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Fermented Beverages in Lactose Intolerance: Clinical Evidence, Mechanistic Insights, Nutritional Implications, and Research Gaps

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Abstract

Background: Lactose intolerance is a common gastrointestinal condition resulting from insufficient intestinal lactase activity and the subsequent fermentation of undigested lactose. Fermented beverages have attracted increasing attention as potentially better-tolerated dietary options. However, their clinical effects vary according to microbial composition, fermentation substrate, residual lactose content, and the availability of microbial β-galactosidase.

Objective: To critically examine clinical and mechanistic evidence regarding dairy and non-dairy fermented beverages in individuals with lactose maldigestion or intolerance, emphasizing milk kefir, water kefir, kombucha, and yogurt.

Methods: A focused literature review was conducted using accessible biomedical literature and reference tracking. Human intervention studies, systematic reviews, mechanistic investigations, and microbiological studies were considered. Evidence was categorized according to direct clinical relevance, indirect gastrointestinal outcomes, and compositional or mechanistic plausibility. Because a fully reproducible, independently screened database search was not completed, the review is presented as a critical scoping-style synthesis rather than a completed PRISMA-ScR systematic scoping review.

Results: Live-culture yogurt has the most consistent evidence for improving lactose digestion, supported by clinical studies and systematic reviews. A small randomized study involving 15 adults demonstrated that milk kefir reduced breath hydrogen production and flatulence compared with milk. Water kefir and kombucha are traditionally lactose-free, but clinical evidence demonstrating improvement in lactose-specific symptoms is lacking. Recent kombucha trials suggest heterogeneous effects on gastrointestinal symptoms and microbiota without establishing therapeutic efficacy for lactose intolerance.

Conclusions: Fermented beverages should not be considered clinically interchangeable. Yogurt and milk kefir may facilitate digestion of residual lactose, whereas water kefir and kombucha primarily offer non-dairy alternatives. Standardized clinical trials are needed to establish whether non-dairy fermented beverages provide benefits beyond lactose avoidance.

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1. Introduction

Lactose intolerance is a clinically relevant nutritional and gastrointestinal condition characterized by symptoms occurring after ingestion of lactose-containing foods in individuals with impaired lactose digestion. Lactose maldigestion results from insufficient intestinal lactase-phlorizin hydrolase activity, which limits the hydrolysis of lactose into glucose and galactose. Undigested lactose may subsequently reach the colon, where microbial fermentation generates gases and osmotically active metabolites. The resulting clinical manifestations include abdominal bloating, flatulence, abdominal discomfort, borborygmi, and diarrhea. Nevertheless, lactose maldigestion and lactose intolerance are not synonymous, because not every individual with reduced lactase activity develops clinically significant symptoms.

The management of lactose intolerance has traditionally emphasized reducing lactose exposure, identifying individual tolerance thresholds, using lactose-free dairy products, and administering exogenous lactase when appropriate. However, complete exclusion of dairy products is not universally necessary and may have nutritional consequences when calcium, protein, vitamin D, and other relevant nutrients are not adequately replaced. Consequently, dietary strategies that preserve nutritional adequacy while improving gastrointestinal tolerance are of particular clinical interest.

Fermented dairy products have long been investigated as alternatives to conventional milk. During fermentation, microorganisms metabolize part of the available lactose and generate enzymes capable of contributing to its digestion. In addition, the physical characteristics of fermented dairy matrices and their effects on gastrointestinal transit may influence lactose availability and symptom generation. Among these products, yogurt has the most established clinical evidence, whereas milk kefir has attracted attention because of its complex microbial ecosystem, which includes lactic acid bacteria, acetic acid bacteria, and yeasts.

In parallel, non-dairy fermented beverages, particularly water kefir and kombucha, have gained popularity among consumers seeking plant-based products, alternatives to dairy, or foods perceived as beneficial to gastrointestinal health. Water kefir is produced through the fermentation of a sugar-containing aqueous substrate by microbial grains, whereas traditional kombucha is prepared through the fermentation of sweetened tea by a symbiotic culture of bacteria and yeasts. Although these beverages generally do not contain lactose when prepared without dairy ingredients, their biological properties differ substantially from those of fermented milk products.

An important conceptual distinction must therefore be established between beverages that may improve the digestion of lactose through fermentation-associated enzymatic mechanisms and beverages that avoid lactose exposure altogether. The latter may be appropriate dietary alternatives but cannot automatically be considered treatments for lactase deficiency. Furthermore, changes in intestinal microbiota or nonspecific gastrointestinal symptoms do not necessarily demonstrate improved lactose digestion.

This review critically examines the available evidence concerning dairy and non-dairy fermented beverages in the context of lactose intolerance, with particular attention to clinical outcomes, fermentation mechanisms, microbial composition, nutritional applicability, product heterogeneity, and priorities for future research.

2. Methods

2.1. Review Design

This article was developed as a critical scoping-style review intended to map and interpret evidence concerning fermented beverages and lactose intolerance. The conceptual framework was informed by scoping review methodology, with emphasis on distinguishing direct clinical studies from indirect mechanistic and nutritional evidence. However, the present synthesis does not claim full compliance with PRISMA-ScR because complete database retrieval, duplicate removal, independent screening, and study-level extraction have not yet been documented.

2.2. Research Question and Eligibility Framework

The review addressed the following question: What clinical, mechanistic, and nutritional evidence supports the use of dairy and non-dairy fermented beverages in individuals with lactose maldigestion or lactose intolerance?

The population of primary interest comprised individuals with objectively documented lactose maldigestion or clinically identified lactose intolerance. Interventions and exposures included yogurt, fermented milk, milk kefir, water kefir, and kombucha. Outcomes of interest included breath hydrogen excretion, gastrointestinal symptoms, lactose digestion, residual lactose content, microbial β-galactosidase activity, and nutritional suitability.

Human intervention studies were prioritized for clinical efficacy conclusions. Systematic reviews, mechanistic investigations, and food microbiology studies were used to contextualize biological plausibility and identify research gaps. Studies evaluating gastrointestinal symptoms in populations without lactose intolerance were considered indirect evidence and were not interpreted as demonstrating lactose-specific efficacy.

2.3. Literature Identification

Relevant publications were identified through targeted searches of accessible biomedical literature, including PubMed-indexed records, journal publications, and reference lists of relevant systematic reviews. Search concepts included lactose intolerance, lactose maldigestion, yogurt, fermented milk, kefir, water kefir, kombucha, lactose digestion, β-galactosidase, and gastrointestinal symptoms.

The search was updated for this manuscript in October 2026. Because complete retrieval logs from PubMed, Embase, Scopus, Web of Science, and Cochrane CENTRAL are not available, no numerical claims regarding records identified, screened, excluded, or included are presented. Likewise, no PRISMA flow diagram is reported.

2.4. Evidence Synthesis

Evidence was synthesized narratively and organized into three categories: direct clinical evidence involving lactose digestion or intolerance; indirect human evidence concerning gastrointestinal outcomes or microbiota; and mechanistic or compositional evidence derived from fermentation research. Particular attention was given to the distinction between biological plausibility and demonstrated clinical benefit.

No quantitative meta-analysis was performed because the studies considered differed substantially in population, beverage composition, intervention protocols, and outcome assessment.

3. Results

3.1. Clinical Evidence Supporting Yogurt Consumption

Among fermented beverages and related fermented dairy products, yogurt has the strongest evidence supporting improved lactose digestion. Early experimental studies demonstrated that individuals with lactose maldigestion experienced lower breath hydrogen excretion after consuming yogurt than after consuming comparable amounts of lactose from conventional milk. The seminal investigation by Kolars and colleagues provided important evidence that the microorganisms present in yogurt contribute to intraluminal lactose hydrolysis.

Subsequent research demonstrated that the beneficial effects of yogurt depend not only on its residual lactose concentration but also on the enzymatic activity of viable microorganisms. In particular, the β-galactosidase produced by conventional yogurt starter cultures may remain functionally relevant during gastrointestinal passage. The bacterial cellular environment and the buffering properties of the dairy matrix appear to contribute to the preservation and activity of this enzyme.

A systematic review by Savaiano and Hutkins identified seven positive-quality randomized trials demonstrating improved lactose digestion or tolerance following consumption of yogurt or kefir containing live cultures. These findings support a clinically meaningful role for selected fermented dairy products, although the evidence is predominantly derived from yogurt studies rather than being equally distributed across all fermented beverages.

Importantly, the favorable effects of yogurt should not be generalized indiscriminately to all products marketed as fermented dairy foods. Processing conditions, heat treatment, microbial viability, storage, and formulation may influence the capacity of a product to facilitate lactose digestion. Products containing viable conventional yogurt cultures therefore have a stronger mechanistic and clinical rationale than products in which microbial enzymes have been substantially inactivated.

3.2. Milk Kefir and Lactose Digestion

Milk kefir represents a more microbiologically complex fermented dairy product than conventional yogurt. Its fermentation typically involves interacting populations of lactic acid bacteria, acetic acid bacteria, and yeasts, although microbial composition varies considerably across grains, production methods, and commercial formulations. These microorganisms contribute to lactose metabolism, organic acid production, and the development of the characteristic sensory properties of kefir.

The most directly relevant clinical investigation was conducted by Hertzler and Clancy in 2003. In a randomized block study, 15 adults with lactose maldigestion consumed milk, plain and flavored kefir, and plain and flavored yogurt under standardized experimental conditions. Each test meal provided approximately 20 g of lactose, and participants were monitored for eight hours using breath hydrogen measurements and symptom assessment.

The breath hydrogen area under the curve was significantly lower after plain kefir than after conventional milk, with reported values of 87 ± 37 versus 224 ± 39 ppm × hours, respectively. Plain yogurt produced a similarly favorable response of 76 ± 14 ppm × hours. The fermented products also reduced perceived flatulence severity compared with milk, although abdominal pain and diarrhea were minimal across experimental conditions.

These findings provide preliminary clinical support for the use of milk kefir as a potentially better-tolerated dairy product among individuals with lactose maldigestion. Nevertheless, several limitations must be considered. The study included only 15 participants, examined acute responses, and did not establish the long-term effects of regular kefir consumption. Furthermore, the results cannot automatically be extrapolated to all commercial or homemade kefir products, which may differ substantially in microbial composition, fermentation duration, residual lactose concentration, and enzyme activity.

The available evidence therefore supports a cautious conclusion: milk kefir may facilitate lactose digestion under certain conditions, but larger and more standardized clinical trials are needed before its efficacy can be considered established across different populations and formulations.

3.3. Water Kefir: Microbial Diversity Without Established Lactose-Specific Efficacy

Water kefir differs fundamentally from milk kefir because it is traditionally produced using water, sugar, and often fruit-derived ingredients rather than milk. Consequently, traditional water kefir does not contain lactose as a substrate. Its fermentation is mediated by a symbiotic microbial community, typically including lactic acid bacteria, acetic acid bacteria, and yeasts embedded within an extracellular polysaccharide matrix.

The review by Lynch and colleagues described the microbiological composition, fermentation processes, and production characteristics of water kefir, highlighting substantial diversity among microbial communities and fermentation conditions. These characteristics provide a basis for investigating possible gastrointestinal effects, but they do not establish an ability to improve lactose digestion.

The distinction is clinically important. Although water kefir may be consumed without exposing individuals to dairy-derived lactose, the absence of lactose does not imply correction of lactase deficiency. Similarly, the presence of lactic acid bacteria should not be interpreted as proof that water kefir delivers sufficient active β-galactosidase to hydrolyze lactose from other foods within the human intestine.

The literature examined for this review did not establish direct clinical efficacy of water kefir in individuals with lactose intolerance. Therefore, water kefir is best understood as a potentially suitable non-dairy beverage alternative rather than an evidence-based intervention for improving lactose digestion.

3.4. Kombucha: Emerging Gastrointestinal Evidence and Its Limitations

Kombucha is traditionally produced by fermenting sweetened tea with a symbiotic culture of bacteria and yeasts. Its composition includes organic acids, tea-derived polyphenols, residual sugars, microbial metabolites, and variable populations of microorganisms. These characteristics have stimulated interest in possible gastrointestinal and metabolic effects.

Earlier reviews emphasized the scarcity of human intervention studies, but more recent clinical investigations have expanded the evidence base. A systematic review published in 2025 identified eight clinical trials, including six randomized controlled trials and two pre–post intervention studies, with intervention durations ranging from 10 days to 10 weeks. Some studies reported improvements in constipation-related complaints, while others identified modest and heterogeneous changes in intestinal microbial composition. However, metabolic outcomes were inconsistent, and the available studies varied substantially in population characteristics, beverage formulations, intervention protocols, and outcome measures.

A controlled clinical investigation involving healthy adults consuming a Western dietary pattern also reported modest changes in intestinal microbial composition following kombucha consumption, without consistent improvements in

systemic inflammatory or biochemical markers. These findings indicate that kombucha may influence selected biological outcomes, but the clinical significance of these changes remains uncertain.

Crucially, the available kombucha studies do not demonstrate improved lactose hydrolysis, reduced breath hydrogen after a lactose challenge, or specific symptom relief in individuals with confirmed lactose intolerance. Improvements in constipation or general gastrointestinal symptom scores cannot be assumed to reflect enhanced lactose digestion.

Accordingly, kombucha should be considered a traditionally lactose-free beverage that may offer an alternative to dairy-based drinks. Claims that it treats lactose intolerance, restores lactase activity, or enables individuals to tolerate larger lactose loads remain unsupported by direct clinical evidence.

3.5. Comparative Interpretation Of The Clinical Evidence

The available literature demonstrates a clear gradient of evidence among fermented beverages. Yogurt has repeatedly been evaluated in individuals with lactose maldigestion using objective measures, particularly breath hydrogen testing. Milk kefir has shown favorable findings in a small controlled study, but replication remains limited. By contrast, the evidence concerning water kefir is largely microbiological, whereas kombucha has an expanding but still heterogeneous body of human research addressing gastrointestinal symptoms, metabolic parameters, and microbial composition rather than lactose-specific outcomes.

These differences highlight the importance of distinguishing three separate concepts: improved digestion of an ingested lactose load, improved gastrointestinal symptoms unrelated to lactose exposure, and avoidance of lactose through the selection of non-dairy beverages. Although all three may influence dietary choices, they represent different clinical outcomes and should not be treated as equivalent evidence of therapeutic efficacy.

3.6. Nutritional considerations and product heterogeneity

The nutritional characteristics of fermented beverages are determined primarily by their substrates and manufacturing processes. Milk kefir and conventional yogurt retain important nutrients associated with dairy products, including protein, calcium, and, depending on the product, vitamin B12 and other micronutrients. Their lactose concentrations may decrease during fermentation, although complete elimination cannot be assumed.

In contrast, traditional water kefir and kombucha are generally poor substitutes for the protein and calcium supplied by dairy foods unless specifically formulated or fortified. Consequently, replacing milk or yogurt with these beverages without considering the overall diet may reduce intake of nutritionally important components.

Residual sugar content also deserves attention. Both water kefir and kombucha commonly begin with sugar-containing substrates, and the concentration of residual carbohydrates varies with fermentation conditions and formulation. Furthermore, fermentation may generate small quantities of ethanol, with concentrations varying among products. Acidity, carbonation, and organic acid content may influence gastrointestinal tolerability, particularly among individuals experiencing bloating, reflux, or functional gastrointestinal symptoms.

Another relevant consideration is the distinction between commercial and homemade products. Industrial manufacturing may provide greater control over microbial contamination, fermentation conditions, and labeling, whereas homemade preparations can exhibit substantial variability. However, commercial products are not necessarily microbiologically equivalent, and the presence of viable microorganisms does not automatically establish a probiotic effect.

3.7. Clinical Applicability

Clinical recommendations should be based on the distinction between lactose digestion and lactose avoidance. For individuals who wish to maintain dairy consumption, yogurt containing live cultures represents the most evidence-supported fermented option. Milk kefir may also be considered according to individual tolerance, although evidence remains less extensive.

For individuals preferring to avoid dairy products, water kefir and traditional kombucha may serve as alternatives, provided that their nutritional limitations and product-specific characteristics are considered. Nevertheless, neither beverage should be recommended as an established treatment for lactase deficiency.

Importantly, symptoms attributed to lactose intolerance may overlap with those of irritable bowel syndrome and other disorders of gut–brain interaction. Consequently, gastrointestinal improvement after switching beverages does not necessarily indicate enhanced lactose digestion. Careful clinical assessment remains essential, particularly when symptoms persist despite lactose restriction.

4. Discussion

The present review highlights an important discrepancy between the growing popularity of fermented beverages and the availability of clinical evidence supporting their use in lactose intolerance. Although yogurt, kefir, water kefir, and kombucha are frequently grouped under the broad category of fermented or functional foods, their biological characteristics and clinical implications differ substantially. The principal finding of this synthesis is that the potential benefit of fermented beverages depends not merely on fermentation itself but on the interaction between the original substrate, microbial composition, residual lactose concentration, enzymatic activity, and gastrointestinal physiology.

The strongest evidence concerns yogurt containing viable starter cultures. Classical studies demonstrated that yogurt improves lactose digestion compared with conventional milk, and subsequent investigations provided a plausible biological explanation involving microbial β-galactosidase activity. This effect is particularly relevant because it allows some individuals with lactose maldigestion to consume a dairy product containing residual lactose without experiencing symptoms comparable to those associated with conventional milk. The available systematic review evidence supports this distinction and provides a stronger foundation for clinical recommendations involving yogurt than for other fermented beverages.

Milk kefir occupies an intermediate position. Its complex microbial community offers a plausible basis for enhanced lactose digestion, and the randomized study by Hertzler and Clancy demonstrated favorable changes in breath hydrogen

excretion and flatulence. Nevertheless, the small sample size, acute experimental design, and lack of extensive replication limit the certainty of these findings. The clinical effects observed with one kefir formulation cannot necessarily be extrapolated to products prepared using different microbial grains, fermentation conditions, or commercial processing methods. Thus, although kefir represents a promising dietary option, the current evidence is insufficient to establish equivalence with yogurt in terms of clinical efficacy.

The interpretation of water kefir and kombucha requires a different framework. Because these beverages are traditionally prepared without milk, their principal relevance to lactose intolerance lies in the avoidance of lactose rather than the facilitation of its digestion. This distinction may appear straightforward, but it has substantial implications for both clinical counseling and scientific communication. A lactose-free beverage may be appropriate for an individual with lactose intolerance without exerting any direct effect on intestinal lactase activity, colonic fermentation of subsequently ingested lactose, or the physiological mechanisms responsible for lactose maldigestion.

The emerging clinical literature on kombucha illustrates this challenge. Recent randomized and nonrandomized studies have investigated changes in gastrointestinal symptoms, intestinal microbial composition, and metabolic parameters. Some findings suggest possible benefits for bowel habits and selected microbiological outcomes, but these observations are heterogeneous and do not establish efficacy in lactose intolerance. In particular, improvements in constipation, stool consistency, or general gastrointestinal symptom scores cannot be interpreted as evidence that kombucha improves the digestion of lactose. Such conclusions would require trials specifically enrolling individuals with confirmed lactose maldigestion and assessing outcomes following standardized lactose challenges.

An additional concern is the widespread assumption that the presence of microorganisms in fermented foods necessarily confers probiotic benefits. Fermentation and probiotic activity are related but distinct concepts. The microorganisms present in a fermented product may contribute to its production without having demonstrated clinically meaningful benefits after consumption. Moreover, microbial populations may vary substantially across batches, brands, storage conditions, and processing methods. Consequently, the designation of a beverage as fermented should not be interpreted as evidence that it contains microorganisms with established therapeutic properties.

Nutritional considerations further complicate the substitution of dairy products with non-dairy fermented beverages. Yogurt and milk kefir may contribute protein, calcium, and other nutrients, whereas traditional water kefir and kombucha generally do not provide comparable nutritional value. Their use as substitutes for milk may therefore be appropriate from the perspective of lactose avoidance but inadequate as a direct nutritional replacement. Clinical recommendations should consider the complete dietary pattern rather than focusing exclusively on gastrointestinal symptoms or the absence of lactose.

The potential effects of acidity, carbonation, residual sugars, and fermentation-derived compounds also deserve attention. Although these characteristics may contribute to the sensory appeal of fermented beverages, they may influence gastrointestinal tolerance in susceptible individuals. Therefore, the assumption that all fermented beverages are inherently beneficial for gastrointestinal health is not supported by the available evidence.

The review also identifies important methodological challenges for future research. Studies evaluating fermented beverages frequently differ in product composition, microbial characterization, intervention duration, control conditions, and outcome measurement. For lactose intolerance specifically, future trials should distinguish objectively confirmed lactose maldigestion from self-reported intolerance, because gastrointestinal symptoms may arise through multiple mechanisms. Standardized breath testing, validated symptom scales, careful quantification of lactose exposure, and characterization of the fermented products would substantially improve the interpretability of future findings.

A particularly relevant research opportunity involves comparing dairy and non-dairy fermented beverages within a standardized clinical framework. Such investigations could determine whether water kefir or kombucha provides benefits beyond lactose avoidance, whether specific microbial or metabolic characteristics influence gastrointestinal symptoms, and whether any observed effects are reproducible across formulations. Until such evidence becomes available, clinical recommendations should remain differentiated according to the strength and directness of the supporting evidence.

The present review has limitations. Its literature identification was targeted rather than exhaustive, and no independently documented systematic screening or formal risk-of-bias assessment was completed. Therefore, the absence of identified trials should not be interpreted as definitive proof that no such studies exist. In addition, the included evidence spans clinical trials, systematic reviews, mechanistic studies, and microbiological investigations, limiting direct comparisons. These limitations do not invalidate the conceptual distinctions identified but restrict the certainty of conclusions concerning the completeness of the evidence base.

Overall, the findings support a clinically meaningful distinction between fermented dairy products that may improve lactose digestion and non-dairy fermented beverages that primarily avoid lactose exposure. Recognizing this difference may improve nutritional counseling, prevent unsupported therapeutic claims, and guide the design of future clinical investigations.

5. Conclusions

Fermented beverages differ substantially in their clinical relevance to lactose intolerance. Yogurt containing live cultures has the strongest evidence for improving lactose digestion and tolerance, while milk kefir has demonstrated favorable effects in a small randomized study. Water kefir and kombucha are traditionally lactose-free and may serve as non-dairy alternatives, but current evidence does not establish that they improve lactase activity or treat lactose intolerance. Emerging gastrointestinal findings involving kombucha should not be extrapolated to lactose-specific outcomes. Future standardized randomized trials are needed to clarify the clinical effects of non-dairy fermented beverages and determine whether their potential benefits extend beyond lactose avoidance.

Table 1: Clinical studies and evidence syntheses relevant to fermented beverages and lactose intolerance

Study	Design / population	Intervention or exposure	Main findings	Evidence relevance
Kolars *et al*., 1984 [2]	Experimental study; 10 lactase-deficient participants	Yogurt versus milk or lactose solution; 18 g lactose	Approximately one-third of the breath hydrogen excretion with yogurt	Direct
Savaiano *et al*., 1984 [3]	Human comparative study in lactase-deficient individuals	Fresh yogurt, pasteurized yogurt, acidophilus milk, cultured milk	Fresh yogurt showed superior lactose digestion and tolerance	Direct
Hertzler & Clancy, 2003 [4]	Randomized block study; 15 adults	Milk, kefir, yogurt; 20 g lactose	Plain kefir and yogurt reduced breath hydrogen and flatulence relative to milk	Direct
Savaiano, 2014 [5]	Mechanistic review	Yogurt bacterial lactase	Explains bacterial β-galactosidase-mediated lactose digestion	Mechanistic
Savaiano & Hutkins, 2021 [6]	Systematic review; 108 studies across health outcomes	Yogurt and cultured fermented milk	Seven positive-quality trials supported lactose digestion/tolerance benefits	Evidence synthesis
Kapp & Sumner, 2019 [8]	Systematic review	Kombucha	Only one human study identified at the time	Indirect
Lynch *et al*., 2021 [9]	Microbiological review	Water kefir	Describes microbial ecology and fermentation variability	Compositional
Kombucha clinical systematic review, 2025 [10]	Systematic review; eight clinical trials	Kombucha	Heterogeneous gastrointestinal and microbiota effects	Indirect
Kombucha controlled clinical study, 2025 [11]	Controlled trial; 24 participants	Kombucha versus control	Modest microbial changes without consistent biochemical improvements	Indirect

Direct evidence refers to outcomes specifically involving lactose digestion or intolerance. Indirect evidence concerns other gastrointestinal or microbiological outcomes. Systematic reviews are not additional independent primary trials.

Table 2: Nutritional and functional comparison of fermented beverages

Characteristic	Yogurt	Milk kefir	Water kefir	Kombucha
Main substrate	Milk	Milk	Sweetened water	Sweetened tea
Residual lactose	Variable	Variable	Usually absent	Usually absent
Dairy protein	Present	Present	Usually negligible	Usually negligible
Calcium contribution	Usually relevant	Usually relevant	Variable, usually limited	Variable, usually limited
β-galactosidase relevance	Established	Plausible, with preliminary clinical evidence	Unproven clinically	Unproven clinically
Clinical lactose evidence	Relatively strong	Limited	Not established	Not established
Main benefit in lactose intolerance	Improved digestion	Potentially improved digestion	Lactose avoidance	Lactose avoidance
Main concern	Residual lactose and processing	Product heterogeneity	Nutritional inadequacy as dairy replacement	Acidity, residual sugars, variable composition

Characteristics refer to conventional preparations. Fortification, additives, fermentation conditions, and manufacturing processes may alter the composition of individual products.

Table 3: Clinical interpretation and research priorities

Clinical question	Current interpretation	Priority
Does yogurt improve lactose digestion?	Supported by controlled human studies	Study formulation differences
Does milk kefir improve lactose tolerance?	Preliminary favorable evidence	Larger randomized crossover trials
Can water kefir replace dairy beverages?	Suitable for lactose avoidance, but nutritionally different	Nutritional substitution studies
Does water kefir improve lactose digestion?	No established direct clinical benefit	Controlled lactose-challenge trials
Does kombucha treat lactose intolerance?	Not demonstrated	Randomized lactose-specific trials
Do fermented beverages modify the microbiota?	Product-dependent and heterogeneous	Standardized microbiome studies
Are homemade and commercial preparations equivalent?	Equivalence not established	Chemical and microbial characterization

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