

INCIDENCE OF LACTOSE INTOLERANCE AMONG THE POPULATION OF BOSNIA AND HERZEGOVINA

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Abstract

Lactose is a carbohydrate only found in the milk of mammals and it is one of the most important components of milk. Upon consumption by humans, the enzyme β -galactosidase (lactase) breaks down lactose into glucose and galactose with the help of water in the small intestine, but its activity decreases or disappears completely when growing up, and consumption of lactose in adulthood can cause indigestion. In this research, based on literature data, it is explained why certain group of people in the world can digest lactose regardless of age, and some others cannot. It is also explained which products can potentially replace milk and milk products. However, the primary goal of this paper is to show the prevalence of lactose intolerance among the population of Bosnia and Herzegovina, and which dairy products cause them the most problems. Most of the previously conducted research showed that the phenomenon of lactase persistence is genetically determined. It occurs in Europeans in whom the activity of β -galactosidase is constantly maintained and the European population is able to digest large amounts of lactose regardless of age. On the basis of the conducted survey on the occurrence of milk lactose intolerance among different groups of people in Bosnia and Herzegovina, it can be concluded that the number of people who are lactose intolerant is significantly low. The results show that more than half, i.e. 58 out of 100 subjects tolerate lactose well, while only 20 respondents do not tolerate lactose. The latter answered that among milk and dairy products milk causes them the greatest digestive and other disturbances due to the highest lactose content, while dairy products, primarily fermented milks such as kefir, ayran and yogurt, cause significantly fewer problems.

Keywords: *lactose, intolerancy, population, milk*

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INTRODUCTION

Milk sugar or lactose ($C_{12}H_{22}O_{11}$) is the main carbohydrate of milk, composed of one molecule of $\alpha(\beta)$ -D-glucose and one molecule of β -D-galactose. The concentration of lactose in milk remains approximately the same throughout the year at about 4.70% in average (Sarić, 2018; Sarić and Brenjo, 2022). It is a reducing disaccharide where glucose and galactose are linked β (1 $\rightarrow$ 4) glycosidic bond (Jelen, 2022; Barać *et al.*, 2025). Its concentration in the milk of most mammals as the main carbohydrate ranges from 0 to 10% (m/m), and milk is the only known significant source of lactose. Lactose is synthesized in the epithelial cells of the mammary gland from two molecules of glucose absorbed from the blood. One molecule of glucose is converted (epimerized) into galactose via the Leloir pathway, which is widely distributed in animal tissues and bacterial cells. Galactose is phosphorylated and condensed with another glucose molecule by the action of a unique two-component enzyme, lactose synthase. Besides lactose, milk contains low concentrations of several sugars, primarily glucose and N-acetylglucosamine (Fox, 2003). In addition, 15-18% of the total carbohydrates in milk are lactose derivatives, chain or branched oligosaccharides consisting of 3-10 monomers, mainly galactose, fucose and sialic acid (Fukuda *et al.*, 2010). It is believed that lactose derivatives contribute to the improvement of the body's health by modulating the defense system against pathogens (Barać and Sarić, 2023).

When lactose reaches the human body for physiological use, it must be hydrolyzed in the intestines using the enzyme β -galactosidase (lactase) or lactase-phlorizin hydrolase (LPH), which is located in the brush border of the small intestine (Swallow, 2003). In the proximal small intestine (duodenum and the initial part of the jejunum), lactase hydrolyzes lactose into glucose and galactose (Barać *et al.*, 2026). The presence of lactase gradually decreases from the jejunum to the ileum (Misselwitz *et al.*, 2019). The problem of intolerance occurs when people do not possess or possess very small amounts of β -galactosidase (lactase) (Barać and Sarić, 2023). Consequently, accumulation of lactose in the small intestine happens which leads to increased fluids inflow into the intestinal lumen. Unabsorbed lactose passes into the large intestine and is exposed to the action of colonic bacteria, which results in the formation of short-chain fatty acids and hydrogen. In mammals, lactase expression is highest at birth and then decreased. Humans, unlike the other mammals (Kaur *et al.*, 2006) retain the activity of lactase, creating thus group of lactase-resistant or lactose-tolerant individuals. They digest lactose and can consume large amounts of fresh milk without difficulty. Those with low lactase in adulthood are described as non-persistent lactase (in the literature they are also called primary adult hypolactasia) and are lactose 'maldigesters'. Poor digestion can lead to symptoms of lactose intolerance, which limits the consumption of fresh milk. However, most people with non-persistent lactase can tolerate small amounts of milk (as in tea or coffee), and some can consume a lot without negative effects. Variations in the composition of intestinal flora between individuals, as well as a psychosomatic component, may be the reason for these variations (Swallow, 2011).

Lactose intolerance is caused by the interaction of genome and diet. When a substantial amount of lactose is not absorbed in the intestines, it is known as lactose malabsorption. According to the degree of lactase activity, two types of conditions can be established: alactasia (i) (complete absence of lactase activity) and hypolactasia (ii) (an imbalance between the amount of lactose consumed and the capacity to hydrolyze it, resulting in extremely low lactase activity in the jejunal mucosa) (Kaur *et al.*, 2006). In addition to lactase expression, other factors that contribute to lactose intolerance include intestinal flora, gastrointestinal motility, small intestinal bacterial overgrowth, lactose concentration, and the gastrointestinal tract's sensitivity to the production of gas and other products of fermentation from lactose digestion (Deng *et al.*, 2015).

In the early 1970s, Simoons published an article in which he hypothesized the origin of lactose intolerance as a cultural-historical hypothesis (Simoons, 1970). He hypothesizes that over time, a low incidence of intolerance has developed in an ethnic group that has had abundant milk supplies and inadequate substitutes, both in quantity and quality, and that consumed milk in forms rich in lactose. However, this phenomenon could not have happened among some ethnic groups if milk and lactose-rich milk products had not been used. To ascertain how long milk was consumed in various areas, the genesis and dissemination of dairy products are described. Given this context, the emergence of many old-world communities with varying degrees of intolerance is the explanation.

All groups studied so far within traditional non-dairy areas have been found to have a high incidence of lactose intolerance. Overseas populations, such as afroamerican population, whose ancestors originated in non-dairy areas, have a high incidence of lactose intolerance. Within the areas of milk consumption in Africa and, moreover, in Europe, there are known group differences in tolerance, which is consistent with the hypothesis. Although there are other points of view, the majority of studies confirm Simoons' thesis that the cultural-historical hypothesis has its foundations, that is, that lactose tolerance arose after the intake of milk and dairy products. One of these is the one that says that lactose tolerance arose later than previously thought, after the Bronze Age, when people began to introduce milk and dairy products into their diet (Allentoft *et al.*, 2015).

Depending on the origin, there are four types of lactose intolerance. **Congenital** lactase deficiency (Table 1) is a metabolic impairment in an autosomal recessive condition that causes lactose intolerance. The enzyme is either completely absent or significantly reduced, while the small intestine's histology is normal. It starts at birth and persists throughout the duration of the person's life (Kuokkanen *et al.*, 2006a). **Developmental** or **neonatal** lactase deficiency (Table 1) can occur due to low lactase levels as a result of premature birth (28-32 weeks), as the activity of the enzyme in the fetus increases from the 34th week and reaches its maximum at birth. However, because of the large intestine's metabolism, which favours colonisation by other microbial species like *Bifidobacterium* spp. or *Lactobacillus* spp. when the pH of the large intestine decreases, babies can withstand this shortage and avoid malnourishment and diarrhoea (Kuokkanen *et al.*, 2006b).

Individuals with **secondary lactase insufficiency** (Table 1) exhibit normal enzyme activity. There are several causes and processes for the decrease in lactase. The villous margin of enterocytes in the small intestine is harmed by chronic enteropathies (secondary to immunological processes), such as Crohn's disease, coeliac disease, villous atrophy from calorie-protein malnutrition, and other gastrointestinal disorders. Here, infection is the main cause (Guarino *et al.*, 2008). The most prevalent type, known as **primary lactase deficiency** or adult hypolactasia (Table 1), is caused by a gradual and irreversible decline in enzyme activity.

Complete loss of enzyme function is uncommon, and the amount of lactase that is still present has a significant role in the emergence of symptoms. The most typical average age is between 5 and 7 years old, with the greatest influence happening between 30 and 40 years old. The method and onset time differ (Kuokkanen *et al.*, 2006b). It is believed that 70% of the world's population has this form of lactose intolerance (Heyman, 2006).

Tabela 1. Kategorije i specifičnosti intolerancije na laktozu

Table 1. Categories and specificities of lactose intolerance

Lactose intolerance categories	Lactase activity	Characteristic	Reference
Congenital lactase deficiency	The enzyme is either completely absent or significantly reduced, and the small intestine's histology is normal	It starts at birth and persists throughout the duration of the person's life	Kuokkanen <i>et al.</i> , 2006a
Developmental or neonatal lactase deficiency	Low lactase levels as a result of premature birth	It begins at birth	Kuokkanen <i>et al.</i> , 2006b
Secondary lactase deficiency	Normal enzyme activity	Damage the villous margin of enterocytes in the small intestine due chronic enteropathies (celiac disease, Crohn's disease)	Guarino <i>et al.</i> , 2008
Primary lactase deficiency (adult hypolactasia)	Progressive and permanent decrease in enzyme activity	The process and time of onset vary	Kuokkanen <i>et al.</i> , 2006b

Adult hypolactasia is mainly present in Asia and Africa regions. It occurs with different frequencies, most rarely in Europe. Thus, the lowest frequency rates were recorded in European countries - Scandinavia and Great Britain 7-14%, Germany 6-9%, Russia 16-37% and France 23-50% while a bit higher in Middle east region (24-73%). On the other hand, the incidence rates were significantly higher in Far east Asian countries where milk and dairy products were consumed little or not at all (China 86-92%, Thailand 97-100%, Vietnam 100%, Indonesia 91% and Japan 73-87%). In African countries it was also high (70-95%) while among afroamerican population somewhat

lower, about 75% (Sahi, 1994; Heyman, 2006; Mattar *et al.*, 2012; Diekmann *et al.*, 2015; Pavlović *et al.*, 2000). Although still high, the latter could lead to thinking that a bit lower incidence at afroamerican population occurred due to adaptation and changes in eating habits over time, but more detailed research and available data are needed to confirm this. The problem of lactose intolerance is less pronounced in fermented milk products such as yogurt, since the added bacterial cultures intensively use most and part of the lactose as a source of energy for their activity. Also, the dairy industry overcomes this problem with products that do not contain it at all, the so-called lactose-free. Here, the removal of lactose is based either on its physical removal (using membrane techniques such as ultrafiltration) or on its hydrolysis with the addition of the enzyme β -galactosidase or lactase which hydrolyzes lactose completely (Barać and Sarić, 2023).

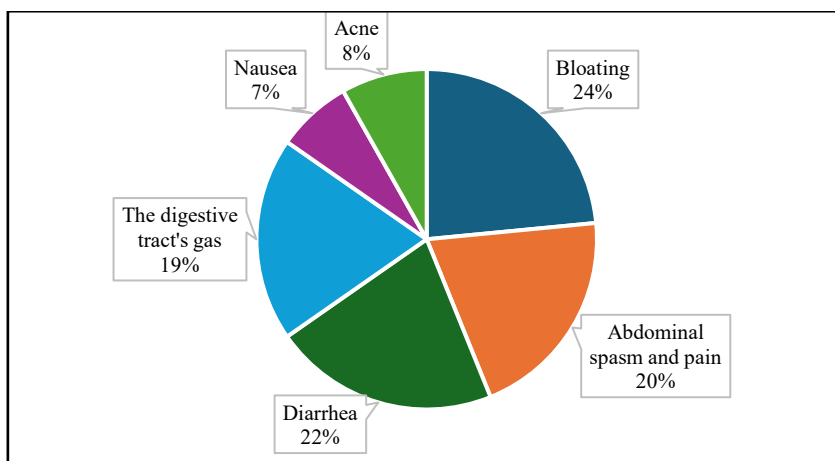
MATERIAL AND METHODS

In order to determine the occurrence of lactose intolerance in different groups of people, an anonymous survey of 100 randomly selected respondents in the territory of Bosnia and Herzegovina was conducted using the Google forms platform, which includes basic information about the respondents as well as their diet. The goal was to determine the prevalence of lactose intolerance of Bosnia and Herzegovina population. The survey included 12 questions related to the age and gender structure of the respondents, information about lactose, frequency and symptoms of lactose intolerance, habits of consuming milk and dairy products and reactions to them. Also, survey included questions about substitutes for milk and dairy products that may be used in the diet. The results are expressed as the number of respondents, or in %.

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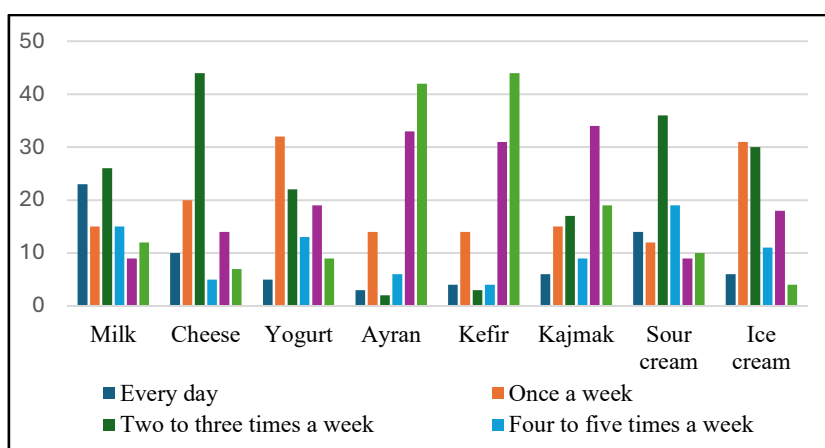
RESULTS AND DISCUSSION

The age range of people who completed the survey was categorized into three age groups: young (<15), mature (16-64), old (>65). Out of 100 respondents, 93 respondents were between 16 and 64 years old, 6 respondents were under 15 and 1 respondent was 65 or older. So, among the respondents, the mature female population prevailed while 72 respondents were female and 28 respondents were male. In terms of information about what lactose is, 15 respondents answered that they do not know while 85 answered that they know it is the sugar found in milk and dairy products. The respondents are quite familiar with the term lactose.



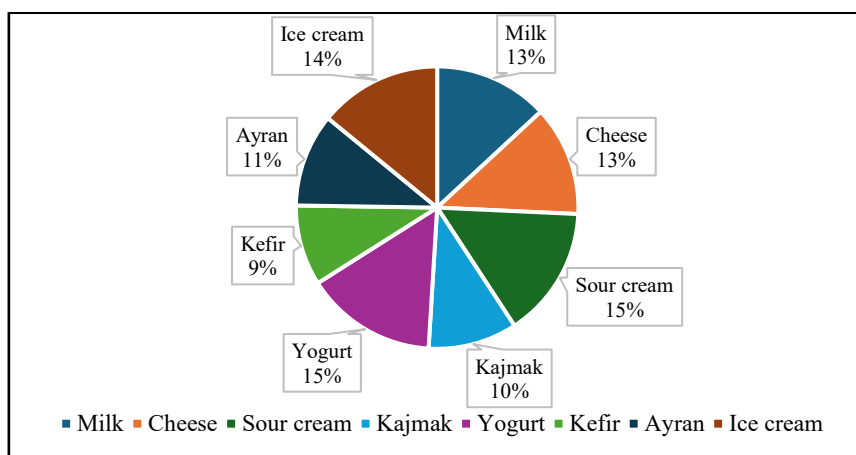
Slika 1. Simptomi intolerancije na laktozu
Figure 1. Symptoms of lactose intolerance

More than half of the respondents answered that they were not lactose intolerant (58%), 20% said they were, and 22% of the respondents did not know. This fits the European pattern when it comes to the incidence of lactose intolerance. However, this has to be taken with caution since for the support of theory of lactase persistency among the population of Bosnia and Herzegovina more detailed clinical research must be conducted. The main symptoms caused by consuming milk and dairy products in lactose intolerant people are bloating, followed by digestive problems such as diarrhea, spasms and abdominal pain, accompanied by gas production (Figure 1). Out of 100 respondents, the majority of them, namely 93 respondents, consume milk and dairy products.



Slika 2. Učestalost konzumiranja mlijeka i mliječnih proizvoda
Figure 2. Frequency of milk and dairy products consumption

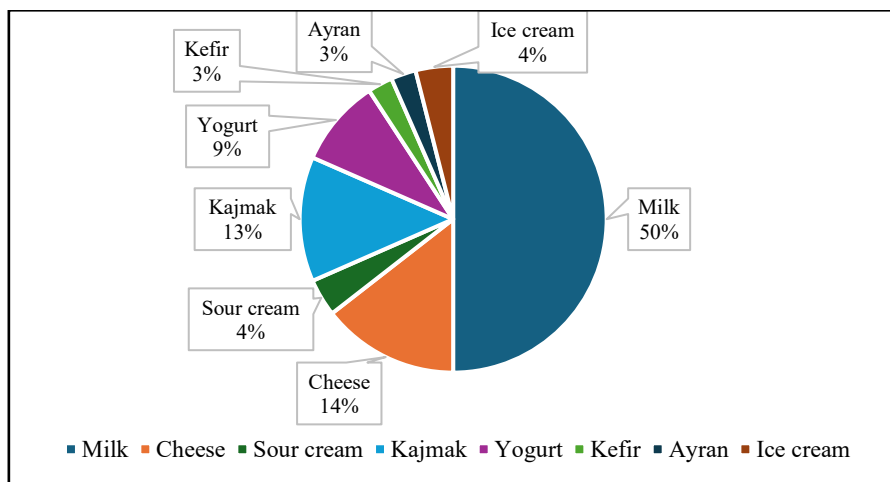
Among the products offered, the respondents had available milk, cheese, yogurt, ayran, kefir, kajmak, sour cream and ice cream. To a large extent, the respondents consume milk every day or two to three times a week, while they consume kefir and ayran the least, i.e. the largest number of respondents, 43 of 100, answered that they do not consume ayran and kefir at all. Also, sour cream, cheese and ice cream are often consumed among the respondents. Based on this data, it can be said that the consumption of kefir and ayran is not sufficiently represented among the population in Bosnia and Herzegovina (Figure 2). When asked whether some of the dairy products do not cause digestive disorders, 58% of the respondents who have intolerance answered that there are certain dairy products that do not cause them digestive disorders.



Slika 3. Mlijeko i mliječni proizvodi koji ne uzrokuju probavne smetnje kod ispitanika
Figure 3. Milk and dairy products that do not cause digestive disorders at respondents

Products that do not generally cause digestive disorders are yogurt and sour cream and, to a somewhat lesser extent, ice cream, milk and cheese. It can be seen that there is no general rule here, so although these are mainly fermented dairy products, some unfermented products such as milk and ice cream do not cause digestive disorders in certain respondents, which means that the individual conditions and metabolisms of the respondents have a considerable influence on this. However, the proportions of yogurt, ayran, kefir and sour cream are significant, all of which have a reduced lactose content and the activity of the starter culture enzymes that is introduced into the body by consuming these products. When looking at cheeses, the data is very relative given the heterogeneity of this group of products (Figure 3). Of course, these data should be taken with a reserve, taking into account the different amounts of dairy products consumed and the relatively small number of respondents. More precise and reliable answers to this are provided by an analysis of data related to the severity of digestive disorders. When asked whether any dairy products cause severe digestive problems, 42% of respondents answered that they do.

When looking at the structure of dairy products when it comes to the severity of symptoms or disturbances after their consumption, milk causes the most severe digestive problems in as many as 50% of respondents, followed by kajmak and cheese with 13% and 14%, respectively, and then yogurt with 9%, while sour cream, kefir and ayran cause more severe consequences in the least number of respondents. The latter is quite expected, although it would be expected that yogurt would also be found in this group. The surprising position of ice cream is with only 4% of respondents who reported severe disturbances after consuming this product (Figure 4). Although it should again be careful in the interpretation of these results, one can nevertheless observe regularity considering the high proportion of milk and the generally lower proportion of fermented milks which is expected in comparison to kajmak and cheeses. However, the type of cheese should be taken into account. This cognition is due to a number of nutritional advantages and functional components, the lower proportion of lactose, and certainly the significant role of the intake of living bacterial cells with their enzymes into the digestive system during consumption. Some positive effects of consuming yogurt and kefir compared to milk among lactose intolerant population were already reported. In the lactose-intolerant population, yoghurt and kefir similarly decreased the perceived intensity of flatulence by 54% to 71% when compared to milk. Flavoured yogurt gave also positive results while flavoured kefir had intermediate results. Since, kefir showed improved lactose digestion and tolerance in this study it was concluded that it has potential to overcome lactose intolerance (Hertzler and Clancy, 2003). Addition to this, lesser amount of lactose in kefir compared to milk and yogurt, 3.1 vs 4.7% was reported by some authors (Li *et al.*, 2023; USDA, 2024; Barać *et al.*, 2026).

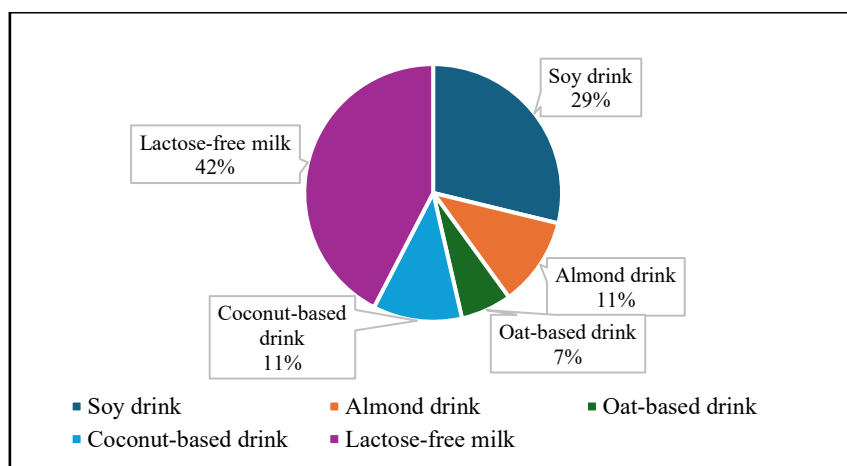


Slika 4. Mlijeko i mliječni proizvodi koji uzrokuju teže probavne smetnje kod ispitanika

Figure 4. Milk and dairy products that cause severe digestive disorders at respondents

In an effort to avoid the problems caused by consuming milk and dairy products, consumers often resort to milk substitutes. Regarding the use of milk substitutes, 31% of respondents said that they use some of them. To a large extent, respondents consume lactose-free milk, followed by soy drinks, and to a much lesser extent almond, coconut or oat drinks (Figure 5).

Based on a survey conducted on the occurrence of lactose intolerance in different groups of people and by comparing it with research data for other countries and regions in the world, it may be said that in Bosnia and Herzegovina there is a much smaller number of people who are lactose intolerant compared to the countries of Asia and Africa. On the other hand, the data are consistent with the results obtained in countries and regions in Europe.



Slika 5. Zamjena za mlijeko i mliječne proizvode koje ispitanici koriste
Figure 5. Substitute for milk and dairy products used by respondents

CONCLUSION

Lactose is the dominant carbohydrate in mammalian milk and is broken down in the small intestine by the action of the enzyme β -galactosidase with the help of water, which breaks down lactose into glucose and galactose. Lactase activity is at its highest level in early childhood, while over time during adulthood it decreases or disappears completely, and then lactose intolerance appears. Undigested lactose passes into the large intestine, and if a larger amount of lactose is remained undigested by active amount of the enzyme β -galactosidase, enteric bacteria produce lactic acid, methane and hydrogen, carbon dioxide, short-chain fatty acids, and the appearance of these products can cause various problems such as gas, bloating, diarrhea, abdominal pain, acne, spasms and nausea.

Lactose intolerance differs and depends on various factors, and the most common form is primary lactase deficiency or hypolactasia in adults as a result of a progressive and permanent decrease in enzyme activity. This type of lactose intolerance is mostly found in Asians and Africans and much less often in Europeans. The phenomenon of lactase persistence occurs in Europeans, which means that the activity of the β -galactosidase enzyme is constantly maintained and that they are able to digest large amounts of lactose regardless of age. This phenomenon is genetically determined. Based on the conducted survey on the occurrence of milk lactose intolerance in different groups of people, it can be concluded that within the population of Bosnia and Herzegovina, the frequency of lactose intolerance is significantly low (20% of respondents) and is at the level of that of many European countries and regions.

The conducted survey found that among respondents who are lactose intolerant, it is milk that causes the greatest digestive disturbances due to the highest lactose content, while other products such as kefir, ayran, yogurt or sour cream cause this to a much lesser extent. Also, based on the data obtained, it was concluded that the respondents did not sufficiently consume kefir and ayran as a useful fermented milk for reducing lactose intolerance.

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UČESTALOST INTOLERANCIJE NA LAKTOZU MEĐU POPULACIJOM BOSNE I HERCEGOVINE

Sažetak

Laktoza je ugljikohidrat koja se jedino nalazi u mlijeku sisara i ona predstavlja jednu od najvažnijih komponenti mlijeka. Nakon unošenja u ljudski organizam, enzim β -galaktozidaza (laktaza) uz pomoć vode u tankom crijevu razgrađuje laktozu na glukozu i galaktozu, ali se njegova aktivost prilikom odrastanja smanjuje ili potpuno nestaje, te konzumiranje laktoze u kasnijem životnom dobu može stvarati probavne smetnje. U ovom istraživanju na bazi literaturnih podataka objašnjeno je zašto pojedine grupe ljudi na svijetu mogu probavljati laktozu bez obzira na starost, a neke druge ne mogu. Takođe je objašnjeno koji proizvodi mogu potencijalno zamijeniti mlijeko i mliječne proizvode. Međutim, primarni cilj ovog rada je pokazati koliko je zastupljena pojava intolerancije na laktozu među stanovništvom Bosne i Hercegovine, te koji mliječni proizvodi im najviše ili najmanje stvaraju probleme.

Većina sprovedenih istraživanja je pokazala da je fenomen perzistencije laktaze genetski određen. Ona se javlja kod evropljana kod kojih se aktivnost β -galaktozidaze konstantno održava i evropska populacija je u mogućnosti da probavi velike količine laktoze bez obzira na starosnu dob. Na osnovu sprovedene ankete o pojavi intolerancije na laktozu kod različitih skupina ljudi u Bosni i Hercegovini može se zaključiti da je znatno manji broj osoba koje su intolerantne na laktozu. Rezultati pokazuju da više od pola, odnosno 58 od 100 ispitanika dobro podnosi laktozu, dok tek 20 ispitanika ne podnosi laktozu. Ovi posljednji su odgovorili da im mlijeko stvara najveće probavne i druge smetnje zbog najvećeg sadržaja laktoze, dok mliječni proizvodi, prvenstveno fermentirana mlijeka kao kefir, ayran i jogurt stvaraju znatno manje problema.

Ključne riječi: *laktoza, intolerancija, skupina, ishrana*