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# Alternative Dairy Products in Lactose Intolerance Management: The Efficacy of Plant-Based Beverages, Lactose-Free Milk and Probiotic Yogurts

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ABSTRACT

Lactose intolerance is a common digestive disorder characterized by gastrointestinal symptoms following the consumption of lactose-containing foods due to insufficient or absent lactase enzyme activity. Although the primary approach in the management of lactose intolerance is the elimination of lactose from the diet, this strategy may lead to various nutritional deficiencies. This narrative review was conducted through a literature search of electronic databases including PubMed, Scopus, and Google Scholar to evaluate current evidence on this topic. To achieve adequate symptom control, alternative dairy products may be incorporated into the diet. Evidence from the literature indicates that probiotic bacteria found in yogurt particularly *Lactobacillus acidophilus* exhibit lactase-like activity and contribute to the digestion of lactose, while lactose-free dairy products minimize symptom occurrence as a result of exogenous enzyme treatment that hydrolyzes lactose during production. This review summarizes current evidence regarding the efficacy of alternative dairy products, probiotic yogurts, plant-based beverages and lactose-free milk in the management of lactose intolerance, and highlights their clinical potential as evidence-based strategies within personalized nutrition approaches for lactose-intolerant individuals.

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## Introduction

***Definition and Pathophysiology of Lactose Intolerance***

Lactose is defined as a disaccharide naturally found in milk, composed of glucose and galactose. The enzyme responsible for lactose digestion in the small intestine is lactase (Madry et al., 2010). Lactase activity begins on the mucosal surface of the small intestine at the 8th week of gestation and reaches its highest levels at the 34th week. Following birth, lactase activity peaks and then tends to decline from the early years of life onward (Catanzaro et al., 2021b). Various genetic, epigenetic, and environmental factors may play a role in the development of lactase deficiency (Tariq et al., 2024).

In infants, the condition of lactase enzyme activity being lower than normal is defined as lactase deficiency, the inability of lactose to be absorbed from the intestine is termed lactose malabsorption, and lactose malabsorption accompanied by gastrointestinal symptoms is referred to as lactose intolerance (Shaukat et al., 2010). Lactase deficiency results in impaired hydrolysis of lactose within the brush border of the small intestine, thereby reducing the conversion of lactose into absorbable monosaccharides, glucose and galactose (Madry et al., 2010). As illustrated in Figure 1, under physiologically normal conditions, lactose is efficiently digested by lactase and subsequently absorbed into the bloodstream without the development of gastrointestinal symptoms. In contrast, reduced lactase activity leads to the persistence of undigested lactose within the intestinal lumen, initiating several pathophysiological processes associated with lactose intolerance (Catanzaro et al., 2021b).

Initially, the accumulation of non-hydrolyzed lactose increases the osmotic load within the intestinal lumen, promoting water retention and accelerating intestinal transit (Catanzaro et al., 2021b; Misselwitz et al., 2019). This osmotic effect contributes directly to symptoms such as diarrhea, abdominal discomfort, and intestinal distension. Subsequently, undigested lactose reaches the colon, where it undergoes rapid fermentation by the colonic microbiota. During this process, microbial metabolism generates short-chain fatty acids (SCFAs) together with gases including hydrogen ($H_2$), carbon dioxide ($CO_2$), and methane ($CH_4$) (Catanzaro et al., 2021b; Szilagyi, 2015).

The production of these gases contributes to luminal distension, bloating, flatulence, cramping, and abdominal

pain, whereas SCFAs may further alter intestinal motility and luminal pH (Deng et al., 2015; He et al., 2008). Furthermore, interindividual differences in gut microbiota composition may influence the extent of fermentation, gas production, and symptom severity (Misselwitz et al., 2019; Szilagyi, 2015). Methane-producing microbiota, for example, have been associated with delayed intestinal transit and altered symptom profiles in some individuals (Szilagyi, 2015). Collectively, these mechanisms demonstrate that lactose intolerance is not solely related to lactase deficiency itself, but also involves complex interactions between intestinal digestion, osmotic imbalance, microbial fermentation, and host–microbiota responses. Figure 1 summarizes the major pathophysiological mechanisms underlying lactose intolerance, including impaired lactose hydrolysis, osmotic imbalance, microbial fermentation, and subsequent symptom generation. This process results in a range of gastrointestinal symptoms, predominantly gas, bloating, abdominal pain, and nausea (Deng et al., 2015; He et al., 2008). In addition to gastrointestinal manifestations, other reported extraintestinal symptoms include headaches, musculoskeletal pain, and fatigue (Bouchoucha et al., 2021; Schiffner et al., 2016). The symptoms and severity of lactose intolerance vary depending on the amount of lactose consumed, intestinal transit time, lactase expression, the resilience and variability of the gut microbiota, the individual's lactose tolerance threshold, and psychological factors (Misselwitz et al., 2019; Szilagyi, 2015). Symptoms associated with lactose intolerance are provided in Table 1.

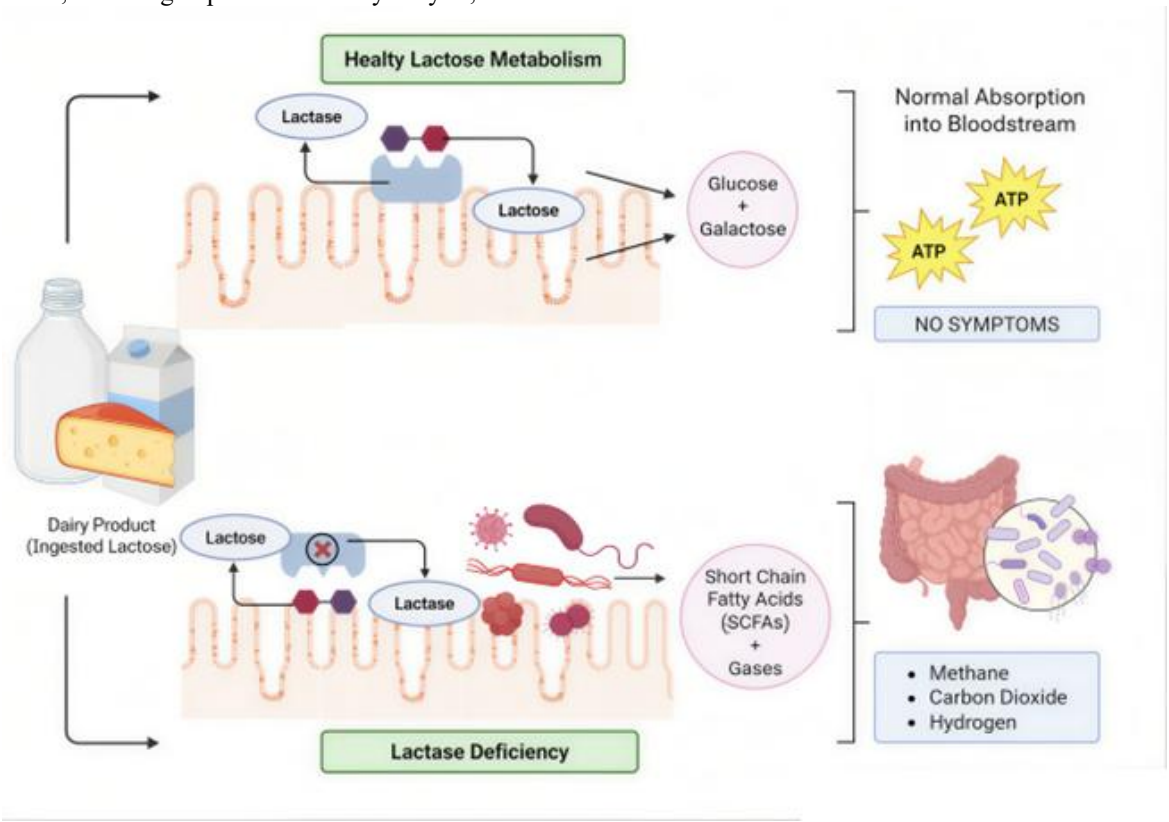


Figure 1. Comparison of Physiological Lactose Digestion and Pathophysiological Mechanisms Underlying Lactose Intolerance

Table 1. Symptoms Associated with Lactose Intolerance (Facioni et al., 2020)

| Symptom Type | Symptoms |
|---|---|
| Gastrointestinal | Abdominal pain<br>Bloating<br>Gas<br>Diarrhea (constipation in some cases)<br>Nausea |
| Systemic *(less common)* | Headache<br>Dizziness<br>Lethargy (low energy)<br>Difficulty concentrating<br>Joint/Muscle pain<br>Mouth sores |
| Gut Microbiota–Related | Abdominal discomfort<br>Increased gas production due to fermentation<br>Irregular bowel movements |

Given the overlap between several gastrointestinal manifestations of lactose intolerance and other milk-related disorders, differential diagnosis becomes clinically important. In clinical practice, lactose intolerance and cow's milk protein allergy (CMPA) are frequently confused because both conditions may present with overlapping gastrointestinal symptoms, particularly during infancy and early childhood. However, these disorders differ fundamentally in their pathophysiological basis, clinical manifestations, age of onset, and diagnostic approaches. Lactose intolerance is a non-immunological carbohydrate malabsorption syndrome resulting from insufficient lactase enzyme activity, whereas CMPA is an immune-mediated disorder triggered by proteins found in cow's milk. CMPA develops through abnormal immune responses and is classified into IgE-mediated and non-IgE-mediated forms. IgE-mediated CMPA is characterized by rapid hypersensitivity reactions involving allergen-specific IgE antibodies, while non-IgE-mediated CMPA involves delayed inflammatory responses mediated by cellular immune mechanisms, predominantly affecting the gastrointestinal tract (Al-Beltagi et al., 2025; Darma et al., 2024).

Clinically, lactose intolerance generally occurs following the ingestion of lactose-containing foods and is mainly associated with gastrointestinal manifestations such as abdominal distension, diarrhea, flatulence, and abdominal pain. In contrast, CMPA demonstrates a broader multisystemic clinical spectrum that may involve gastrointestinal, dermatological, respiratory, and systemic manifestations. Dermatological findings such as eczema, urticaria, and angioedema, as well as respiratory manifestations including wheezing, chronic cough, and nasal congestion, are more suggestive of CMPA than lactose intolerance. Severe IgE-mediated reactions may additionally progress to anaphylaxis, which is not observed in lactose intolerance (Al-Beltagi et al., 2022). Cow's milk protein allergy may present with heterogeneous clinical manifestations involving gastrointestinal, dermatological, and respiratory systems, which may complicate the differential diagnosis process, particularly in pediatric populations (Gökmen, 2012). Therefore, the differential diagnosis between lactose intolerance and CMPA is clinically important, as symptom misinterpretation may lead to delayed diagnosis, inappropriate dietary restrictions, nutritional deficiencies, and unnecessary elimination diets. Epidemiological evidence indicates that CMPA is among the most common food allergies during infancy, whereas primary lactose intolerance rarely presents during the first years of life due to physiologically elevated lactase activity in infancy (Belgrave et al., 2015; Salvatore et al., 2021). Consequently, gastrointestinal symptoms occurring during early infancy should not automatically be attributed to lactose intolerance without appropriate clinical and immunological evaluation.

Furthermore, several conditions frequently overlap with CMPA and complicate the diagnostic process. Gastroesophageal reflux disease (GERD), infantile colic, and functional gastrointestinal disorders may present with symptoms similar to CMPA, including regurgitation, irritability, feeding difficulties, vomiting, abdominal discomfort, and altered bowel habits. Consequently, reliance solely on nonspecific symptoms without confirmatory testing may increase the risk of both overdiagnosis and underdiagnosis of CMPA (Belgrave et al., 2015; Salvatore et al., 2021). This diagnostic process may become even more complicated because CMPA may present with variable clinical severity ranging from mild gastrointestinal or cutaneous findings to severe systemic reactions (Gökmen, 2012).

The two conditions also differ considerably in their diagnostic evaluation. Lactose intolerance is typically diagnosed using methods such as the hydrogen breath test, lactose tolerance test, stool acidity test, dietary elimination, serum gaxilose or urinary galactose tests, genetic testing, and jejunal biopsy for direct lactase activity assessment (Malik & Panuganti, 2023; Misselwitz et al., 2019; Porzi et al., 2021). Although jejunal biopsy is considered the gold standard for determining lactase deficiency, its invasive nature and high cost limit routine clinical use. Therefore, the hydrogen breath test is more commonly preferred in clinical practice because of its noninvasive and practical application (Misselwitz et al., 2019; Porzi et al., 2021).

By contrast, the diagnosis of CMPA requires immunological assessment. Diagnostic approaches include skin prick testing (SPT), serum-specific IgE measurements, elimination diets followed by oral food challenge (OFC), and detailed clinical history (Al-Beltagi et al., 2025; Vandenplas et al., 2023). In this context, identifying and eliminating the responsible food allergen is a key component of clinical management and symptom control in food allergy (Gökmen, 2012). Importantly, distinguishing between IgE-mediated and non-IgE-mediated CMPA is essential for accurate clinical management. While SPT and serum-specific IgE tests demonstrate relatively high diagnostic utility in IgE-mediated reactions, their sensitivity and specificity remain limited in non-IgE-mediated forms, where diagnosis often depends on clinical improvement following elimination and recurrence after reintroduction of cow's milk proteins (Al-Beltagi et al., 2025; Vandenplas et al., 2023). Accurate differentiation between lactose intolerance and CMPA is essential to prevent diagnostic confusion, avoid unnecessary dietary restrictions, and ensure appropriate nutritional and therapeutic management.

***Methods***

This narrative review was conducted to evaluate the efficacy of alternative dairy products, probiotic yogurts, and lactose-free milk in the management of lactose intolerance. A comprehensive literature search was performed using electronic databases including PubMed, Scopus and Google Scholar.

The search included studies published in English up to 2025 using the following keywords and their combinations: "lactose intolerance", "lactose-free milk", "probiotic yogurt", "alternative dairy products", "plant-based milk", and "lactase deficiency".

Original research articles, clinical trials, and relevant review papers focusing on dietary management strategies and alternative dairy products in lactose intolerance were included. Studies not directly related to nutritional management or lacking sufficient scientific evidence were excluded.

The selected studies were evaluated and synthesized to provide an up-to-date overview of current evidence.

## Classification of Lactose Intolerance

Lactose intolerance resulting from this enzyme deficiency is generally classified into four main subtypes (Di Costanzo & Canani, 2018; Malik & Panuganti, 2023).

***Primary Lactase Deficiency***

Primary lactase deficiency is the most common cause of lactase insufficiency. Lactase enzyme activity tends to decline with age. Although enzyme activity begins to decrease from infancy, symptoms typically emerge during adolescence or early adulthood (Lomer et al., 2008; Malik & Panuganti, 2023).

***Secondary Lactase Deficiency***

Damage to the intestinal mucosa due to various infectious, inflammatory, or other diseases may lead to secondary lactase deficiency (Srinivasan & Minocha, 1998). Common causes of lactase deficiency include gastroenteritis, celiac disease, Crohn's disease, ulcerative colitis, chemotherapy, and antibiotic treatments (Di Costanzo & Canani, 2018; Malik & Panuganti, 2023).

***Congenital Lactase Deficiency***

This condition, associated with an autosomal recessive inheritance pattern, is characterized by reduced or absent lactase enzyme activity from birth. Clinical manifestations generally appear following milk consumption in the neonatal period. This form represents a rare etiology of lactase deficiency, and its genetic basis has not yet been fully elucidated (Malik & Panuganti, 2023; Pratelli et al., 2024).

***Developmental Lactase Deficiency***

In premature infants particularly those born between the 28th and 37th weeks of gestation lactose digestion may be impaired due to insufficient intestinal maturity. The underdeveloped intestinal epithelium results in reduced lactase enzyme activity, thereby preventing the hydrolysis of lactose. However, this condition generally resolves spontaneously with advancing age as enzyme activity increases through intestinal maturation (Malik & Panuganti, 2023; Pratelli et al., 2024).

## Epidemiology: Global and Regional Prevalence

Lactose intolerance, although widely reported on a global scale, is rarely observed during childhood and has a low prevalence particularly among children under five years of age. It is estimated that approximately 65% of the world's population is lactose intolerant, with the condition most commonly manifesting in adolescents and young adults (Goosenberg & Afzal, 2025)

The prevalence of lactose intolerance varies markedly according to geographic region and ethnicity. In Asia, prevalence exceeds 90% in many populations and may approach 100% in some countries. In Africa, prevalence typically ranges from 65% to 75%, reaching nearly 100% in certain regions. In South America and Latin America, prevalence is reported to exceed 50%. (Fassio et al., 2018a). In contrast, lower prevalence rates are observed in Northern and Central Europe, ranging from 2% to 20%, with approximately 5% reported in Scandinavian countries. In Southern Europe, prevalence is higher, around 40%–70%. In the United States, prevalence varies by ethnicity, with lower rates among individuals of European descent (15%–20%) and significantly higher rates among Mexican-Americans/Hispanics (~53%) and African Americans (60%–80%) (Bouchoucha et al., 2021b; Fassio et al., 2018a)

## Nutritional Management of Lactose Intolerance

The primary approach in the management of lactose intolerance involves restricting or completely eliminating foods and beverages containing lactose, and using lactase supplements concurrently with milk consumption. This strategy is generally sufficient to control symptoms (Facioni et al., 2020). An overview of primary and potential sources of dietary lactose is presented in Table 2.

The cornerstone of medical nutrition therapy in individuals with lactose intolerance is a lactose-free diet. However, recent updates in the literature indicate that most individuals with lactose intolerance can tolerate 12–15 g of lactose per day (Catanzaro et al., 2021b; Fassio et al., 2018). Therefore, an individualized dietary plan should be developed, and the patient's lactose tolerance threshold should be determined.

In a study conducted by JanssenDuijghuijsen et al. (2024), participants received twice-daily lactose interventions in gradually increasing doses. The findings demonstrated a significant increase in the proportion of *Bifidobacterium* in the microbiota, a two-fold rise in fecal β-galactosidase activity, and a 33% reduction in hydrogen excretion an indicator of improved lactose tolerance. Participants' symptom scores also showed a decrease (JanssenDuijghuijsen et al., 2024). Regular lactose intake may promote an adaptive response in the gut microbiota in individuals with lactase deficiency, enhancing lactose tolerance through increased bifidobacterial abundance and reduced gas production. These results suggest that complete elimination of lactose from the diet may not be necessary.

Rather than fully excluding lactose from the diet, reducing its quantity may be a more appropriate strategy to prevent nutritional deficiencies in individuals with lactose intolerance (Catanzaro et al., 2021a). In the nutritional management of lactose intolerance, lactose-free dairy products, plant-based milk alternatives, lactase enzyme replacement, and prebiotic and probiotic supplementation are used to promote colonic microbiome adaptation (Facioni et al., 2020; Ianiro et al., 2016; Katoch et al., 2022; Kies, 2014; Porzi et al., 2021; Tomar, 2014). In a study evaluating the efficacy of galactooligosaccharide (GOS), a type of prebiotic, in the treatment of lactose intolerance, GOS supplementation was shown to beneficially modify the gut microbiota by increasing *Bifidobacterium* levels. Additionally, GOS use significantly reduced the incidence of diarrhea and improved symptom severity. GOS supplementation has emerged as an effective and promising prebiotic strategy for the management of lactose intolerance (Angima et al., 2025). When used for a certain duration, GOS supplementation may exert therapeutic effects even without probiotic combinations. However, to ensure sustained outcomes, regular supplementation and individual responses should be considered (Mysore Saiprasad et al., 2023).

Table 2. Overview of Primary and Potential Sources of Dietary Lactose

| Milk and Dairy Products | Cheeses | Milk-Based Desserts and Processed Products | Other Sources (Hidden Lactose) |
|---|---|---|---|
| • Cow, goat, sheep milk<br>• Yogurt<br>• Ayran<br>• Kefir<br>• Cream<br>• Butter<br>• Clotted cream / Kaymak | • Fresh and soft cheeses<br>• Curd cheese (Lor)<br>• White cheese<br>• Cream cheese<br>• Mozzarella<br>• Ricotta<br>• (Aged hard cheeses e.g., Parmesan, aged cheddar; generally, contain less lactose) | • Milk chocolates<br>• Ice cream<br>• Milk pudding, rice pudding, custard<br>• Ready-made cakes and pastries (containing milk)<br>• Milk-based coffees (latte, cappuccino, etc.)<br>• Creamy sauces and soups<br>• Some biscuits and crackers (contain milk powder) | • Processed meats (sausage, salami, hot dogs — may contain milk protein/lactose as an additive)<br>• Instant soups, packaged sauces<br>• Protein bars and powders<br>• Certain medications and tablets (lactose may be used as an excipient) |

Table 3. Nutritional Composition of Plant-Based Milks and Cow's Milk (Walther et al., 2022)

| Product | Energy (kcal/kg) | Total Protein (g/kg) | Total Amino Acids (g/kg) | Total Fat (g/kg) | Total Carbohydrates (g/kg) |
|---|---|---|---|---|---|
| Almond milk | 328 kcal | 10.2 g | 8.1 g | 25.6 g | 13.0 g |
| Cashew milk | 415 kcal | 13.3 g | 11.5 g | 27.6 g | 22.8 g |
| Coconut milk | 230 kcal | 3.2 g | 2.5 g | 10.2 g | 27.7 g |
| Cow's milk | 655 kcal | 32.6 g | 33.0 g | 35.4 g | 50.3 g |
| Hemp milk | 310 kcal | 7.2 g | 5.4 g | 32.6 g | 16.0 g |
| Oat milk | 415 kcal | 4.6 g | 4.0 g | 14.5 g | 36.7 g |
| Rice milk | 546 kcal | 1.7 g | 1.3 g | 12.6 g | 48.2 g |
| Soy milk | 416 kcal | 37.8 g | 34.6 g | 20.6 g | 14.7 g |
| Spelt (hulled wheat) milk | 420 kcal | 7.2 g | 5.9 g | 12.2 g | 49.5 g |

**Alternative Dairy Products for Lactose Intolerance**

A variety of alternative products have been developed for individuals with lactose intolerance to replace conventional milk and dairy products. In addition to lactose-free dairy products, milk and milk derivatives produced from plant-based sources such as soy, almond, hazelnut, coconut, oat, and rice serve as suitable options. Since these plant-based milk products do not contain lactose, they contribute to the prevention of lactose-related gastrointestinal symptoms and help improve quality of life (Antunes et al., 2022; Katoch et al., 2022; Walther et al., 2022).

Health issues such as cow's milk allergy, as well as lifestyle choices including veganism and vegetarianism, have increased consumer interest in plant-based milk alternatives. Consequently, plant-based milk products have become widely used as an option to meet different nutritional needs (Antunes et al., 2022).

It is important to consider that plant-based milk alternatives may be inadequate in terms of essential nutrients when consumed instead of cow's milk, and consumers should be informed accordingly. In general, plant-derived proteins are considered inferior to animal-derived proteins in terms of amino acid composition. This discrepancy may result in differences in the bioavailability of plant and animal proteins. While cow's milk contains casein and whey proteins, which can be used efficiently by the body, plant-based milks typically lack a complete amino acid profile. Although alternative milk products do not provide full nutritional equivalence to cow's milk, this discrepancy can largely be minimized by fortifying them with macro- and micronutrients such as protein, calcium, vitamin D, vitamin B12, and omega-3 fatty acids. Furthermore, these fortifications may improve the omega-6/omega-3 fatty acid ratio, resulting in a more balanced nutritional profile (Antunes et al., 2022; Katoch et al., 2022; Li et al., 2023; Paul et al., 2020; Walther et al., 2022). Nutritional composition of plant-based milks and cow's milk is illustrated in Table 3.

Long-term consumption of plant-based milk alternatives may lead to serious health concerns, particularly in children. Consumption of milk alternatives instead of cow's milk in young children has been associated with growth retardation and shorter stature development (Morency et al., 2017). For children in the growth period, cow's milk should be prioritized; if a plant-based milk alternative is required, fortified soy milk is recommended (Szilagyi & Ishayek, 2018). Although plant-based milk alternatives may provide symptomatic relief in lactose intolerance, their long-term effects particularly on gut microbiota should be critically evaluated. The exclusion of lactose from the diet removes a potential substrate for beneficial microbial activity, which may negatively influence microbial balance. Overall, while plant-based milk alternatives may serve as a useful option for symptom management in lactose-intolerant individuals, their role should be considered within a balanced, evidence-based dietary framework that accounts for both nutritional adequacy and long-term health outcomes (Antunes et al., 2022).

In recent years, studies have focused on the type and amount of casein in animal milks used in the dietary management of lactose intolerance. β-Casein is a major bioactive protein component and constitutes approximately 30% of protein content in cow's milk. There are two variants of β-casein: A1 and A2. Milk containing A2 β-casein has been reported to undergo digestion more easily in tolerant individuals (Kay et al., 2021). In a study investigating the effects of milk containing only A2 β-casein, Jersey milk (25/75 A1/A2 β-casein), traditional milk (75/25 A1/A2 β-casein), and lactose-free milk on lactose digestion and gastrointestinal symptoms, individuals who consumed milk containing only A2 β-casein reported less abdominal pain compared to those consuming traditional milk (Ramakrishnan et al., 2020). Thus, the casein content of the milk consumed may have the potential to alleviate symptoms in the management of lactose intolerance. However, individual tolerance levels and symptomatic responses vary; therefore, personal differences should be taken into consideration in dietary planning for lactose intolerance.

**Efficacy of Probiotic Yogurts in Lactose Intolerance**

Probiotics are live microorganisms frequently used in the treatment or prevention of various medical conditions due to their beneficial effects on the gastrointestinal system. The United States Food and Drug Administration (FDA) and the World Health Organization (WHO) define probiotics as "live microorganisms which, when administered in adequate amounts, confer a health benefit on the host." Probiotics offer multiple advantages including regulation of gut microbiota, support for lactose digestion, and enhancement of resistance against pathogens and are therefore considered an effective alternative approach in the management of lactose intolerance (Cano-Contreras et al., 2022; Facioni et al., 2020; Hodges et al., 2019).

*Bifidobacterium longum* and *Bifidobacterium animalis* are among the most common species found in the gut microbiota and are among those with the best-characterized probiotic properties. These microorganisms contribute to the metabolic activity of the gut microbiota, particularly through the fermentation of complex carbohydrates and oligosaccharides, and play a significant role in maintaining intestinal homeostasis (Zhong et al., 2006; He et al., 2008).Current literature indicates that these species are associated with various physiological effects, including the suppression of harmful microorganisms, improvement of intestinal function, reduction of inflammation, and regulation of gastrointestinal transit time (Bouvier et al., 2001; Bottacini et al., 2011).

In the context of lactose intolerance, clinical data suggest that Bifidobacterium species may help alleviate symptoms by modulating the colonic microbiota. In particular, supplementation with *B. longum* and *B. animalis* has been reported to increase β-galactosidase activity, induce changes in microbial composition, and be associated with improvements in symptom scores (He et al., 2008). However, it is understood that these effects occur primarily at the colonic level rather than causing a significant change in lactose digestion in the small intestine. Additionally, the resistance of these species to stomach acid and bile salts enables them to reach the colon and maintain their functional effects (He et al., 2008; Oak &Jha, 2019). In contrast, some studies have reported that B. animalis supplementation did not result in a significant improvement in symptoms (Levri et al., 2005) . In a study investigating the effects of *Bifidobacterium adolescentis*, it was demonstrated that the iVS-1 strain, which possesses high β-galactosidase activity, significantly reduced gas production derived from the fecal microbiota in the presence of lactose. The findings indicate that not only enzyme activity but also microbial competition for the substrate plays a decisive role in symptom control. Clinical results showed that individuals receiving *Bifidobacterium* supplementation experienced a significant improvement in total symptom scores compared to placebo, particularly regarding fecal urgency and diarrhea. However, a recurrence of symptoms was observed following the discontinuation of the intervention (Ramakrishnan et al., 2015). While the majority of findings are generally positive, the consistency of the results remains limited due to heterogeneity in study designs.

Studies have shown that yogurt is better tolerated by individuals with lactose intolerance compared to milk containing equal amounts of lactose (Fuller, 1991; Mustapha et al., 1997). The literature on the health effects of yogurt has increasingly focused on the functional role of the live microorganisms it contains (Marco et al., 2017). In this context, yogurt is considered not only a dairy product but also a carrier matrix for probiotic microorganisms. Yogurt products are generally categorized into conventional yogurt, bio-yogurt, and bifido-yogurt according to their microbial composition and functional properties. Conventional yogurt is traditionally produced using *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus*, whereas bio-yogurts are enriched with additional probiotic strains such as *Lactobacillus acidophilus*. In contrast, bifido-yogurts specifically contain *Bifidobacterium* spp., including strains such as *Bifidobacterium animalis* subsp. *lactis* and *Bifidobacterium bifidum*, which are associated with distinct metabolic and gastrointestinal effects (Marco et al., 2017; Hadjimbei et al., 2022; Saleem et al., 2024). Current evidence suggests that yogurt consumption may increase gut microbial diversity and provide potential benefits for the gastrointestinal system and immune function (Masoumi et al., 2021). Additionally, its beneficial effects on inflammatory bowel disease, irritable bowel syndrome, and lactose intolerance are frequently highlighted (Marco et al., 2017; Hadjimbei et al., 2022). However, since these effects have largely been evaluated based on microbial content, a more detailed examination of the underlying mechanisms is required.

Although both bio-yogurt and bifido-yogurt are classified as probiotic dairy products, their mechanisms of action may differ according to the dominant bacterial strains they contain. Lactobacillus-containing bio-yogurts primarily contribute to lactose digestion through direct lactase (β-galactosidase) activity in the small intestine, thereby facilitating lactose hydrolysis into glucose and galactose. In addition to improving lactose digestion, these microorganisms may also enhance intestinal barrier integrity and modulate local immune responses (Fuller, 1991; Mustapha et al., 1997). Additionally, strains such as *Lactobacillus bulgaricus* and *Streptococcus thermophilus* have also been reported to produce lactase and may provide

clinical benefits in individuals with lactose malabsorption (de Vrese et al., 2001; Gingold-Belfer et al., 2020). By contrast, bifido-yogurts exert additional effects predominantly within the colon. *Bifidobacterium* spp. are capable of fermenting undigested lactose that reaches the large intestine and producing microbial metabolites such as short-chain fatty acids (SCFAs), including acetate and lactate. This process contributes to a reduction in luminal pH, suppression of gas-producing pathogenic bacteria, and modulation of intestinal microbial composition. Furthermore, certain *Bifidobacterium* strains exhibit β-galactosidase activity, which may facilitate colonic lactose degradation and improve symptom tolerance in individuals with lactose malabsorption (de Vrese et al., 2001; Gingold-Belfer et al., 2020). Therefore, while bio-yogurts primarily support lactose digestion through direct enzymatic hydrolysis in the small intestine, bifido-yogurts appear to exert broader colonic and microbiota-mediated effects through lactose fermentation and SCFA production. Collectively, these mechanisms are considered to contribute to the reduction of abdominal pain, bloating, flatulence, and diarrhea observed following probiotic yogurt consumption in individuals with lactose intolerance. Therefore, the beneficial effects of probiotic yogurts appear to extend beyond simple lactose hydrolysis and may involve broader interactions between microbial metabolism, intestinal permeability, immune modulation, and gut microbiota composition.

In a study conducted by Masoumi et al. (2021), probiotic yogurt containing *Lactobacillus acidophilus* and *Bifidobacterium* was shown to reduce symptoms of lactose intolerance. After a one-week intervention, individuals consuming probiotic yogurt exhibited a significant decrease in hydrogen breath test results and marked improvement in symptoms such as bloating and gas (Masoumi et al., 2021). Probiotic yogurts therefore represent an effective nutritional strategy for symptom control in lactose intolerance and can be considered an important alternative among dairy options.

**Efficacy of Lactose-Free Milk in Lactose Intolerance**

To prevent nutritional deficiencies in individuals with lactose intolerance and to ensure continued intake of calcium and high-biological-value protein, the dairy industry has developed lactose-reduced and lactose-free milk products. These products are based on the principle of hydrolyzing lactose into glucose and galactose via the exogenous β-galactosidase (lactase) enzyme added to milk; thus, lactose digestion is facilitated, preventing the onset of symptoms associated with intolerance (Churakova et al., 2019).

Indeed, in a study comparing whole milk containing 20 g of lactose with lactose-free milk in individuals reporting symptoms of lactose intolerance, it was demonstrated that consumption of lactose-free milk resulted in significant improvements in both symptom scores and hydrogen breath test results. (Oh et al., 2022). For this reason, lactose-free milk is considered a suitable alternative for individuals with lactose intolerance.

However, the effects of lactose-free milk on the gut microbiota are not yet clear, particularly in healthy individuals. In a study conducted using an in vitro model, it was shown that lactose-free milk modulates the gut microbiota differently from regular milk; it was associated with a decrease in levels of beneficial bacteria such as *Bifidobacterium* and ,*Lactobacillus* as well as a reduction in short-chain fatty acid production. Additionally, potentially adverse microbial changes, such as increased indole production and a rise in the relative abundance of Escherichia species, were observed. In contrast, milk containing lactose has been associated with a more balanced microbial and metabolic profile. These findings suggest that lactose-free products should be used only when necessary, and their routine consumption in healthy individuals should be carefully evaluated (Casciano et al., 2025). A summary of scientific studies on lactose intolerance is presented in Table 4.

Table 4. Summary of Scientific Studies on Lactose Intolerance

| Author / Year | Study Type | Sample | Intervention | Outcome Measures | Key Findings |
|---|---|---|---|---|---|
| Janssen Duijghuijsen et al., 2024 | Controlled trial | Lactase nonpersistent genotype | Daily lactose exposure (increasing doses) | Microbiota composition, B-galactosidase activity | ↑Bifidobacterium, ↓$H_2$, ↓Symptoms, improved tolerance |
| Angima et al., 2025 | Randomized controlled trial | Lactose intolerant individuals | GOS supplementation | Microbiota, diarrhea incidence | ↓ Diarrhea, ↑Bifidobacteria; promising therapeutic approach |
| Ramakrishnan et al., 2020 | Double blind crossover | Lactose-intolerant adults | A2 β-casein milk vs traditional vs lactose-free milk | GI symptoms | A2 β-casein significantly reduced abdominal pain compared to traditional milk |
| Masoumi et al., 2021 | Randomized controlled trial | 28 patients with lactose intolerance 27 patients with lactose intolerance | Probiotic yogurt with L. acidophilus & Bifidobacterium | $H_2$ breath test, symptom score | Significant reductions in bloating, gas & $H_2$ levels; improved tolerance |
| Oh et al., 2022 | Clinical trial | Korean adults with lactose intolerance | Lactose-free flavored milk | Symptom score, $H_2$ test | Significant improvement in symptoms and digestion |

B-galactosidase: Beta-galactosidase, $H_2$: Hydrogen, GOS: Galactooligosaccharides, GI: Gastrointestinal, A2 β-casein: A2 Beta Casein, *L. Acidophilus: Lactobacillus Acidophilus*

## Limitations of Current Research

The number of recent studies highlighting the potential benefits of diet-based interventions in the management of lactose intolerance symptoms is increasing; however, a critical review of the existing literature reveals the presence of certain significant methodological and conceptual limitations. In particular, clinical trials evaluating probiotic supplements and plant-based milk alternatives often involve small sample sizes, which limits the generalisability of the findings to larger and more heterogeneous populations.

Furthermore, a notable lack of standardisation in intervention protocols is striking. Significant variations in the probiotic strains used, dosages, and duration of administration across studies reduce the comparability of results and hinder the development of clear, evidence-based recommendations for clinical practice.

In addition, it is observed that the majority of existing studies focus on short-term symptomatic improvements, whilst long-term colonic adaptation processes and microbiota-based mechanisms are not sufficiently addressed. This situation points to a significant gap in the literature regarding the assessment of the sustainable effects of dietary interventions.

## Conclusions

Lactose intolerance is a common gastrointestinal condition characterized by symptoms triggered by the ingestion of lactose-containing dairy products. Nutritional management is a key component in improving patient outcomes and quality of life. In this context, probiotic yogurts, lactose-free milk, and plant-based beverages are commonly considered alternative strategies.

Probiotic yogurts may alleviate symptoms primarily through the β-galactosidase activity of live microbial strains, which facilitates lactose hydrolysis within the gastrointestinal tract. Similarly, in lactose-free milk, lactose is enzymatically pre-hydrolyzed into glucose and galactose via exogenous lactase supplementation, thereby preventing symptom onset. Plant-based beverages, in contrast, do not contain lactose and may therefore provide a symptom-free alternative for individuals with lactose malabsorption.

However, beyond symptom control, these alternatives differ substantially in their physiological and microbiological implications. Emerging evidence suggests that lactose-containing dairy products may contribute to gut microbial homeostasis by supporting beneficial taxa such as *Bifidobacterium* and *Lactobacillus* and promoting a favorable short-chain fatty acid profile. In contrast, lactose-free products may exhibit a less pronounced prebiotic effect due to the absence of intact lactose. Similarly, plant-based beverages, while effective in eliminating lactose exposure, do not provide lactose as a fermentable substrate and therefore may not exert comparable effects on colonic microbiota.

These findings indicate that while plant-based beverages and lactose-free milk can be effective in symptom management, their broader impact on gut microbiota should be considered. Consequently, complete avoidance of lactose may not always be necessary or optimal. A more individualized approach based on tolerance thresholds and incorporating fermented dairy products such as yogurt alongside appropriate alternatives may represent a more balanced nutritional strategy.

Future research should focus on strain-specific probiotic effects, standardized evaluation methods, and long-term clinical outcomes to better define the role of these dietary options in lactose intolerance management.

## Declarations

### *Author Contribution Statement*

Concept: Kuran, Ö; Ekici, E.M.; Design: Kuran, Ö; Ekici, E.M.; Data Collection or Processing: Kuran, Ö; Ekici, E.M.; Analysis or Interpretation: Kuran, Ö; Ekici, E.M.; Literature Search: Kuran, Ö; Ekici, E.M.; Writing, Review and Editing: Kuran, Ö; Ekici, E.M.

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### *Conflict of Interest*

We declare that there is no conflict of interest between us as the article authors.

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