

Study of the Parameters of Obtaining Low Lactose Whey Suitable For Baby Food

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Abstract. *Since childhood is characterized by rapid metabolic processes, the development of organs and body systems, and the formation of functional activity, nutrition is especially important for a child. It is known that breast milk is the most rational and important method of feeding a child, as it contains all the essential nutrients a child needs during this period. Breast milk lays the foundation for future health, preventing diabetes, coronary heart disease, obesity, and other diseases. Breastfeeding also has a profound emotional impact, bringing mother and child closer together during feeding, and this desire for each other lasts a lifetime. Breastfeeding is not always possible. Many mothers develop hypogalactia, and milk production ceases completely. Illnesses of both mother and child, premature birth, and other factors can lead to the cessation of breastfeeding. Children deprived of breast milk are transferred to artificial feeding using specially adapted formulas that are as close as possible to breast milk. Thanks to new information about the individual components of breast milk, work is constantly underway to create and improve adapted formulas. Due to its amino acid content, the use of milk protein in infant formula is very convenient. Whey protein is more easily digested than powdered milk. However, the lactose it contains can sometimes negatively impact digestion, making it difficult for infants to digest. For this reason, it is possible to hydrolyze the lactose contained in the protein to the required concentration. This article examines the parameters affecting lactose hydrolysis and tests optimal options. The temperature, enzyme concentration, and hydrolysis time required for adequate lactose hydrolysis are determined.*

Keywords: *breast milk, baby food, artificial formula, whey, lactose hydrolysis*

Introduction

Another term used to describe fermented milk products is "probiotic products." This definition refers only to fermented milk products containing probiotic microorganisms (Wijesekara et al., 2025). Over the years, significant work has been done to improve the composition of these products, select ideal starter cultures, and study their effectiveness in both healthy and sick children (Jena & Choudhury, 2025). One of the major achievements is the development of high-quality dry fermented milk products, which has made it possible to provide children living in remote areas with modern, high-quality fermented milk products. These products are manufactured under strict quality and safety controls in large factories equipped with specialized equipment (Baranov & Sher, 2023).

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It is well known that breast milk is the most rational and important way to feed a child, as it contains all the essential nutrients a child needs during this period. Breastfeeding lays the foundation for future health, preventing diabetes, coronary heart disease, obesity, and other diseases. Breastfeeding also has a profound emotional impact; feeding brings mother and child closer together, and this bond lasts a lifetime. These children become wonderful parents who love and care for their children.

Breastfeeding is not always possible. Many mothers develop hypogalactia, and milk production ceases completely. Illnesses of both mother and child, premature birth, and other factors can lead to the cessation of breastfeeding. Children deprived of breast milk are transferred to formula feeding using adapted formulas, which are as close as possible to breast milk. In recent years, adapted formulas have been supplemented with pre- and probiotics, nucleotides, lutein, and long-chain fatty acids, and their mineral and vitamin composition has been improved (Ladodo, 2019). Despite advances in the composition of adapted formulas, some children experience allergic reactions and digestive problems when using them, and these children are more likely to suffer from respiratory and intestinal diseases than breastfed children. The renowned Russian pediatrician Georgy Nestorovich Speransky decided to use fermented milk products for children and, in 1922, opened a milk kitchen at the Institute of Mother and Child, which he headed, and began producing diluted kefir (Gao Yu et al., 2016). He described his experience organizing a milk kitchen and producing products there, including kefir-based formulas, in his book "The Milk Kitchen" (Baranov & Sher, 2023).

In recent years, pre- and probiotics, nucleotides, lutein, and long-chain fatty acids have been added to adapted milk formulas, and the mineral and vitamin composition has been improved. Research by various scientists shows that using whey instead of powdered milk during formula feeding yields better results (Tang et al., 2025).

Methods

Whey is a valuable secondary raw material. The feasibility of its use has been discussed by many authors (Raimbekov et al., 2018), and the following key aspects of its application should be emphasized:

- nutritional value, allowing whey to be used in the preparation of functional foods;
- reduction of dairy industry emissions and a reduction in the overall negative impact on the environment;
- availability of whey as a raw material, taking into account production volume data;
- reduction in the cost of finished products due to partial or complete replacement of dairy raw materials without loss of finished product quality.

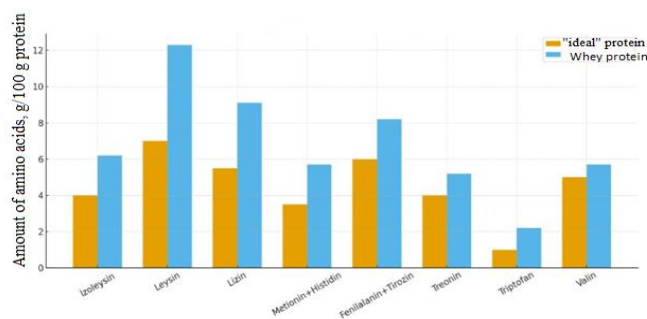


Figure 1

Composition of essential amino acids in whey protein and “ideal” protein. Whey proteins are known to contain all essential amino acids, and their amino acid composition is close to that of an “ideal” protein (Table 1 and Figure 1) (Gorissen, 2018)

Table 1

Composition of essential amino acids in whey protein and “ideal” protein

Essential amino acids	Amount of amino acids, g/100 g protein	
	The "Ideal" Protein	Whey protein
Isoleucine	4,0	6,2
Leucine	7,0	12,3
Lysine	5,5	9,1
Methionine, histidine	3,5	5,7
Phenylalanine, tyrosine	6,0	8,2
Threonine	4,0	5,2
Tryptophan	1,0	2,2
Valine	5,0	5,7

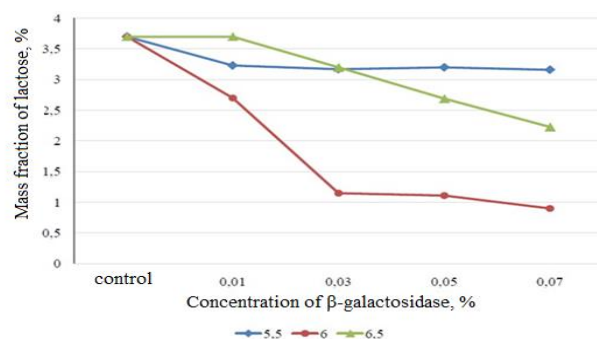
Using enzyme preparations for whey lactose hydrolysis is less expensive in terms of equipment and product quality, and therefore offers significant opportunities for the dairy industry. To study the process of whey lactose hydrolysis, the enzyme preparation β -galactosidase Nola Fit®, obtained by submerged fermentation of a selected *Bacillus licheniformis* strain, was selected (Bella et al., 2024). The following parameters were selected for the whey hydrolysis study using β -galactosidase:

- hydrolysis temperature;
- pH of the medium;
- hydrolysis time;
- enzyme concentration.

Process efficiency was monitored by measuring the residual lactose content in the hydrolysate. Hydrolysis temperature is an important parameter for the enzymatic reaction (Lukushkina et al., 2015).

The effect of temperature on lactose content in the system was studied to determine the optimal hydrolysis temperature. Hydrolysis was carried out for 2 hours at pH 6.0 with enzyme concentrations of 0.01%, 0.03%, 0.05%, and 0.07%. The data are presented in Figure 2.

The figure shows that increasing the enzyme concentration reduces the residual lactose content. At an enzyme concentration of 0.03%, the lactose concentration in the system drops sharply, and further increases in enzyme concentration have virtually no effect on the process.

**Figure 2**

Dependence of residual lactose content on hydrolysis temperature and β -galactosidase concentration

At a temperature of 45 ± 1 °C, lactose hydrolysis proceeds more slowly, which can be explained by accelerated thermal denaturation of the enzyme, leading to a decrease in its activity. The optimal temperature for whey hydrolysis is 40 ± 1 °C. This temperature is characterized by the lowest residual lactose content. At enzyme concentrations of 0.03%, 0.05%, and 0.07%, the lactose content was 1.15%, 1.11%, and 0.9%, respectively.

To assess the effect of pH on lactose hydrolysis, the enzyme preparation was tested at concentrations of 0.01%, 0.03%, 0.05%, and 0.07%. The process temperature was 40 ± 1 °C, and the duration was 2 hours. Whey acidity was adjusted using sodium carbonate salts. The obtained data are presented in Figure 3.

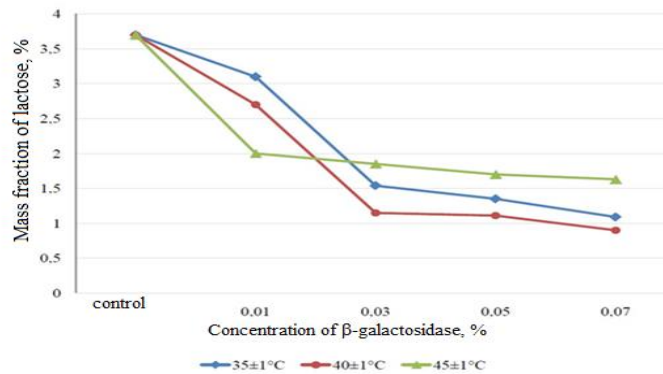


Figure 3

Dependence of lactose content on the acidity of the medium and the concentration of β -galactosidase

At pH 5.5, the amount of residual lactose in whey remains virtually unchanged, and increasing the enzyme concentration does not alter the hydrolysis process. At pH 6.5 and an enzyme concentration of 0.01%, lactose hydrolysis does not occur, and with an increase in concentration from 0.03% to 0.05%, it becomes less intense than at pH 6, indicating that these conditions are unsuitable for the production of hydrolyzed whey (Gao et al., 2016).

Results and Discussion

Lactose hydrolysis duration was determined at enzyme concentrations of 0.01%, 0.03%, 0.05%, and 0.07%, at a pH of 6 and a temperature of 40 ± 1 °C. Hydrolysis was carried out for 2, 3, 4, and 24 hours. Process intensity was assessed by the decrease in lactose mass fraction. The data are presented in Table 2.

Table 2

Effect of hydrolysis duration and enzyme concentration on lactose content

Concentration of β -galactosidase, %	Mass fraction of lactose, %			
	2 hours	3 hours	4 hours	24 hours
control	3,70	3,70	3,70	3,70
0,01	2,70	2,50	2,50	0,60
0,03	1,15	1,00	0,61	0,60
0,05	1,11	0,61	0,60	0,45
0,07	0,90	0,45	0,45	0,10

Studies have shown that as the time of exposure of whey to β -galactosidase increases, lactose hydrolysis continues, and its content decreases to 0.1%. The most intense lactose hydrolysis occurs

at an enzyme concentration of 0.05% and a processing time of 3 hours, as well as at an enzyme concentration of 0.03% and a processing time of 4 hours. Further increases in concentration at the indicated hydrolysis times have little effect on reducing residual lactose content. At all enzyme concentrations and a hydrolysis time of 24 hours, the lactose content is less than 0.6%. This process time ensures the maximum degree of hydrolysis under these conditions, but is not optimal (Granier et al., 2013).

Based on the obtained data, the determined parameters of whey hydrolysis using the enzyme preparation β -galactosidase Nola Fit® are presented in Table 3.

Table 3

Optimal parameters for lactose hydrolysis in whey

Concentration of β -galactosidase, %	Parameters		
	pH	Temperature, °C	Duration, hours
0,05 ± 0,005	6,0 ± 0,1	40 ± 1	3

The lactose content of whey impairs its processing; its low sweetness, solubility, and microbial fermentation limit its use in the creation of functional foods. Using a lactose modification method based on selected parameters allows the production of whey with a low lactose content and improved properties (residual lactose content does not exceed 0.61%), suitable for use as a base for pectin-whey gels in the creation of functional foods (Schurman et al., 2010).

Conclusion

The results of these studies support the successful use of low-lactose whey in the preparation of infant formula. The nutrients obtained from using this whey will not only be easily absorbed by the baby's body but will also promote healthy growth.

1. Using whey from various dairy products in baby food is more effective than using dry milk powder.
2. The lactose content of whey is affected by its concentration, pH, and hydrolysis time.
3. Whey hydrolyzed to lactose can also be used in the preparation of other functional foods.

Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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