* and *Bifidobacteria* produce lactate and acetate. Other beneficial bacteria, like *Anaerobutyricum hallii*, then use these substances to create butyrate. This butyrate is important because it promotes healthy cell growth, reduces inflammation, and can have anti-cancer effects, all of which are relevant to breast cancer biology and how well a patient handles treatment.

Estrobolome and microbial β -glucuronidase (GUS)

Certain gut bacteria produce an enzyme called GUS that can reactivate estrogen, which may increase the body's overall estrogen levels. Recent research suggests that probiotics and prebiotics might reduce this enzyme's activity, but the results depend heavily on the specific types of bacteria and fibers used. Scientists are now investigating drugs that block the GUS

enzyme to reduce side effects from cancer treatments. This approach could also be relevant for breast cancer, which is often driven by estrogen.

ISAPP defines postbiotics as inanimate microbes or components that confer health benefits. EVs and metabolites from *Lactobacillus* spp. have shown anti-cancer and immunomodulatory signals in vitro and in animals, supporting interest in safe,

shelf-stable food-compatible postbiotics for future trials. In addition to probiotics, certain food-derived phytochemicals may engage the same apoptotic axes relevant to therapy sensitization; for example, ethanol extract of *Medicago sativa* enhanced gemcitabine-induced apoptosis and modulated the BAX/BCL-2/caspase-3 pathway in pancreatic cancer cells (41).

Table 1: Mechanisms of Food-Derived Probiotics in Breast Cancer Supportive Care

Mechanism	Description	Representative Strains	Dietary Sources
1. Immune Modulation	Enhances Th1/NK activity, reduces inflammatory cyto-	<i>Lactobacillus casei</i> (CRL431, BL23), <i>L. acidophilus</i>	Yogurt, fermented milk, probiotic capsules
2. Barrier Integrity & Inflammation	Strengthens epithelial tight junctions, reduces endotoxemia	<i>Bifidobacterium animalis</i> subsp. <i>lactis</i> , <i>Lactiplantibacillus</i>	Yogurt, kimchi, sauerkraut
3. SCFA Production & Cross-Feeding	Produces lactate/acetate → fuels butyrate producers (e.g., <i>Eubacterium hallii</i>)	<i>L. delbrueckii</i> subsp. <i>bulgaricus</i> , <i>Streptococcus thermophilus</i> , <i>L. brevis</i>	Yogurt, kefir, fermented vegetables
4. Estrobolome Modulation	Alters microbial β-glucuronidase activity → affects estro-	<i>Lactobacillus rhamnosus</i> , <i>Bifidobacterium</i> spp.	Yogurt, fermented milk, probiotic blends
5. Postbiotic Effects	Delivers bioactive metabolites (e.g., EVs, bacteriocins, exopol-	<i>Lactobacillus</i> spp. (heat-killed or EV-producing strains)	Fermented foods, postbiotic supplements

Clinical Evidence in Breast Cancer

Cognitive outcomes

A randomized, double-blind, placebo-controlled trial in women receiving chemotherapy for BC found that a multi-strain probiotic significantly reduced the incidence of chemotherapy-related cognitive impairment (CRCI) and improved global cognition, with concomitant shifts in gut microbiota and plasma metabolites; preclinical work implicated p-mentha-1,8-dien-7-ol as a candidate mediator.

Gastrointestinal and mucosal toxicities

Across mixed-cancer meta-analyses, multi-strain probiotics reduce chemotherapy-induced diarrhea and oral mucositis more consistently than single strains. In BC specifically, a 2023 double-blind RCT of synbiotics reported reductions in several chemotherapy side effects versus placebo. A 2025 randomized trial in postoperative BC patients receiving pegylated liposomal doxorubicin reported lower rates and severity of hand-foot syndrome and oral mucositis with probiotic supplementation.

Microbiome predictors of toxicity and response

Baseline alpha diversity before chemotherapy predicted subsequent GI toxicity in BC, nominating a window for dietary/probiotic prehabilitation. Observational data in triple-negative BC suggest antimicrobial exposure during curative-intent therapy is associated with dysbiosis, lower lymphocyte counts, and inferior outcomes—underscoring stewardship and microbiome-aware supportive care.

Immunotherapy (ICIs): opportunities and cautions

Microbiome composition correlates with ICI efficacy and toxicity in several cancers. Reviews note detrimental associations of concurrent antibiotics, PPIs, and steroids with ICI outcomes, whereas evidence for over-the-counter probiotics remains mixed and largely non-randomized; indiscriminate probiotic use during ICI therapy is not currently recommended outside trials.

Human Evidence for Fermented Foods

Research in non-cancer populations indicates that kimchi and sauerkraut consumption increases fecal lactobacilli and is associated with improved metabolic

and inflammatory markers. Yogurt has a well-established safety profile and potential psychobiotic effects. Despite these promising signals, there is a critical gap in RCTs specifically investigating these whole-food fermented interventions in the context of breast cancer, highlighting a key priority for future research.

Safety, Contraindications, and Quality Considerations

Overall, *Lactobacillus*/*Bifidobacterium* probiotics have strong safety records in the general population. In oncology, rare bloodstream infections have been reported, especially with central venous catheters, severe mucositis, critical illness, or profound neutropenia. Case reports include *Lactocaseibacillus*/*Lactobacillus rhamnosus* and *Bifidobacterium* species bacteremia. Risk mitigation includes: avoiding probiotic capsules during uncontrolled mucositis or severe neutropenia unless directed by the oncology team; never opening capsules near central lines; selecting products with documented strain identity, CFU at end of shelf-life, and third-party quality testing; and documenting use in the medical record. D-lactate accumulation is theoretically possible with heavy LAB intake in short bowel syndrome or SIBO, monitor symptomatic patients.

Practical, Food-First Guidance

The foundational nutritional approach involves a diverse, plant-based diet rich in fiber (targeting 25-30 grams daily) from sources like legumes, whole grains, nuts, and polyphenol-rich foods to selectively support beneficial butyrate-producing gut microbiota, complemented by the inclusion of well-tolerated fermented foods such as yogurt, kefir, and kimchi. When probiotic supplementation is warranted, multi-strain preparations containing *Lactobacillus* and *Bifidobacterium* at a dosage of 1-10 billion CFU per day are advised, ideally commencing 1-2 weeks prior to chemotherapy and sustained throughout treatment cycles. Synbiotic formulations with prebiotics like inulin may be considered for patients without significant bloating, introduced with a gradual titration. This regimen necessitates close coordination with the entire oncology care team, with special attention to concurrent therapies including immune checkpoint inhibitors, antibiotics, and proton-pump inhibitors. To establish a high-

quality evidence base, future research must adhere to rigorous reporting standards, documenting specific strain identities, verified CFU counts at end-of-shelf-life, placebo details, dietary controls, and adherence, while systematically collecting biospecimens and patient-reported outcomes against predefined core endpoints.

Conclusions

Food-derived probiotics represent a promising, biologically plausible adjunct for breast cancer supportive care. Early RCT evidence suggests tangible benefits for mitigating chemotherapy-related cognitive impairment and gastrointestinal toxicities. Mechanistic and observational data further support targeting the gut-microbiome axis through enhanced immune modulation, SCFA cross-feeding, and estrogen metabolism. A practical, food-first approach, centered on a high-fiber diet supplemented with tolerated fermented foods, forms a solid foundation. When probiotic supplementation is indicated, well-characterized, multi-strain formulations should be initiated prior to chemotherapy and carefully coordinated with the oncology team to manage interactions with treatments like ICIs, antibiotics, and PPIs. For the field to mature, the current promising signals must be validated through targeted, rigorous research. Future priorities include conducting strain-resolved RCTs with standardized outcomes, performing head-to-head comparisons of fermented foods versus supplements, defining optimal prehabilitation timing, and clarifying interactions with immunotherapy and endocrine therapy. Ultimately, by integrating these scientific advances with safety-conscious and individualized clinical implementation, food-derived probiotics may meaningfully improve treatment tolerance and quality of life for women with breast cancer.

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