

Lactose intolerance: The most significant nutritional recommendations of lactose free diet

Judit Molnár^{1*}, Renátó Kalocsai¹, Pál Szakál¹, Tamás Szakál¹, and Dávid Vasas¹

¹Albert Kázmér Faculty of Agricultural and Food Sciences of Széchenyi István University in Mosonmagyaróvár, Department of Water Management and Natural Ecosystems, Vár Square 2, H-9200 Mosonmagyaróvár, Hungary

Abstract. Background: Milk and dairy products play a key role in healthy diet. In case of lactose intolerance, the digestion of these products becomes difficult. It is associated with stomach and intestinal complaints. Purpose: The purpose of the manuscript is to summarize the literature on lactose, lactose intolerance, lactose-free diet and lactose-free products development opportunities. We hope that we can contribute to a more accurate understanding of the lactose-free diet and reveal connections between consumer expectations and consumption. Methods: Electronic searches were conducted in Google Scholar, Medline, PubMed and Science Direct databases. We used 34 specialist literature and 3 URL to write our conference publication. Results: We summarized the most important characteristics of lactose, the symptoms and treatment options of lactose intolerance, the importance of lactose-free diet and calcium supplementation in the therapy of lactose intolerance and the latest and most informative publications on the development of lactose-free functional foods. Conclusion: Today, the consumption of lactose-free products is an outstanding way to treat the growing number of people with lactose intolerance. The food industry also pays special attention to the application of new technologies and product development. We hope to contribute to a wider understanding of lactose, lactose intolerance, the lactose-free diet and lactose-free product development opportunities with our conference manuscript.

1 Introduction

According to nutritional recommendations, it is extremely important to consume half a liter of milk and dairy products per day. These complex protein sources have an important disease prevention effect for example milk and dairy products contribute to the development of bones and teeth [1]. Lactose is one of the main components of milk as a disaccharide. Indigestion of lactose is an increasingly common disease [2]. The structure of lactose is illustrated in Figure 1 [3].

In case of lactose intolerance, gastrointestinal symptoms appear in the human body [4]. Following dietary recommendations plays an important role in its therapy [5]. Lactose-free

* Corresponding author: molnar.judit@sze.hu

milk and dairy products are extensively available to consumers and the importance of these product developments shows a growing trend nowadays. The main purpose of the manuscript is to give an overview of lactose and lactose intolerance, its dietary treatment and the development possibilities of lactose-free milk and dairy products. We hope that our manuscript can provide useful information for professionals working in the fields of nutrition science, food science and medicine.

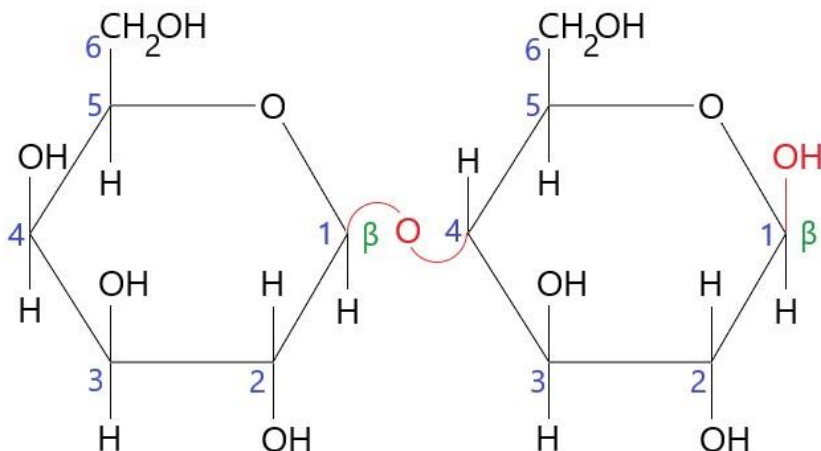


Fig. 1. The structure of lactose (modified scheme) [3].

2 Material and methods

We first collected electronic information in the Google Scholar, Medline, PubMed and Science Direct databases. The search keywords included lactose, lactose intolerance, lactose-free diet, lactose-free milk and dairy products, lactose-free product development. 34 of the collected manuscripts were used to prepare our conference manuscript. Furthermore we also used 3 URL. The total number of citations for the collected manuscripts in Google Scholar on 14 April 2024 is 2773. Most of the manuscripts were published after 2011, as illustrated in figure 2. 25 manuscripts belong to scientifically ranked quartiles, 17 manuscripts to Q1.

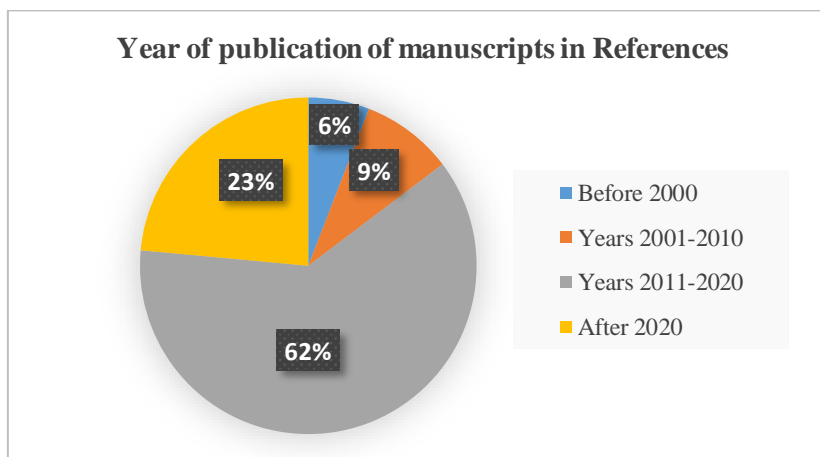


Fig. 2. Year of publication of the manuscripts cited in this article (own editing).

3 Results

3.1 Lactose, lactose intolerance, symptoms and treatment

Lactose is broken down into glucose and galactose by the β -galactosidase (hereinafter: lactase) enzyme found in the small intestine. In the absence of lactose breakdown, symptoms of the stomach and intestinal system appear, which cause a significant deterioration in the quality of life. In case of lactose intolerance, replacement of the lactase enzyme becomes necessary [6]. In addition to enzyme supplementation, recommendations for a lactose-free diet help to achieve a better quality of life. Figure 3 illustrates the breakdown of lactose [7].

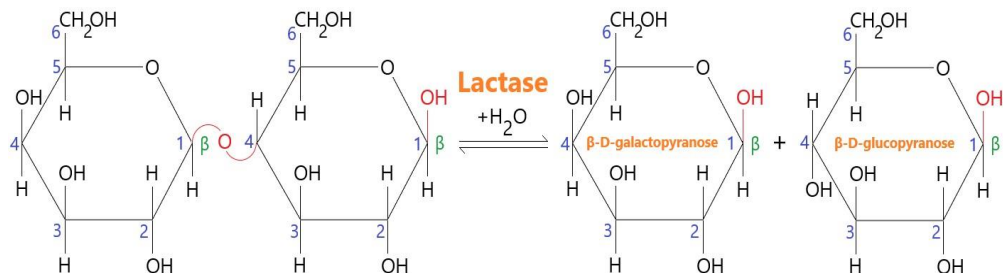


Fig. 3. The enzymatic breakdown process of lactose (modified scheme) [7].

The structure, digestion and absorption of lactose are discussed in many manuscripts. Some of them are summarized in Table 1.

Table 1. Structure, digestion and absorption of lactose in human body.

	The topic of the publications	References
Lactose	Components of lactose physical and chemical properties were investigated for example: melting point and heat of combustion molecular compounds of lactose were searched: the analysis by infrared spectroscopy and Thin-Layer Chromatography	[8]
	Interesting experiments with lactose: the article searched the connection between historical developments in analytics with contexts of today and school experiments	[9]
	The importance of lactose in nutrition difficulty digesting lactose	[10]
	Lactose and other components of milk The association between milk lactose content and other milk components: (for example.: protein and fat), somatic cell count (SCC), and total bacteria count (TBC) was measured using a database of bulk tank milk (BTM) samples.	[11]

Symptoms of lactose intolerance also depend on various factors [12]. Relevant articles on lactose intolerance, symptoms, diagnosis and treatment are summarized in Table 2.

Table 2. Lactose intolerance, symptoms, diagnosis and treatment.

	The topic of the publications	Refs.
Lactose intoleran ce	Diet for lactose intolerance <ul style="list-style-type: none"> - nutritional management: the calcium and vitamin supplementation are the most important in the diet - lactose intolerant people need to be informed about food ingredients - lactose-free alternatives: for example: fermented dairy and plant based milk food 	[13]
	Characteristics and dietary treatment of lactose intolerance: <ul style="list-style-type: none"> - the role of lactase and lactose - biological mechanism of lactose intolerance - there are several methods for diagnosing lactose intolerance - treatment with lactase enzyme, using probiotics, lactose-free diet 	[14]
	Characteristics of lactose intolerance <ul style="list-style-type: none"> - Intolerance to carbohydrates - types of lactose intolerance - lactose intolerance compared to cow's milk allergy: lactose intolerance (enzyme deficiency), cow's milk allergy (immune-mediated reaction) 	[15]
	Differences between lactose intolerance and milk protein allergy	[16]
	Literature review on lactose intolerance <ul style="list-style-type: none"> - clinical manifestations: gastrointestinal symptoms - available tests: stool testing, hydrogen breath test, lactose tolerance test, lactase activity at brush border, genetic test - management of lactose free diet: prebiotics, probiotics for gut microbiome, lactose-free diet 	[17]
	The lactose-free diet <ul style="list-style-type: none"> - lactose-free diet management in lactose intolerance: the role of gastronomy in lactose-free diet with lactose-free dishes. 	[18]
	Correlations between lactose intolerance and peak bone mass <ul style="list-style-type: none"> - calcium deficiency due to lactose intolerance can increase the chance of developing peak bone mass. 	[19]

3.2 The importance of lactose-free diet in case of lactose intolerance

Among gastrointestinal diseases, lactose intolerance also requires special dietary treatment. Dietary recommendations for lactose intolerance are based on a healthy diet. However, the lactose-free version of milk and dairy products plays a prominent role in the diet [20]. Accordingly, foods containing milk or dairy products should also be avoided. Plant-based drinks (e.g. soy, almond, hazelnut, rice, oat) can be excellent alternatives to replace milk [20]. Fats, oils, meat and fish, vegetables, fruits and tofu don't contain lactose. Some of the baked goods may contain lactose so their consumption requires careful attention. Eggs also fit into a lactose-free diet in different form. The consumption of most sweets such as chocolate, milk candies, cakes aren't recommended in lactose-free diet as they contain lactose in most cases. In addition to following nutritional recommendations, intestinal support with probiotics and calcium supplementation also important in case of lactose intolerance [14, 17, 20, 21].

3.3 The role of calcium and the importance of calcium supplementation in human body

Calcium is one of the most important minerals in human body. Among other things, it contributes to the health of teeth and bones, blood clotting, muscle contraction and normal nerve function. In addition, calcium is a component of many enzymes. The recommended daily intake value (RDA = 1000 mg) can mostly be provided to the human body with dairy products. In case of lactose intolerance, the main source of calcium intake can be walnuts, spinach, broccoli or other functional foods with increased nutrient content (juices, soy products) [13, 22-24].

The most important features of lactose-free diet are discussed in numerous publications. Some of them are summarized in Table 3.

Table 3. Nutritional recommendations for lactose-free diet.

	The topic of the publications	Refs.
<i>Lactose-free diet</i>	The lactose-free diet and its costs - Even with a lactose-free diet, Ca replacement and cost-effective alternatives are also important	[25]
	Lactose-free product database in Spain	[26]
	Dietary treatment of lactose intolerance - The lactose free diets can decrease gastrointestinal symptoms in individuals with lactose malabsorption or lactose intolerance.	[27]
	Lactose intolerance and lactose-free products - genetics of lactose intolerance - detection limit of lactose free products	[28]
	Nutritional support for African patients with malnutrition and lactose intolerance - lactose free formulae are well tolerated and result in positive nitrogen balance in malnourished people in the study	[29]

3.4 The role of food industry in the development of lactose-free functional foods

The role of the food industry in the production and development of lactose-free functional foods shows an increasing trend with the growth of consumer demands. Thanks to development activities, many lactose-free foods have become available. In addition, plant-based functional foods have also increased in the recent period. They can also be well integrated into the lactose-free diet. Product development is the result of coordinated work of many specialist areas. Innovative processes and technologies are greatly improving the quality and production efficiency of low-lactose (lactose content should be less than 1 g/100 g) and lactose-free (lactose content should be less than 10 mg /100 g) dairy products, creating new market opportunities. The most common methods are enzymatic hydrolysis, membrane separation and fermentation. Low-lactose and lactose-free dairy products such as liquid milk, breast milk powder, Greek-style yoghurt, kefir, cheese and ice cream are increasingly popular with consumers. Non-lactose dairy products are the fastest growing sector of the dairy industry, as illustrated in Figure 4 for the year 2022. Of the lactose-free products, milk represents 66% of the market, followed by yoghurt [30, 31] The market for lactose-free dairy products is forecast to reach USD 21.59 billion by 2030, which is about one and a half times more than the value obtained in 2022 [32].

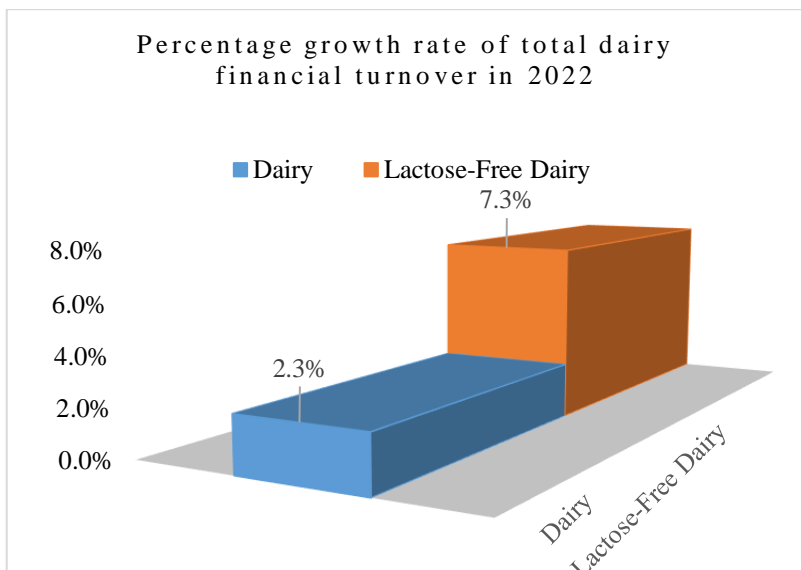


Fig. 4. Percentage growth rate of total dairy financial turnover in 2022 [31] (own editing).

In addition to food industry researchers and developers, research and development specialists in the fields of marketing, nutrition science, biotechnology, chemistry and environmental sciences also play an important role. In the rest of our manuscript, we analyzed articles that provide extensive information regarding lactose-free consumer needs and the development of lactose-free functional foods (Table 4).

Table 4. Lactose-free product development for human health.

	<i>The topic of the publications</i>	<i>References</i>
Development of lactose-free milk and lactose-free dairy products	Lactose-free food development - Alternate sources of milk, lactose hydrolysed milk and their composition (carbohydrates, fat, protein, calcium, moisture) - Different plant-based milk and their positive effects on human body	[20]
	Development of lactose-free dairy products for health - market developments of lactose-free dairy (lactose-free milk, lactose-free cheese) lactose-free yogurt - fermented milk products	[31]
	Lactose-free functional food analysis for product development purposes	[33]
	Development of milk drink with low lactose content - milk base selection, enzyme hydrolysis, formulation development, development of manufacture procedure, product investigation	[34]
	Research gaps in milk components	[35]
	Consumers' desires for lactose-free milk	[36]

	Detection of lactose in products - selection of dairy, sample preparation, using analytical methods for lactose quantification	[37]
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4 Conclusion

In our manuscript, we focused on lactose intolerance and the most important features of lactose-free diet. In the course of our research, we analyzed a number of specialized literature and we also examined the development possibilities of lactose-free foods. We found a close connection between the growth of food industry developments and the increased consumer demand for lactose-free products. Following a lactose-free diet plays the most significant role in the treatment of lactose intolerance. Replacement of the lactase enzyme effectively helps to break down lactose. Probiotics and calcium supplementation are an outstanding part of the diet. In addition to lactose-free dairy products (yogurt, cheese), plant-based products are also popular among consumers.

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