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Development of Lactose Free Yogurt Technology for Personalized Nutrition

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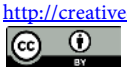

Abstract

Due to the widespread use of antibiotics, the bad ecological situation, fermented milk drinks are gaining more and more popularity because of associating with an array of health benefits. Fermented milk products contain a unique in its kind disaccharide of animal origin lactose, which has the ability to stimulate the development of lactic acid microorganisms that suppress the vital activity of pathogenic microflora in the human intestine, promoting the absorption of calcium, magnesium and phosphorus. A significant part of the world's population suffers from lactose intolerance, linked to a genetically determined deficiency of the β-galactosidase enzyme, which is one of the main reasons for the decrease in demand for dairy products among consumers suffering from primary or acquired intolerance to milk sugar. Lactose is a natural disaccharide contained in dairy products. Lactase deficiency is a variant of fermentopathy caused by the inability to break down lactose due to the activity decrease of lactase—the parietal digestion enzyme in the small intestine. Lactose intolerance in the gastrointestinal tract of a person suffering from hypo- and alactasia leads to dispersion, diarrhea and other undesirable phenomena. For the successful prevention and treatment of these diseases, it is necessary to reduce or completely eliminate the lactose intake. A technology for lactose-free milk production was developed using fermentation technology. On the basis of lactose-free milk, a range of lactose-free yoghurts was developed of animal origin of the following types: natural, enriched and fortified. Flax seeds, sesame seeds and chia seeds, which are rich in vitamins, were used to produce a range of enriched yogurts. To obtain fortified yoghurts, the mineral iron was used, which prevent the development of anemia and oncological pathologies. Experimental assortment of lactose-free yoghurts was assessed by physicochemical and organoleptic methods. All developed samples meet the standards of technical documentation for this type of food product. The organoleptic characteristics were highly appreciated. Developed lactose-free products are an opportunity for many people to return to a normal healthy

diet.

Keywords

Intolerance, Fermented Milk Products, Lactose Free, Fermentation Technology, Healthy Diet

1. Introduction

Milk is an essential component of the diet of ~6 billion people. World milk production reaches 730 million tones/year [1]. Even though mammals produce milk to feed their offspring, in many parts of the world humans continue to consume milk throughout their lives. Currently, lactose intolerance is widespread throughout the world and a large part of the population does not benefit from the positive effects of milk.

Many dairy products such as yogurt, kefir, etc., have their production origins and have been consumed since ancient times. Various studies state that milk is very healthy, that it is the best source of calcium and that it prevents osteoporosis, promoting it as a real superfood. This is mostly due to its composition; the milk of any mammal has exactly the amount of protein, calcium and vitamins needed for the growth and development of their young. No other food provides all the necessary nutrients, in an ideal ratio for the body of the chicks, than milk [2].

In the years 2015-2020, the American food guides claimed that the principles of a healthy diet are based on the consumption of fat free or low-fat dairy products (1%), including milk, yogurt, cheese, etc. However, there are people who for health reasons or based on their food preferences cannot consume dairy products. These people need to ensure their intake of nutrients (protein, calcium, potassium, magnesium, vitamin D, and vitamin A) from products with similar compositions such as fortified products [3] [4].

Dairy products are the best source of calcium for humans. Calcium in milk and dairy products is absorbed in a higher percentage than in products of plant origin, containing certain favorable factors, such as lactose, casein and vitamin D (in the case of fortified products), thus dairy products should still be considered the superior sources of calcium [5].

Yogurt is a popular food product, appreciated for its health benefits. Since its discovery, extensive research has been conducted to understand and improve its texture, taste and properties. Consumption of yogurt has been associated in particular with the improvement of intestinal health and the immune system [6]. Today's consumers benefit from a wide variety of yoghurts available on the market [7]. Consumption of yogurt per capita has steadily increased in recent decades in most countries around the world. In the last 5 years, most developed countries have reported an increase of over 10% in sales volume [8].

Yogurt enjoys a high popularity among consumers due to the fact that it con-

tains both *Lactobacillus bulgaricus and Streptococcus thermophilus*, and it is also known to contain nutrients (calcium, vitamin D and potassium) that are missing from the traditional diet [9]. Recent studies have associated the consumption of yogurt with several benefits for human health and the assimilation of certain nutrients, improved bone mineral intake, weight management, heart health, metabolic health and digestive and immune health [10]. Beneficial and special cultures can be added to yogurt and offer additional health benefits [11]. The properties of yogurt and fermented dairy products were initially investigated by Metchnikoff and highlighted their influence on human longevity, especially due to the positive effect on the intestinal flora [12].

Lactose is the main sugar in milk and dairy products, being an important source of energy for the body, but also involved in the absorption of important minerals, such as calcium or magnesium. To be used, lactose must be processed in the intestine by an enzyme called lactase that cleaves this disaccharide into glucose and galactose monomers [13]. Lactase activity is especially important during infancy, when milk is the main source of nutrition. From the eighth month of pregnancy, lactase activity can be detected on the surface of the intestinal mucosa. The activity increases until the 34th week, and at birth the lactase expression reaches its peak [14] [15]. Numerous studies have demonstrated that the ability to digest lactose during the period of breast-feeding is essential for the infant's health in order to avoid the congenital lactase deficiency that is extremely rare and fatal if not recognized very early after birth. Congenital lactose intolerance occurs when the newborn lacks the genes for lactose secretion. Missing genes appear due to defective mutations. Finally, it causes a lifelong intolerance to all types of milk, including breast milk. Physiologically, lactase has an increased activity in newborns, and its concentration will decrease over time, resulting in the primary deficiency of adult lactase (hypolactasia or non-persistence of lactase), a situation encountered in most individuals around the world. As we age, there is a progressive physiological reduction in lactase activity in the intestinal cells. It is estimated that 75% of adults worldwide suffer from a decrease in the amount of lactase produced by the body in adulthood—which is actually the normal course [16]. It has been shown that the descendants of populations that traditionally practice cattle domestication are an exception to this rule, having the ability to digest milk and other dairy products into adulthood. **Figure 1** shows the frequency of "lactase persistence trait", this being higher in northern European populations, with a decreasing trend across southern Europe and the Middle East and reduced in Asia and most of Africa [17].

As a result of lactase deficiency lactose is not absorbed in the intestinal tract and leads to symptoms of lactose intolerance [18]. They are manifested by an increase in the content of intestinal water, and lactose is easily fermented by the colonic microbiome leading to the production of short-chain fatty acids and gases (mainly hydrogen (H_2), carbon dioxide (CO_2) and methane (CH_4)) [19] [20].

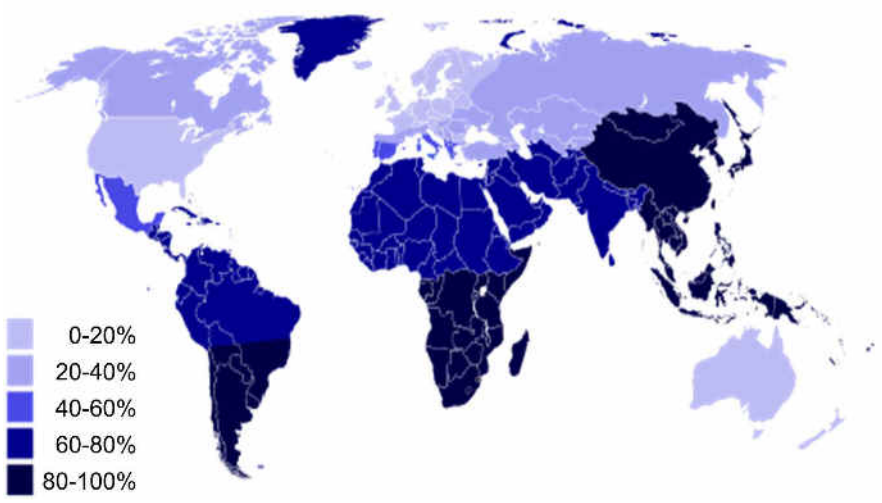

Figure 1. Lactose intolerance worldwide, % of total population.

Lactose intolerance is a medical problem that has a significant impact on the lives of those affected. Patients report symptoms, including: abdominal pain, diarrhea, bloating, flatulence and abdominal cramps. Lactose maldigestion occurs when the concentration of the enzyme lactase is reduced at the edge of the brush of the mucosa of the small intestine. This usually occurs in early childhood. 75% of the population is susceptible and sensitive to lactose [21]. In the Republic of Moldova, it is estimated that up to 18% of people have the potential for lactose intolerance [22] [23] [24]. Unfortunately, statistical data on consumer behavior regarding the consumption of lactose-free products, at the moment, doesn't exist [25].

In case of lactose intolerance, doctors recommend consuming alternative sources of calcium and vitamin D, either of animal origin (egg yolk, liver, fish—especially fatty), or of vegetable origin (dried beans, parsley, spinach, basil, arugula, seaweed, broccoli, almonds, hazelnuts, soy). Special preparations of lactose free milk are also recommended, as well as the consumption of calcium-rich mineral waters. However, this advice carries a significant nutritional risk.

Studies conducted between 1967 and 2009 and analyzed by the United States Department of Health and Human Services have elucidated the fact that low dietary milk and dairy intake was a risk factor for bone fracture, osteoporosis and other adverse health outcomes [26]. The study showed that dietary calcium supplements did not consistently increase bone mineral density or reduce fracture risk. Thus, research on stimulating dairy consumption while limiting the symptoms of intolerance is encouraged at international scientific forums [27]. In addition to health consequences, dairy avoidance weakens the immune system due to lack of vitamin B12, also intestinal health may suffer because the body is deprived of good bacteria and probiotics that improve intestinal health and are found in dairy products.

Studies have shown that children and adolescents who do not consume the recommended quantities of milk and milk products fail to meet their needs in

calcium, which also impedes them to reach the peak of required bone mass. Consumption of insufficient amounts of dairy products could increase at the same time the risk of osteoporosis in elderly adults and lead to an increased risk of pathological bone fractures [28]. It was established that a nutritional diet containing insufficient amounts of vitamin D increases blood pressure by activating the renin-angiotensin-aldosterone system, which causes vasoconstriction as well as sodium and water retention in the body [29] [30]. Other minerals contained in dairy products, such as magnesium and potassium, might be able to regulate blood pressure, but their individual contribution is difficult to be assessed since both nutrients are usually in foods rich in calcium [31] [32]. Several studies have shown that dairy products may prevent loss of muscle mass and strength that occurs with age, as well as functional foods [33]. This phenomenon, called sarcopenia, could be prevented thanks to physical activity and a diet rich in dairy products and vitamin D [34]. The recommendations are made by The International Osteoporosis Foundation and The Society on Sarcopenia and Cachexia [35] and are based on the fact that regular use of milk products would have a positive impact on muscles, increasing skeletal muscle mass and force [36] [37], improving trabecular structure and at the same time increasing bone mineral density and bone mass [38].

As a solution for those who do not digest lactose would be the consumption of lactose-free products, which actually has the same nutritional profile as regular milk, so that they still get the same vitamins, minerals, calcium and protein, without discomfort. Over the last decade, lactose-free milk and vegetable milk have become commonplace in major supermarket chains. Sales of alternative dairy products, worth $7.37 billion in 2016, are projected to grow to $14.13 billion in 2022, Dairy Reporter reports. As a consequence, lactose-free dairy is now the fastest growing market in the dairy industry. Lactose-free foods are a chance for several people to return to a traditional healthy diet [39]. Yogurts, fermented dairy products with a high mass fraction of dry matter, are gaining special popularity among the population. Therefore, it is important to expand the range of lactose-free fermented dairy products as well as animal and vegetable origin. The main aim of this work is to develop a technology for lactose-free milk produced using fermentation technology; to develop range of lactose-free yoghurts on the basis of lactose-free milk of animal origin of the following types: natural, fortified and with additives.

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