



Lactose-free Products: Production Technology and Future Market

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ABSTRACT

Milk provides humans with nutrients that the body needs, such as calcium. It also enables the host to have higher levels of short-chain fatty acids, thus providing a major source of energy for the host's body. Lactase helps humans to break down large molecules of lactose into smaller molecules of glucose and galactose. Unfortunately, however, the frequency of lactase persistence varies greatly in human populations due to a variety of factors, including geographical and dietary cultural differences, as well as genetic phenotypes. Many people lose their lactase enzyme in adulthood. As a result, they are unable to digest milk. Most Asians are lactose intolerant. To date, there is still a lack of sufficient evidence to explain the genetic pattern of lactase persistence. In recent years, the product range of lactose-free products has diversified and consumers have more choices. This paper will discuss the persistence of lactase, production technologies for lactose-free products by literature review, (intermittent and aseptic) have some problems including high cost, uncontrollable amount of lactase and unstable reaction rate at high temperature. Based on the existing problems and disordered market, it is suggested that the relevant international organization should establish a standard level of lactose-free products and standardize market.

Keyword: *lactose persistence; lactase; lactose-free product; lactose-intolerant; hydrolysis of lactose*

1. INTRODUCTION

About 10,000 years ago, humans began to domesticate mammals, and milk and milk products began to gradually appear in the daily diet of humans. [1] However, studies have shown that the frequency of LPs varies widely in different human populations. LP refers to the fact that after human adulthood - that is, at the age of eighteen, lactase is still present in the body and has the ability to break down large molecules of lactose into small molecules of galactose and glucose. LNP deserves to be a type of person who does not have the ability to digest lactose independently, that is, lactose intolerant. The distribution trend of LP on the world map is distinct, and the population with high LP frequency mainly exists in countries located in Europe. The difference is huge. In Southeast Asia, such as Thailand, the frequency of LNP has reached an astonishing 100%. However, in most European countries, such as the Netherlands, the frequency of LNP is 1%. [2] This suggests that most Europeans have the ability to digest lactose independently, and they can obtain energy from dairy products. Although scientists have made many efforts in the past, they have explored how LPs select humans. LP

is a classic example of convergent evolution, but it is still debated in the scientific community. Because there is still a lack of sufficient evidence to explain the LP frequency in the Hadza people of Tanzania and the Wolos of Senegal. These two peoples have never included lactose in their diets in history, but LPs reached 41% and 51%. [1]

Milk has a high level of short-chain fatty acids, can quickly ferment, and is an important source of nutritional supplements. Milk is rich in carbon ions and protein, which can strengthen bones. At the same time, there are a large number of bioactive peptides in dairy products, which play a role in helping the human body to resist hypertension and thrombosis. Milk is very attractive to people who are lactose intolerant. For people with lactose intolerance, many companies have developed lactose-free and lactose-reduced dairy products. These special dairy products provide the essential nutrients in milk.

There are two different types of lactase on the market today. Some consumers tend to use acid lactase, which is taken together with dairy products. The lactose is decomposed in the stomach, and these monosaccharides are absorbed in the small intestine, avoiding the

occurrence of lactose intolerance symptoms. Industrial-scale lactose-free dairy products are produced using neutral lactase. [3]

This review focuses on the application of neutral lactase in industrial production, we will touch on the market outlook of lactose-free products, industrial production techniques and potential problems posed by the consumption of lactose-free dairy products. The aim of this article is to provide the guides for dairy production industry.

2. PRODUCTION OF LACTOSE-FREE DIARY

This paper will give an overview of the different methods used to remove lactose or reduce lactose levels in the traditional lactose-free product industry. In addition to this, it also describes the techniques for determining lactose in lactose-free products.

In different countries, governments have adopted different regulatory requirements for dairy production and so far no uniform industry requirements have been reached. Unlike the regulatory standards in the past, the government approved milk with a lactose content of 0.1%. Now the government's requirements are becoming more stringent, and milk with lactose levels below 0.01% is considered lactose-free milk. In order to remove as much lactose as possible, the amount and type of lactase plays a crucial role. The main lactase enzymes used in the lactose industry are *K. lactis-galactosidase* enzyme and *oryzae*. Under different conditions, both enzymes have their own advantages. At 10 ° C, *K. lactis-galactosidase* enzyme exerted a higher hydrolysis efficiency. However, at 55 ° C, both whey and lactose were completely hydrolyzed. [3] Currently, two main methods, intermittent and aseptic, are adopted worldwide for the production of lactose-free dairy products. In both processes, manufacturers optimize the stability of the enzyme by using a large number of soluble lactase. [4] The hydrolysis of lactose is influenced by various factors, including enzyme concentration, temperature and reaction time, which affect the rate of hydrolysis.

2.1. Batch process

First, a certain amount of lactase is added to the dairy product. The mixing time will last 24 hours in order to prevent the appearance of cream. After finishing, the milk is pasteurized, homogenized and standardized separately. This batch of lactase must meet the following properties, including maximum activity at low temperatures.(Figure1) [5].

2.2. Aseptic Process

The milk is first sterilized using the UHT process and the lactase is added to the milk. Normally, the UHT

process ensures that the milk is kept in isolation for up to 3 days. During this process, the lactose is fully hydrolyzed in the milk, changing from large molecules to small molecules of glucose and galactose. Aseptic lactase can be obtained by two different procedures. Lactase will be sterilized and this production step will be done by special aseptic metering equipment, such as the Flexdos® system from a Swedish company. In the last procedure, workers will filter and sterilize the enzyme, which will then be injected into the aseptic milk in the plant.(Figure1) [6]

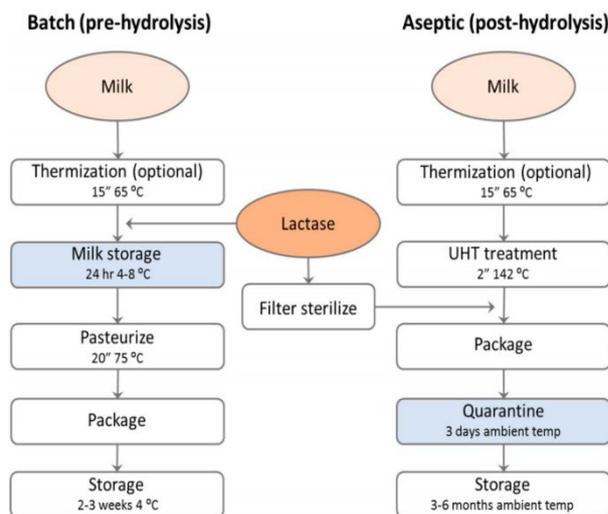


Figure1: Process of hydrolysis of lactose [6]

2.3. Other Method

In order to better analyze the residues in lactose-free products, a more common method in commerce is to measure the release of glucose after β -galactosidase hydrolysis. However, this method cannot be applied to lactose-free milk due to the release of monosaccharides. A number of methods are already in use. For example, chromatography, gravimetric methods, mid-infrared detection, and polarization methods. Among their differential ph, the gas chromatography, and cryoscopy have been approved by several institutions. [7]

In commerce, the more common method is to measure glucose released from the hydrolysis of β -galactosidase. This method is relatively simple to operate, rapid, and low-cost. However, this method cannot give specific values of the final lactose content, and the sensitivity is low during the experiment, and the final error is large.

The most accurate method to detect lactose content is the Bio lactose biosensor (Biolan) method. [8] However, Russian scholars consider the use of high performance liquid chromatography with mass spectrometry detection and high performance anion exchange chromatography with pulsed amplifier detection (HPAEC-PAD) as international standard reference methods for the

determination of lactose in low-lactose and lactose-free dairy products to be also appropriate. [9]

3. POTENTIAL CUSTOMERS AND FUTURE MARKET

Lactose-free dairy products are the most promising sector in the milk industry, with a projected turnover of €91 billion in 2023. Potential consumers are mainly concentrated in Western Europe and Latin America, growing with a share of 8.4%. [10] Between 2012 and 2016, lactose-free products drove the growth of the entire dairy industry, making it the new healthy food in the eyes of consumers. More and more consumers are making lactose-free products a priority choice due to health concerns. The growing variety of lactose-free products is also encouraging and stimulating this consumption. In addition, because lactose-free foods taste better and are of better quality, if there is a lactose-intolerant person in a family, the others will accommodate him and switch to dairy products that do not contain any lactose. Consumer psychology has also stimulated the development of this field. Neutral β -galactosidase is the lactase commonly used in industry and this enzyme is produced by four companies. DSM Food Specialties (Heerlen, The Netherlands) (sold exclusively under the Maxilact® brand), Godo (Japan), Amano (Japan), and Nagase (Japan). The Japanese company handles sales through secondary suppliers, such as DuPont (Wilmington, DE, USA) (Godo YNL2®), Chris Hansen (Öresund, Denmark) (Halactase®) and Novozymes (Bagsværd, Denmark) (Lactozyme® Pure), as well as unknown suppliers. [3]

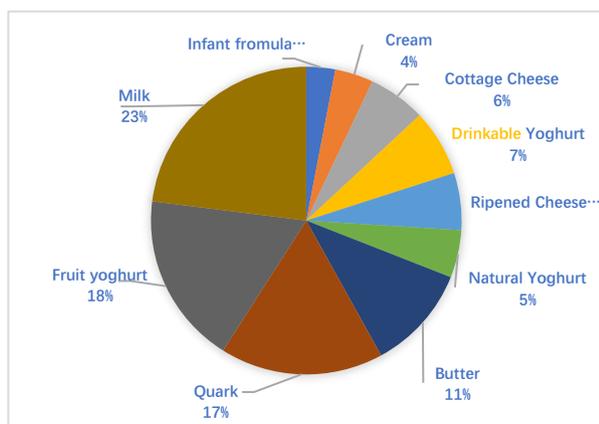


Figure2: Availability of various dairy products in the examined shops (%) [11]

The variety of lactose-free foods is growing and is not limited to the traditional perception of milk, but also includes cakes, chocolates and other derivatives that use milk as an ingredient. These offer more options for lactose-intolerant consumers. The image in Figure 2 shows the different proportions of lactose-free products in online stores, showing that cheese (6%), cream (4%) and baby food (3%) have the lowest proportions of

lactose-free products, while drinking milk, flavored yogurt and cream have the highest proportions. [9] indicates that for infants and some people who prefer cheese, they do not have access to the nutrients in milk. Also, the survey on the price of lactose-free products shows a higher price compared to traditional milk, starting at 4% and even reaching up to 166%. This suggests that milk producers need to better control costs and that high prices could lose a large number of potential consumers.

4. PUBLIC CONCERNS AND HEALTH PROBLEMS

A company producing lactose-free milk in Poland conducted a consumer acceptance test based on Meilgaard's methodology. Fifty-two volunteers took part in the test. They were all milk-loving consumers, aged between 17 and 62 years old. The test used a nine-point hedonic scale intended to test consumer acceptance of lactose-free products, ranking them on a scale of 1 to 9 from extreme love to extreme dislike. The end result was that 70% of people clearly indicated that they gave a score of 5 to lactose-free milk. [12] However, the test is significant flawed, and due to the relatively small sample size (only 52 people), the final data and test results do not represent the opinions of all consumers. Some academics have suggested that food labelling could be used to allow consumers to better distinguish the proportion of lactose. But so far there is still a lack of a homogeneous standard. [13]

The National Institute for Health Research in the UK considers that 12 grams of lactose per serving is not likely to have an effect on people with lactose malabsorption. In the US, 75% of people refuse to buy lactose-free foods. They fear that avoiding lactose in the long term will have a negative impact on their health. In a survey in the USA, 56% of respondents stated that they were lactose intolerant and therefore did not consume milk. A further 43% refused to consume milk for other reasons such as personal perceptions and dietary preferences. Vitamin D is present in milk, but the amount of vitamin D in dairy products is reduced after processing. Some academics believe that milk is not the best way to consume vitamin D. Therefore, there is no need for consumers to pursue a high intake of milk for health reasons. [14]

5. PREDICTION

As there is still a lack of sufficiently effective methods to treat the symptoms of lactose intolerance, lactose-free products are taking a prominent place in the market. The emergence of these products offers consumers more opportunities to obtain nutrients such as calcium ions from milk products. The promotion of these products will effectively enhance consumers' perception of the nutritional value of dairy products. This area of

lactose-free remains an untapped and unexplored area for dairy manufacturers, with high margins and a large market. The technology for lactose-free products is becoming more sophisticated, but the range of products needs to be improved. Products for infants and for people with specific diets still need to be developed. At the same time, the high costs should be reduced. Despite the benefits of lactose-free products, it is also worth considering the safety issues that lactose-free products may pose. There should also be a consensus between countries to set stricter testing standards for lactose-free products.

6. CONCLUSION

This paper analyses the distribution of lactose-free product and technology, evaluation of lactose-free product in different countries. And it discusses the current situation of lactose-free product market. However, this paper is a review of the preliminary method of manufacturing dairy products. The major limitation of this study is the lack of data and quantitative analysis. In the future, more experiments are required to investigate the view of this article.

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