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Study of technological parameters of the fermentation process in the technology of low-lactose yoghurts based on buttermilk

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Abstract. Expanding the range of low-lactose dairy products, including yoghurts, is a relevant direction and task for the food industry in the context of the growing number of people suffering from lactase deficiency. Research into the technological aspects of the fermentation process was an important step in the development of such products. The main objective of this work was to analyse the technological conditions of the fermentation process in the production of low-lactose yoghurts using whey. The studies used milk mixtures based on buttermilk, normalised for dry matter content and hydrolysed lactose, and starter cultures containing the lactic acid bacteria *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*. The effect of fermentation temperature, starter culture dose and fermentation duration on the organoleptic and physicochemical properties of the finished product was investigated. It was established that the rational parameters for obtaining sour milk curd and reducing the lactose content are: fermentation temperature 40-45°C, fermentation agent dose 2.6-2.8 mg/100 g, and fermentation duration 180-240 minutes. The results showed that during fermentation, the lactose content in the finished product decreased by 45%, which allowed it to be classified as a low-lactose dairy product. At the same time, an increase in the concentration of vitamins, in particular B vitamins, indicated an increase in the nutritional value of the product. The resulting low-lactose yoghurt based on buttermilk had a thick consistency, a pleasant sour milk taste and sweetness due to the accumulation of monosaccharides – glucose and galactose – as a result of lactose hydrolysis. The technological parameters of the fermentation process determined in this work can be used in the production of low-lactose yoghurts for people with lactase deficiency and will contribute to the expansion of the range of low-lactose dairy products produced in Ukraine

Keywords: secondary milk raw materials; lactase deficiency; starter culture; fermentolysis; fermented products; fermented milk drinks; nutritional value

Introduction

Modern scientific programmes and development priorities in the food industry within the European Union are focused on creating innovative products with proven nutritional value and health benefits. In this context, considerable attention was paid to establishing requirements for the correct use of nutritional and medical-biological claims, as well as developing technologies that combine traditional ingredients with low-cost technological solutions. This approach enables the production of affordable, balanced, and nutritious products aimed at supporting the health of broad population groups (Faienza *et al.*, 2024). Special importance is placed on research in the field of specialised food products designed for individuals with increased sensitivity to specific nutrients. These include consumers with chronic diseases, fermentopathies, and food allergies who require dietary adjustments through the replacement or exclusion of certain components. According to M. Essa *et al.* (2023), the development of such technologies not only improves the quality of life of these groups, but also corresponds to global trends in functional and therapeutic-prophylactic nutrition.

As noted by Yu. Honchar & V. Gnitsevych (2024), the number of individuals in the population with health problems related to lactase deficiency, i.e., the inability to digest lactose contained in dairy products, increases annually. One of the most effective methods for treating lactase deficiency is diet therapy, which includes either the complete exclusion of dairy products from the diet or the consumption of fermented dairy products such as sour cream, cottage cheese, kefir, ryazhanka, and yoghurts, where lactose is partially converted into lactic acid. In milk, the lactose content is 4.5-5.2%; in cottage cheese, it is 1.8-2.0%; in sour cream, 2.7-3.2%; in kefir, about 4.0%; and in ryazhanka and drinking yoghurts, about 3.5%. Thus, fermentation of dairy raw material using starter cultures based on lactic acid bacteria strains can reduce only 25-30% of the initial lactose content (Ryzhkova *et al*., 2024). The final lactose level in such products remains quite high, which makes their regular use in the diets of people suffering from lactase deficiency impossible.

However, milk and dairy products are an important source of complete proteins, vitamins, and mineral substances, especially calcium. Their exclusion from the diet can lead to a deficiency of essential nutrients and, as a consequence, to a decrease in work capacity and the body's resistance to diseases and negative environmental factors. This is why one of the promising directions for solving this problem is the development of technologies for producing dairy products, particularly yoghurts, that are lactose-free or have a reduced lactose content. Research by T. Yudina & A. Serenko (2021) established that the assortment of lactose-free and low-lactose dairy products of Ukrainian origin is quite limited. It is proven that yoghurts are highly popular among consumers. However, the volume of low-lactose and lactose-free yoghurts on the country's dairy market constitutes only 36.4%, which is almost 2 times less compared to imported products.

Thus, the development of scientifically substantiated technologies for yoghurts with a regulated carbohydrate composition for individuals with lactase deficiency, in the context of state policy regarding resource conservation and the increase of high-quality Ukrainian-produced goods, is a topical and timely task. The aim of this study was to establish the optimal technological parameters of the fermentation process for the production of low-lactose yoghurts based on buttermilk.

Literature Review

The fermentation process is one of the most important stages in yoghurt production. It is at this stage that the sour milk clot is formed, and the structural and mechanical properties and characteristic organoleptic indicators of yoghurt are formed. A key factor in the fermentation process is the use of starter cultures, which carry out biochemical reactions that lead to the formation of curds and the desired organoleptic properties (Savaiano & Hutkins, 2021). According to DSTU 4343:2004 (2005), in order for a fermented milk product to be labelled "yoghurt", the enzyme preparation used in its production must contain cultures of the lactic acid bacteria *Streptococcus thermophilus* and *Lactobacillus delbrueckii bulgaricus*. The strains *Str. thermophilus* and *L. bulgaricus* are used as starting material for the creation of symbiotic starters for yoghurt. The main condition for the selection of these strains is their symbiotic relationship. Milk fermented under the action of a single strain of *Str. thermophilus* or *L. bulgaricus* has a different consistency than milk fermented by a combination of these microorganisms (Ibrahim *et al*., 2021). When strains are used together, the finished product has a thicker consistency with a pronounced taste and aroma. During milk fermentation, Bulgarian bacillus strains produce acetaldehyde, which gives the products a characteristic taste and aroma, as well as antibiotic substances that suppress negative intestinal microbiota. When *Str. thermophilus* and *L. bulgaricus* strains are used together, both microorganisms have higher acid resistance. Thus, in the process of fermenting milk raw materials when *Str. thermophilus* is used separately, the maximum acidity for it is 110...120°C, while in combination with *L. bulgaricus*, it can withstand an acidity of 180-190°T, which plays a significant role in the production of fermented milk products (Asiimwe *et al*., 2021; Hussein *et al*., 2021).

According to E. Yamamoto *et al*. (2021), in the production of fermented dairy products, including yoghurts, for people suffering from lactase deficiency, the characteristic of microorganisms in terms of their β-galactosidase activity is of particular importance. Most strains of microorganisms included in starter cultures have selective enzymatic activity towards lactose. During the life cycle of these microorganisms, a small amount of lactose (0.4-0.8%) is broken down. Thanks to the use of lactic acid bacteria, up to 30% of the initial lactose content is fermented (Minorova *et al.*, 2022). When fermentation using starter cultures is used in the production of yoghurt, in addition to lactic acid fermentation, biochemical processes occur, resulting in the accumulation of lactose breakdown products – volatile and organic acids, alcohols, diacetyl, which determine the taste and aroma characteristic of fermented milk products (Li *et al.*, 2023). Among lactic acid bacteria, thermophilic lactic acid streptococci show the highest activity in lactose fermentation. The β-galactosidase enzyme of thermophilic streptococcus actively hydrolyses lactose, demonstrating high activity and stability. In addition, according to I. Romanchuk (2020), cations in milk raw materials help stimulate the fermentation process. Research data on the properties of lactic acid bacteria show that during fermentation, they produce folic acid, niacin, vitamins B12, B6, and enzymes that are essential for the human body (Chen *et al.*, 2023). Lactic acid bacteria, by fermenting milk raw materials, increase the absorption of proteins and fats and promote the formation of short-chain fatty acids, which are an important source of energy for the body. The fermentation process also improves the bioavailability of calcium and other minerals, which has a positive effect on bone health (Helikh *et al.*, 2022).

Thus, analysis of recent studies indicates significant potential for the use of fermentation in improving food quality. Fermented dairy products have a higher content of vitamins, probiotics and other substances, making them beneficial to human health. However, despite numerous studies in this area, there is a need for further research into fermentation processes to determine the conditions that will allow products with maximum beneficial properties to be obtained. The situation on the dairy market is complicated by the fact that, as a result of hostilities in Ukraine, some milk processing enterprises have ceased operations, leading to a decline in milk production and an increase in prices for Ukrainian dairy products (Yudina & Serenko, 2021). One of the main problems remains the attraction and effective use of the food potential of secondary milk raw materials (skimmed milk, milk whey, and buttermilk) formed during the traditional processing of milk into cream, sour milk cheese, and butter (Singh *et al.*, 2021).

The theoretical and practical aspects of the production of food products for special dietary purposes, in particular lactose-free and low-lactose dairy products, have been the subject of research by many scientists in different countries. Scientists G. Polishchuk *et al.* (2020), H. Deynychenko *et al.* (2022), V. Gnitsevych & Yu. Honchar (2022) have identified priority areas for the use of secondary milk raw materials in technologies for food products for special dietary purposes. Research by M. Corgneau *et al.* (2017) confirms the need to expand the range of these products for the special nutrition of people suffering from lactose intolerance. Despite the large number of scientific studies, work in this area continues and focuses on the development of new technologies and the expansion of the range of dairy products with reduced lactose content, thanks to the use of new raw materials that are a natural source of essential nutrients and have a wide range of technological properties.

Materials and Methods

Experimental studies were conducted in the laboratories of the Department of Restaurant and Craft Technologies of the State University of Trade and Economics; the Department of

Milk and Children's Products of the Institute of Food Resources of the National Academy of Agrarian Sciences of Ukraine during 2023-2024. The subject of the research was buttermilk obtained during butter production by whipping cream (Table 1); milk mixtures based on buttermilk, normalised with milk protein concentrate in terms of dry matter content and hydrolysed lactose (Tables 2, 3); YC-X11 direct-added yoghurt starter culture (manufacturer Christian Hansen, Denmark), containing strains of lactic acid bacteria *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus* (Table 4), low-lactose yoghurt based on buttermilk.

***Table 1.** Physicochemical indicators of buttermilk*

Acidity		Mass fraction of ash, %	Mass fraction of dry matter, %	Mass fraction of fat, %	Mass fraction of lactose, %
titrated, °T	active, pH				
16.0 ± 0.3	6.67 ± 0.01	0.64 ± 0.02	8.22 ± 0.03	0.40 ± 0.05	4.5 ± 0.04

Source: developed by the authors based on T. Yudina & A. Serenko (2022)

***Table 2.** Model compositions of milk mixtures normalised by dry matter content*

Raw material	Mixture 1	Mixture 2
Buttermilk, %	93.5	92.0
Dry milk protein concentrate, %	6.5	8.0
Total	100	100

Source: developed by the authors based on T. Yudina & A. Serenko (2022)

***Table 3.** Physical and chemical indicators of milk mixtures based on buttermilk, normalised for dry matter content and hydrolysed lactose*

Sample	Acidity		Mass fraction of ash, %	Mass fraction of dry matter, %	Mass fraction of fat, %	Mass fraction of lactose, %
	titrated, °T	active, pH				
Buttermilk (Control)	16.0 ± 0.3	6.67 ± 0.01	0.64 ± 0.02	8.22 ± 0.03	0.40 ± 0.05	4.5 ± 0.04
Mixture 1	30.0 ± 0.3	6.53 ± 0.01	0.4 ± 0.01	14.1 ± 0.02	0.48 ± 0.04	1.34 ± 0.04
Mixture 2	32.0 ± 0.4	6.52 ± 0.01	0.44 ± 0.02	15.3 ± 0.03	0.50 ± 0.02	1.21 ± 0.04

Source: developed by the authors based on T. Yudina & A. Serenko (2022)

***Table 4.** Characteristics of the YC-X11 fermentation preparation*

Indicator	Meaning/characteristic
Appearance	Lyophilised cultures in granules
Optimal operating temperature	35-45°C
Fermentation duration	4-5 hours
Recommended dosage	3 mg/100 g

Source: developed by the authors based on Y. Song *et al.* (2023)

For the hydrolysis of lactose in raw milk, neutral lactase was used – an enzyme preparation of yeast-derived β-galactosidase GODO-YNL2, manufactured in Japan, the characteristics of which are given in Table 5. A detailed methodology for the hydrolysis of lactose in milk mixtures based on buttermilk, which was used as the raw material in the current study, is provided in the work of T. Yudina & A. Serenko (2022).

Table 5. *Characteristics of the GODO-YNL2 lactase enzyme preparation*

Indicator	Meaning/characteristic
Activity	50,000 ONPGU/g
Appearance	Yellowish liquid
Solubility	Completely soluble in liquid
Specific gravity	1.17
Optimal active acidity	5.5...6.5 pH
Optimal operating temperature	20...45°C
Thermal stability at temperature	up to 55°C
Recommended dosage	0.1%

Source: developed by the authors based on T. Yudina & A. Serenko (2022)

Fermentation of milk mixtures based on buttermilk with dry matter content of 14.1% and 15.3% was carried out in a thermostat at a temperature of 40±2°C. The dosage of the starter culture varied between 2.2 and 3.0 mg/100 g, and the fermentation time was 30 to 300 minutes with samples taken every 30 minutes. The effectiveness of the starter culture was evaluated according to physical and chemical indicators in accordance with DSTU 4343:2004 (2005), taking into account that the standard titrated acidity for yoghurts should be within the range of 80-140°T. The study of the effect of temperature on the activity of the starter culture was carried out with temperature variations within the range of 15...55°C, a starter culture dose of 2.6...2.8 mg, and a process duration of 210 min. Samples were taken every 30 minutes. For each variant of the experiment, five parallel samples of milk mixture with a volume of 200 ml each were prepared.

The carbohydrate composition of the mixtures and low-lactose fermented milk product was determined using a high-performance liquid chromatograph LC-6A with a refractometric detector (RI detector), column HC-75-Ca++ (250×4.7 mm) (manufactured by Shimadzu, Japan). The method was based on the removal of fat and protein by filtration, the determination of carbohydrates in the filtrate of the samples obtained relative to standard samples with a known concentration of added carbohydrates. The efficiency of lactose hydrolysis was determined using formula (1):

$$E = \left(\frac{Ci-Cc}{Cc}\right) * 100\%, \quad (1)$$

where E – lactose hydrolysis efficiency, %; Ci – initial lactose content in mixtures before hydrolysis g/100 g; Cc – lactose content in milk raw material hydrolysate, g/100 g.

The following physicochemical parameters were determined in the test samples: titrated acidity – by titrimetric method according to DSTU ISO 6091:2007 (2009); active acidity – by potentiometric method according to DSTU 8550:2015 (2017); mass fraction of fat – by gravimetric method according to DSTU ISO 11870:2007 (2009); mass fraction of protein – by the Kjeldahl method according to DSTU ISO 8968-1:2005 (2007), vitamin content – by high-performance liquid chromatography according to DSTU EN 14164:2019 (2019). The physicochemical parameters were determined in three parallel samples for each sample.

The rheological parameters of the finished product were determined using a RHEOTEST II (Ukraine) rotational viscometer with a cylinder-cylinder (S/S3) measuring system by recording the deformation (flow) kinetics curves. The measurements were carried out in mode "a", which was set experimentally taking into account the structural and mechanical properties of the test samples. The measuring cylinder (rotor) S2 was selected so that the gradient layer spread throughout the entire thickness of the product layer located in the annular gap of the viscometer measuring device. A new portion of the product was taken for each experiment. The shear stress τ (Pa) was measured for 12 values of the shear rate gradient γ in the range from 0.33 to 145.8 s-1 in the forward and reverse directions. For this purpose, the value of α was recorded at the maximum angle of deflection of the pointer on the instrument scale.

The organoleptic indicators of the developed products were determined by a tasting commission based on a developed sensory evaluation scale for low-lactose fermented milk drinks based on buttermilk. The tasting commission consisted of scientists in the field of food technology, as well as practitioners from food industry enterprises and catering establishments. The organoleptic evaluation was carried out with the participation of 12 qualified tasters. The evaluation was carried out in a specially equipped tasting room at a temperature of 20 ± 2°C, with samples served in identical 50 ml containers. The work of the tasting commission was organised in accordance with the ethical standards of the WMA (2013). All participants were familiarised with the aim of the study and gave their informed consent to participate. The sensory evaluation of yoghurt was carried out on a 5-point scale, taking into account the main characteristics to be evaluated (appearance, colour, taste, smell, consistency) in accordance with DSTU 4343:2004 (2005).

The results of the experimental studies were statistically processed using the least squares method to determine the error of the obtained data. All experiments were repeated five times. Statistical processing of the experimental data was performed using Statistica 10.0 software (StatSoft Inc., USA). For each indicator, the arithmetic mean (M), standard deviation (SD) and standard error of the mean (SEM) were calculated. The reliability of the difference between the groups was assessed using one-way analysis of variance (ANOVA). The difference was considered statistically significant at $p < 0.05$.

Results

The main stage in the production of low-lactose yoghurts is the fermentation of the hydrolysed milk base, which results in the formation of the properties of the sour milk curd, safety indicators and the quality of the finished product. Based on an analysis of the market for fermentation preparations and the work of scientists, the YC-X11 direct-addition yoghurt fermentation preparation (manufactured by Christian Hansen, Denmark) was selected for the production of low-lactose fermented milk drinks. The fermentation parameters recommended by the manufacturer for the use of the direct-addition starter culture YC-X11 are specified for whole milk as the raw material for yoghurt production. Thus, in order to justify the conditions for the action of the YC-X11 starter culture in another dairy system, the effect of its dosage on the quality indicators of low-lactose yoghurt based on buttermilk was investigated (Figs. 2, 3; Table 6).

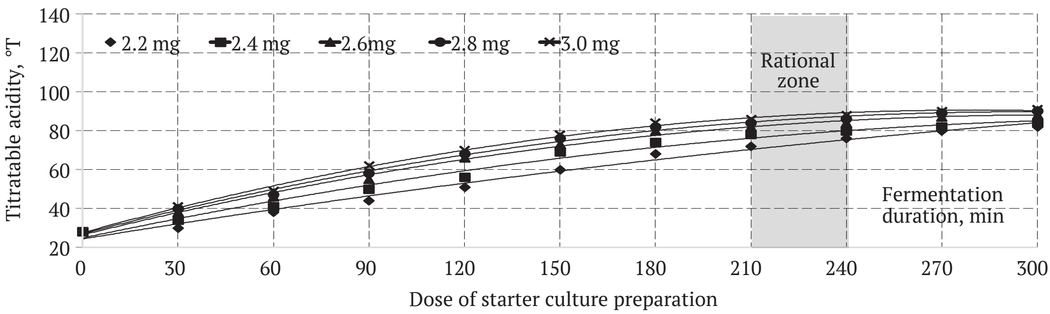

Figure 1. Effect of the dose of starter culture on the duration of fermentation of milk mixture with a dry matter content of 14.1%

Source: developed by the authors

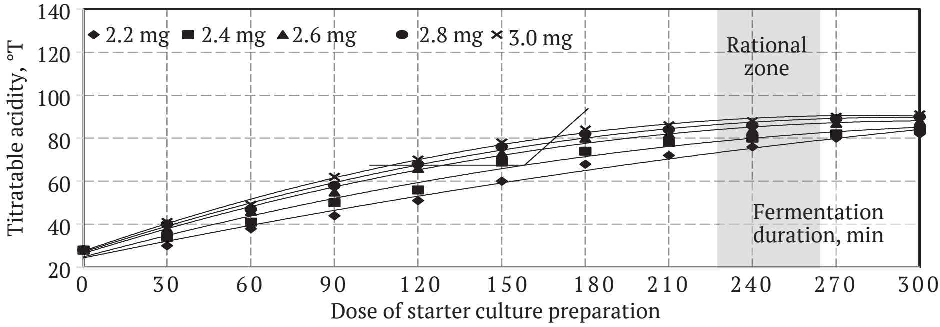

Figure 2. Effect of the dose of starter culture on the duration of fermentation of milk mixture with a dry matter content of 15.3%

Source: developed by the authors

Table 6. *Quality indicators of milk mixtures with hydrolysed lactose after fermentation*

Indicators	Milk mixtures based on buttermilk, normalised with milk protein concentrate									
	Mixture 1					Mixture 2				
Dose of FP, mg	2.2	2.4	2.6	2.8	3.0	2.2	2.4	2.6	2.8	3.0
Titrated acidity, °T	80.0		82.0	83.0	84.0	80.0		81.0	83.0	85.0
Consistency	Heterogeneous, with disturbed curd; slight serum secretion		Homogeneous, tender, with undisturbed curd, moderately dense			Heterogeneous, with disturbed curd; slight serum secretion		Homogeneous, tender, with undisturbed curd, moderately dense		
Colour	Milky white with a yellowish tint									
Smell	Pure, characteristic of fermented milk drinks; extraneous aromas and odours are absent									
Taste	Characteristic of fermented milk products, with a pleasant malty flavour; without extraneous tastes									

Note: FP – fermentation preparation

Source: developed by the authors

The research results indicate that the formation of a fermented milk curd with specified organoleptic properties and regulated titratable acidity within the range of 80-140°T was achieved under the following rational parameters: for a milk mixture with a total solids content of 14.1%, the starter culture dosage was 2.6-2.8 mg/100 g, with a process duration of 210-240 minutes; for a milk mixture with a total solids content of 15.3%, the starter culture dosage was 2.6-2.8 mg/100 g, with a process duration of 180-210 minutes. The use of lower starter culture dosages resulted in a reduction in the intensity of curd formation and an increase in fermentation time, leading to unnecessary energy expenditure, which is undesirable. Applying a starter culture dosage of 3 mg/100 g did not significantly affect the quality indicators of the developed product but did contribute to an increase in production costs.

The strains of lactic acid bacteria in the YC-X11 fermentation preparation are chemoorganotrophic microorganisms (Romanchuk, 2020). This means that they obtain energy by oxidising organic substances, i.e. lactic acid bacteria oxidise lactose, converting it into glucose and galactose. Glucose and galactose serve as substrates for the synthesis of lactic acid. Temperature affects the activity of lactic acid bacteria and their metabolic rate. At higher temperatures, the enzymes involved in the metabolism of lactic acid bacteria work faster, producing more lactic acid per unit of time and, as a result, accelerating the process of sour milk curd formation. Considering the above, in the next series of experiments, the effect of fermentation temperature on the activity of the starter culture in milk mixtures normalised for dry matter content was investigated (Figs. 4, 5).

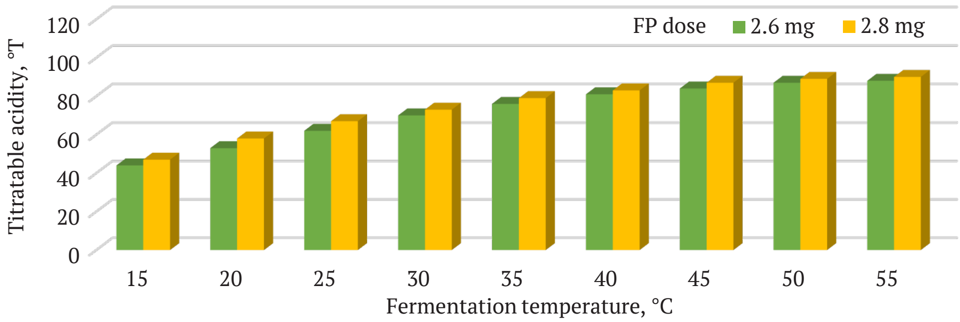

Figure 3. Effect of temperature on the activity of the starter culture in a milk mixture with a dry matter content of 14.1%

Source: developed by the authors

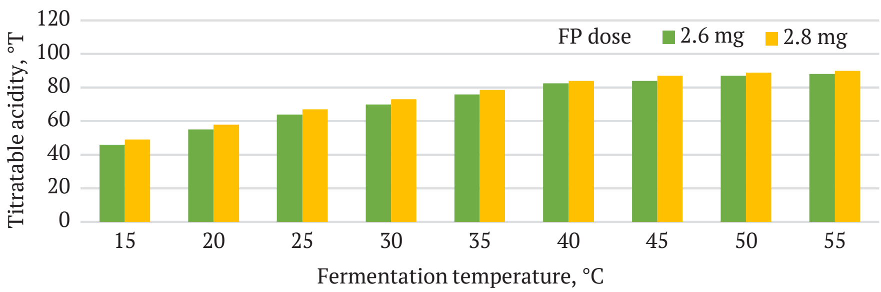

Figure 4. Effect of temperature on the activity of the starter culture in a milk mixture with a dry matter content of 15.3%

Source: developed by the authors

The results showed that the fermentation agent was most effective at temperatures between 40 and 45°C. At lower temperatures, the fermentation process and curd formation were slower, which can be explained by the low activity of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* lactic acid bacteria at these temperatures. When the temperature rose above 45°C, the effectiveness of the starter culture decreased due to the inactivation of lactic acid bacteria at high temperatures. Thus, the most rational parameters for the fermentation process of milk mixtures with a high dry matter content, which ensure the formation of a sour milk curd with the specified organoleptic properties, standardised titrated acidity within the range of 80-140°C and reduce energy consumption, are fermentation temperature – 40-45°C, a starter culture dose of 2.6-2.8 mg/100 g, and a process duration of 180-210 minutes for milk mixtures with a dry matter content of 14.1% and 210-240 minutes for milk mixtures with a dry matter content of 15.3%.

Consistency – one of the most important indicators of the consumer properties of low-lactose fermented milk drinks, including yoghurts. It is formed during the technological process and depends on many factors, including the properties of the milk base, the dose of enzyme and starter cultures, and production parameters. Figures 6 and 7 show the results of a study of the effect of the dose of the starter culture and the duration of fermentation of milk mixtures with different dry matter contents on the rheological properties of low-lactose yoghurt.

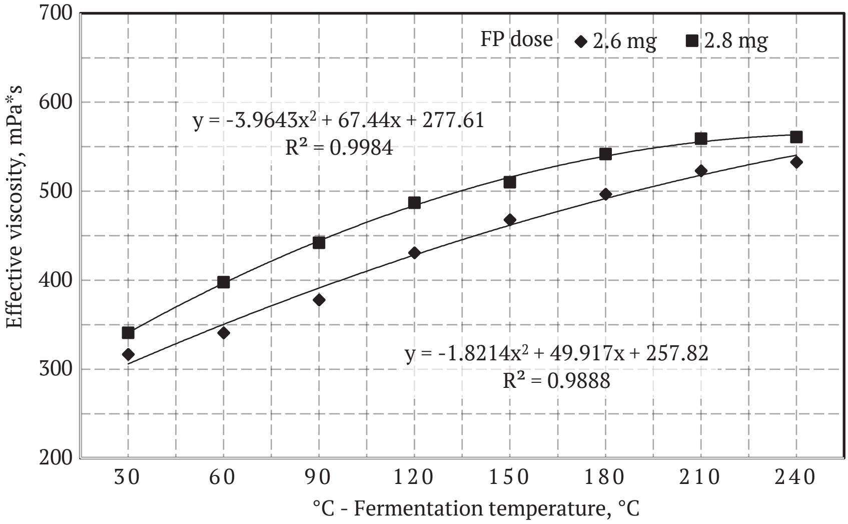

Figure 5. Dynamics of effective viscosity change during fermentation of milk mixture with dry matter content of 14.1%

Source: developed by the authors

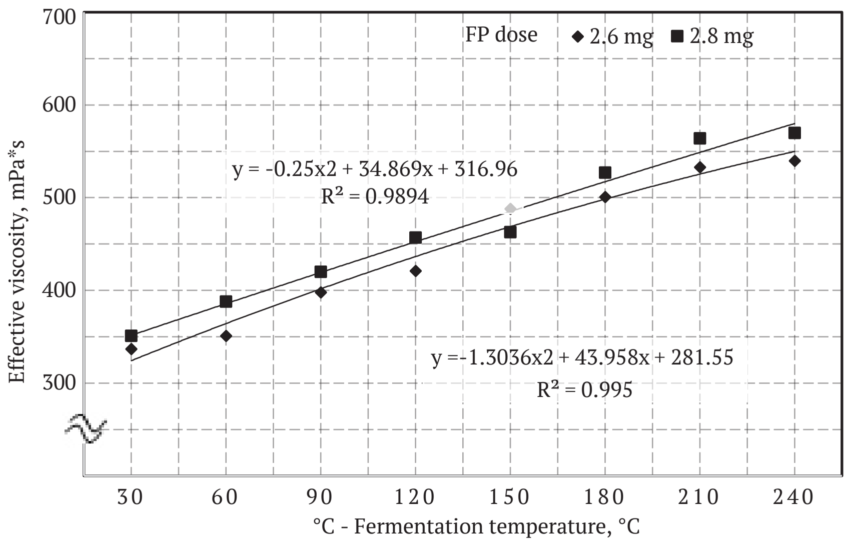

Figure 6. Dynamics of effective viscosity change during fermentation of milk mixture with dry matter content of 15.3%

Source: developed by the authors

The results of the studies show that as the fermentation time increases, the viscosity of the test samples increases. This is because the components of the milk mixture, such as proteins and lactose, are involved in the formation of sour milk curds. The lactic acid bacteria contained in the fermentation preparation convert lactose into glucose and galactose, which serve as substrates for biochemical reactions that result in the formation of lactic acid. Lactic acid causes protein coagulation, followed by the formation of lactic acid curds. Thus, when adding 2.6-2.8 mg/100 g of starter culture and fermenting for 180-210 minutes the viscosity of the finished product was 523-559 mPa*s, and for a milk mixture with a dry matter content of 15.3%, it was 560-564 mPa*s, respectively. The resulting low-lactose yoghurt is characterised by a stable structure and semi-liquid consistency. During the further fermentation process for 210-240 minutes, insignificant changes in viscosity were observed in the test samples, while the consistency of the yoghurt remained homogeneous, semi-liquid, without whey separation. In order to determine the compliance of the products obtained after fermentation with the requirements for low-lactose products set by the European Food Safety Authority (2010), their carbohydrate composition was determined (Fig. 8).

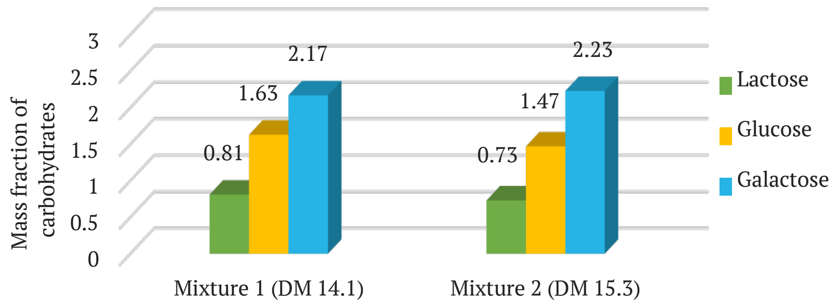

Figure 7. Carbohydrate composition of fermented milk mixtures with hydrolysed lactose
Source: developed by the authors

The results of the studies show that in the obtained milk mixtures with a dry matter content of 14.1% and 15.3%, the lactose content after fermentation is less than 1%, which complies with the recommendations for its content in low-lactose dairy products. For further research and development of low-lactose yoghurt technology, a milk mixture with a dry matter content of 15.3% was selected as the milk base, as it has a lower residual lactose content, and the higher dry matter content in the specified milk base makes it possible to obtain a finished low-lactose fermented milk drink with a stable structure and consistency.

During the fermentation of the milk base in the production of low-lactose yoghurt, biochemical processes occur that affect changes in the chemical composition of the finished product. In particular, under the action of lactic acid bacteria, lactose is converted into glucose and galactose, which, in turn, serve as a substrate for the formation of lactic acid, which participates in the formation of a fermented milk curd (Bolgova *et al.*, 2021). In addition to lactic acid, the lactic acid bacteria that make up the yoghurt starter culture are a source of vitamins, particularly B vitamins. Analysis of the research results (Table 7) shows that the carbohydrate composition changes during the fermentation of the milk base in yoghurt production. Thus, the lactose content in yoghurt after fermentation decreased by 45%, which indicates the high β-galactosidase activity of the lactic acid bacteria included in the starter culture (Wolf *et al.*, 2015).

Table 7. Effect of fermentation on the chemical composition of low-lactose yoghurt based on buttermilk

Indicator	Before fermentation	After fermentation
Carbohydrate content, g/100 g:		
Lactose	1.33	0.73
Glucose	1.69	1.47
Galactose	1.44	2.23
Vitamin content, mg/100 g:		
B_1	0.128	0.131
B_2	0.111	0.122
B_3	0.937	1.0
B_5	0.372	0.386

Source: developed by the authors

Since low-lactose yoghurt based on buttermilk falls into the category of special health foods and is recommended for people with lactase deficiency, the lactose content in the final product is particularly important. The data obtained show that a lactose content of 0.73% per 100 g of product meets the requirements of the European Food Safety Authority (2010). There is also an increase in the vitamin content in the finished yoghurt, which indicates the ability of lactic acid bacteria to produce, in addition to lactic acid, other biologically active substances that increase the nutritional value of the product.

The combination of biochemical transformations in the yoghurt production process affects not only the change in chemical composition, but also the formation of the organoleptic properties of the finished product. During fermentation, in addition to the conversion of lactose to lactic acid, side processes also occur with the formation of organic acids, aldehydes, alcohols, and peptides, which determine the characteristic sour milk taste and aroma of yoghurt. The quality characteristics of the developed low-lactose yoghurt based on buttermilk are shown in Table 8.

Table 8. Quality indicators of low-lactose yoghurt based on buttermilk

Indicators	Characteristics
Titrated acidity, °T	83.0
Active acidity, pH units	4.78
Consistency	Homogeneous, delicate, with intact curds, moderately dense
Colour	Milky white, homogeneous, with a yellowish tint
Smell	Pure sour milk, mild; no foreign odours
Taste	Pronounced sour milk, mild, balanced, with a characteristic sweet taste

Source: developed by the authors

The developed low-lactose yoghurt is characterised by high organoleptic indicators that meet the requirements of DSTU 4343:2004 (2005). Thanks to the accumulation of glucose and galactose, whose sweetness indices are 5-6 times higher than that of lactose, low-lactose yoghurt based on buttermilk has a pleasant sweet taste, which makes it possible not to use sugar in its recipe and recommend the product for low-calorie diets.

Discussion

The results of the study of the fermentation process in low-lactose yoghurt technology based on buttermilk confirm the importance of determining technological parameters to achieve the desired organoleptic and physicochemical properties of the product. Analysis of the results obtained shows significant correspondence with other scientific works devoted to the study of the fermentation process of food products. Thus, the research by S. Sarıtaş *et al*. (2024) confirms that a temperature range of 38-45°C is optimal for the activity of most lactic acid bacteria and ensures the production of fermented milk products of the required quality. The rational fermentation parameters established in the current study ensure the formation of a stable sour milk clot with standardised titrated acidity (80-140°T) and active acidity (pH 4.78), which correlates with the optimal conditions described in the study by A. Asiimwe *et al*. (2021), where a temperature of 40-42°C contributed to better rheological stability of yoghurts with added probiotics. Compared to the study by E. Halbmayr-Jech *et al*. (2020), where the concentration of β-galactosidase from *Lactobacillus paracasei* (0.3%) reduced the lactose content in 100 g of yoghurt to 2.5 g, the approach used in the current study, combining enzymatic hydrolysis of lactose with the action of the YC-X11 starter culture based on lactic acid bacteria, demonstrates a lower final lactose content (0.73%), which makes the product more attractive for people with lactase deficiency.

In the work of F. Tonolo *et al*. (2020), it was determined that the fermentation of dairy products at a temperature of 40-45°C ensures high efficiency of lactic acid bacteria and promotes the formation of a stable sour milk clot. At the same time, according to the results of scientific research, the most effective temperature range for reducing lactose is 42-44°C. Research by Y. Gao *et al*. (2025) shows that temperatures above 45°C can cause the inactivation of lactic acid bacteria, which leads to a decrease in fermentation efficiency. The results obtained in the study prove that fermentation of the milk base at temperatures above 45°C has a negative effect on the activity of starter cultures, confirming the importance of precise temperature control to achieve stable results. Thus, the results of the current study confirm the conclusions of previous studies, according to which the optimal temperature range for reducing lactose content is 42-44°C. The selected fermentation parameters were found to be comparable to scientifically substantiated data.

It is worth noting the study by K. Kondrotiene *et al*. (2024), which examined the effect of fermentation duration on the quality of dairy products. Their study indicated that prolonging fermentation for more than 240 minutes leads to a decrease in the activity of lactic acid bacteria, which negatively affects the organoleptic properties of the product. This coincides with the observations of the authors of the current work: a process duration of more than 210 minutes affects the reduction in the activity of lactic acid bacteria, which indicates the need to control this parameter to achieve high product quality. An increase in the concentration of B vitamins and the accumulation of short-chain fatty acids in the finished yoghurt indicates the biosynthetic activity of lactic acid bacteria during fermentation. This is consistent with the findings of D. Savaiano & R. Hutkins (2021), where fermentation with *Bifidobacterium longum* under similar parameters increased the content of B vitamins and organic acids, improving the bioavailability of minerals, in particular calcium. Research by H. Abbas *et al*. (2024) also demonstrates that bifidobacteria in the fermentation of yoghurt not only enrich the product with biologically active substances, but also increase its antioxidant activity. The data obtained also correlates with the conclusions of B. Namshir *et al*. (2025), where the fermentation of goat's milk with similar strains of lactic acid bacteria led to an increase in the content of B vitamins by 5-15%, increasing the biological value of the product. Scientists W. Li *et al*. (2020) also note that the addition of probiotics to yoghurt promotes vitamin synthesis and improves its stability during storage. Research by L. Li *et al*. (2023) proves that the fermentation of dairy products not only reduces the lactose content but also improves the nutritional value of the product by increasing the concentration of vitamins, in particular B vitamins. This was confirmed by the results of the current study, which note an increase in the content of vitamins, in particular B vitamins, during the fermentation of the milk base of buttermilk yoghurt.

Scientists E. Yamamoto *et al*. (2021) have confirmed that the fermentation of lactose in the production of yoghurt contributes to the accumulation of glucose and galactose, which determines the natural sweetness of the product. According to their data, this process makes it possible to significantly reduce the need to add sugar to achieve the desired taste. The results of the studies also confirm that the process of lactose hydrolysis and monosaccharide accumulation gives yoghurt a natural sweet taste, which makes it less caloric due to the absence of sugar in the recipe. In conclusion, the consistency of the results obtained in the current study with the data from previous studies confirms their scientific validity and emphasises the importance of controlling the fermentation process as a determining factor in the formation of the nutritional value of dairy products.

Conclusions

Based on comprehensive analytical and experimental studies, the role of fermentation in the production of low-lactose yoghurts has been determined. The patterns of influence of technological factors on the fermentation process and the formation of sour milk curd in low-lactose yoghurt have been established. It has been determined that the rational parameters of the fermentation process of milk mixtures with a dry matter content of 15.3%, which ensure the formation of a sour milk curd with the specified organoleptic properties and a standardised titrated acidity within the range of 80-140°T, are a fermentation temperature of 40-45°C, a dose of YC-X11 direct-added yoghurt starter culture of 2.6-2.8 mg/100 g, and a fermentation time of 210 minutes. The effect of fermentation on the nutritional value of the finished product was investigated. It was proven that during the fermentation of the milk base, the lactose content decreased by 45% and did not exceed 1% in the finished yoghurt, which meets the requirements of the European Food Safety Authority for its content in low-lactose dairy products. At the same time, the recorded increase in the concentration of vitamins, in particular group B, indicates an increase in the nutritional value of low-lactose yoghurt. The accumulation of monosaccharides, such as glucose and galactose, in the process of lactose hydrolysis during fermentation determines the natural sweetness of the finished product, which makes it possible to avoid adding sugar to its recipe.

The resulting low-lactose yoghurt based on buttermilk was characterised by favourable consumer properties – a thick consistency, pleasant sour milk taste and natural sweetness, which meet the requirements of DSTU 4343:20024. The technological parameters of the fermentation process determined in the work can be used in the production of yoghurts for people with lactase deficiency, which will contribute to the expansion of the range of low-lactose dairy products of Ukrainian production based on secondary milk raw materials. Further research involves the development of a recipe and technological scheme for the production of low-lactose yoghurt based on buttermilk, as well as research into changes in the quality and safety indicators of the finished product during storage, which will allow determining its shelf life while ensuring the preservation of its beneficial properties.

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Conflict of Interest

None.

References

[1] Abbas, H., Altamim, E., Farahat, E., Mohamed, A., & Zahran, H. (2024). Enhancing *Bifidobacterium* and lactic acid bacteria activity, and improving oxidative stability in functional algal concentrated yoghurt with *Spirulina platensis* powder. *Scientific Horizons*, 27(6), 98-110. doi: 10.48077/scihor6.2024.98.

[2] Asiimwe, A., Kigozi, J., & Muyonga, J. (2021). Physicochemical properties, sensory acceptance and storage stability of yogurt flavored with refractance window dried passion fruit powder. *Asian Food Science Journal*, 20(5), 38-49. doi: 10.9734/afsj/2021/v20i530297.

[3] Bolgova, N., Samilyk, M., Nazarenko, Yu., & Sokolenko, V. (2021). Technology of lactose-free yogurt production in compliance with the principles of the HACCP system. *Tavria Scientific Bulletin. Series: Technical Sciences*, 4, 33-46.

[4] Chen, L., Bagnicka, E., Chen, H., & Shu, G. (2023). Health potential of fermented goat dairy products: Composition comparison with fermented cow milk, probiotics selection, health benefits and mechanisms. *Food & Function*, 14(8), 3423-3436. doi: 10.1039/d3fo00413a.

[5] Corgneau, M., Scher, J., Ritie-Pertusa, L., Le, D.T.L., Petit, J., Nikolova, Y., Banon, S., & Gaiani, C. (2017). Recent advances on lactose intolerance: Tolerance thresholds and currently available answers. *Critical Reviews in Food Science and Nutrition*, 57(15), 3344-3356. doi: 10.1080/10408398.2015.1123671.

[6] Deynychenko, H., Huzenko, V., Dmytrevskyi, D., Zolotukhina, I., & Perekrest, V. (2022). Waste-free technologies implementation for secondary dairy raw materials processing. *Restaurant and Hotel Consulting. Innovations*, 5(1), 82-96. doi: 10.31866/2616-7468.5.1.2022.260878.

[7] DSTU 4343:2004. (2005). *Yoghurts. General technical conditions*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=72933.

[8] DSTU 8550:2015. (2017). *Milk and dairy products. Measurement of pH by potentiometric method*. Retrieved from https://online.budstandart.com/ru/catalog/doc-page?id_doc=71694.

[9] DSTU EN 14164:2019. (2019). *Foodstuffs. Determination of vitamin B by high-performance liquid chromatography*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=84143.

[10] DSTU ISO 11870:2007. (2009). *Milk and dairy products. Determination of mass fraction of fat*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=85098.

[11] DSTU ISO 6091:2007. (2009). *Milk powder. Determination of titrated acidity*. Retrieved from https://zakon.isu.net.ua/sites/default/files/normdocs/dstu_iso_6091_2007.pdf.

[12] DSTU ISO 8968-1:2005 (IDF 20-1:2001). (2007). *Milk. Determination of nitrogen content. Part 1. Kjeldahl method*. Retrieved from https://zakon.isu.net.ua/sites/default/files/normdocs/dstu_iso_8968-1_2005.pdf.

[13] Essa, M.M., Bishir, M., Bhat, A., Chidambaram, S.B., Al-Balushi, B., Hamdan, H., Govindarajan, N., Freidland, R.P., & Qoronfleh, M.W. (2023). Functional foods and their impact on health. *Journal of Food Science and Technology*, 60(3), 820-834. doi: 10.1007/s13197-021-05193-3.

[14] European Food Safety Authority. (2010). Scientific opinion on lactose thresholds in lactose intolerance and galactosaemia. *EFSA Journal*, 8(9), article number 1777. doi: 10.2903/j.efsa.2010.1777.

[15] Faienza, M.F., Giardinelli, S., Annicchiarico, A., Chiarito, M., Barile, B., Corbo, F., & Brunetti, G. (2024). Nutraceuticals and functional foods: A comprehensive review of their role in bone health. *International Journal of Molecular Sciences*, 25(11), article number 5873. doi: 10.3390/ijms25115873.

[16] Gao, Y., Liu, Y., Ma, T., Liang, Q., Sun, J., Wu, X., Song, Y., Nie, H., Huang, J., & Mu, G. (2025). Fermented dairy products as precision modulators of gut microbiota and host health: Mechanistic insights, clinical evidence, and future directions. *Foods*, 14(11), article number 1946. doi: 10.3390/foods14111946.
[17] Gnitsevych, V.A., & Honchar, Yu.M. (2022). Technology and properties of low-lactose semi-finished product based on sweet milk whey. In *Innovative technologies and equipment: Development prospects of the food and restaurant industries* (pp. 118-136). Riga: Baltija Publishing. doi: 10.30525/978-9934-26-205-0-6.
[18] Halbmayr-Jech, E., Kittl, R., Weinmann, P., Schulz, C., Kowalik, A., Sygmund, C., & Brunelle, S. (2020). Determination of lactose in lactose-free and low-lactose milk, milk products, and products containing dairy ingredients by the LactoSens®R amperometry method: First action 2020.01. *Journal of AOAC International*, 103(6), 1534-1546. doi: 10.1093/jaoacint/qsaa080.
[19] Helikh, A., Danylenko, S., Kryzhska, T., & Semernya, O. (2022). Optimization of rheological indicators of yoghurt structure with addition of hemp seed protein isolate. *Food Resources*, 10(18), 51-60. doi: 10.31073/foodresources2022-18-05.
[20] Honchar, Yu., & Gnitsevych, V. (2024). Improving the quality of dairy sauces by using condensed low-lactose milk whey. In O. Priss (Ed.), *Food technology progressive solutions* (pp. 152-168). Tallinn: Scientific Route OÜ. doi: 10.21303/978-9916-9850-4-5.ch6.
[21] Hussein, Z.E.H., Silva, J.M., Alves, E.S., Castro, M.C., Ferreira, C.S.R., Chaves, M.L.C., da Silva Bruni, A.R., & Santos, O.O. (2021). Technological advances in probiotic stability in yogurt: A review. *Research, Society and Development*, 10(12), article number e449101220646. doi: 10.33448/rsd-v10i12.20646.
[22] Ibrahim, S.A., Gyawali, R., Awaisheh, S.S., Ayivi, R.D., Silva, R.C., Subedi, K., Aljaloud, S.O., Siddiqui, S.A., & Krastanov, A. (2021). Fermented foods and probiotics: An approach to lactose intolerance. *Journal of Dairy Research*, 88(3), 357-365. doi: 10.1017/S0022029921000625.
[23] Kondrotiene, K., Zavistanaviciute, P., Aksomaitiene, J., Novoslavskij, A., & Malakauskas, M. (2024). *Lactococcus lactis* in dairy fermentation – health-promoting and probiotic properties. *Fermentation*, 10(1), article number 16. doi: 10.3390/fermentation10010016.
[24] Li, L., Zhou, L., Liu, X., Gong, J., & Xiao, G. (2023). Physicochemical, microbiological, and sensory properties of low-lactose yogurt using *Streptococcus thermophilus* with high β-galactosidase activity. *Journal of Science Food and Agriculture*, 103(15), 7374-7380. doi: 10.1002/jsfa.12840.
[25] Li, W., *et al*. (2020). Fermentation characteristics of *Lactococcus lactis* subsp. *lactis* isolated from naturally fermented dairy products and screening of potential starter isolates. *Frontiers in Microbiology*, 11, article number 1794. doi: 10.3389/fmicb.2020.01794.
[26] Minorova, A.V., Romanchuk, I.O., Danylenko, S.H., Rudakova, T.V., Krushelnytska, N.L., Potemska, O.P., & Narizhnyi, S.A. (2022). Selection and study of the effectiveness of leavening preparations with increased β-galactosidase activity. *Food Resources*, 10(19), 88-98. doi: 10.31073/foodresources2022-19-10.
[27] Namshir, B., Kim, G.-H., Lkhagvasuren, N., Jeong, S.-A., Mijid, N., & Kim, W.-S. (2025). Fermentation and functional properties of plant-derived *Limosilactobacillus fermentum* for dairy applications. *Fermentation*, 11(5), article number 286. doi: 10.3390/fermentation11050286.
[28] Polishchuk, G., Breus, N., Shevchenko, I., Gnitsevych, V., Yudina, T., Nozhechkina-Yeroshenko, G., & Semko, T. (2020). Determining the effect of casein on the quality indicators of cream with different fat content. *Eastern-European Journal of Enterprise Technologies*, 4(11(106)), 24-30. doi: 10.15587/1729-4061.2020.208954.

[29] Romanchuk, I. (2020). *Scientific justification and development of methods for improving resource efficiency in industrial dairy raw material processing*. (Doctoral thesis, National University of Food Technologies, Kyiv, Ukraine).

[30] Ryzhkova, T.M., Danilenko, S.G., Mykhaylov, V.M., & Heyda, I.M. (2024). *Biotechnologies of fermented products from cow and goat milk*. Kharkiv: I.S. Ivanchenko Publishing House.

[31] Sarıtaş, S., *et al*. (2024). The impact of fermentation on the antioxidant activity of food products. *Molecules*, 29(16), article number 3941. doi: 10.3390/molecules29163941.

[32] Savaiano, D.A., & Hutkins, R.W. (2021). Yogurt, cultured fermented milk, and health: A systematic review. *Nutrition Reviews*, 79(5), 599-614. doi: 10.1093/nutrit/nuaa013.

[33] Singh, R., Nikitha, M., Shwetnisha, & Mangalleima, N. (2021). The product and the manufacturing of yoghurt. *International Journal for Modern Trends in Science and Technology*, 7, 48-51. doi: 10.46501/IJMTST0710007.

[34] Song, Y., Li, S., Zhang, R., Tuo, Y., Li, X., Mu, G., & Jiang, S. (2023). Physicochemical properties, antigenicity and allergenicity of yoghurt fermented by *Lactiplantibacillus plantarum* AHQ-14 combined with starter. *International Journal of Food Science and Technology*, 58(5), 2527-2539. doi: 10.1111/ijfs.16396.

[35] Tonolo, F., *et al*. (2020). Identification of new peptides from fermented milk showing antioxidant properties: Mechanism of action. *Antioxidants*, 9(2), article number 117. doi: 10.3390/antiox9020117.

[36] Wolf, I.V., Vénica, C.I., & Perotti, M.C. (2015). Effect of reduction of lactose in yogurts by addition of β-galactosidase enzyme on volatile compound profile and quality parameters. *International Journal of Food Science and Technology*, 50(5), 1076-1082. doi: 10.1111/ijfs.12745.

[37] World Medical Association (WMA). (2013). *Declaration of Helsinki. Ethical principles for medical research involving human subjects*. Retrieved from https://www.wma.net/wp-content/uploads/2016/11/DoH-Oct2013-JAMA.pdf.

[38] Yamamoto, E., Watanabe, R., Ichimura, T., Ishida, T., & Kimura, K. (2021). Effect of lactose hydrolysis on the milk-fermenting properties of *Lactobacillus delbrueckii* ssp. *bulgaricus* 2038 and *Streptococcus thermophilus* 1131. *Journal of Dairy Science*, 104(2), 1454-1464. doi: 10.3168/jds.2020-19244.

[39] Yudina, T., & Serenko, A. (2021). Formation of the domestic market for lactose-free and low-lactose dairy products. *Commodities and Markets*, 2, 33-43. doi: 10.31617/tr.knute.2021(38)03.

[40] Yudina, T., & Serenko, A. (2022). Technology of low-lactose milk mixtures for yogurts. *Commodity Science. Technologies. Engineering*, 3(43), 108-116. doi: 10.31617/2.2022(43)09.

Дослідження технологічних параметрів процесу ферментації у технології низьколактозних йогуртів на основі сколотин

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Анотація. Розширення асортименту низьколактозних молочних продуктів, зокрема йогуртів, є актуальним напрямом та завданням для харчової промисловості в контексті зростаючої кількості осіб, що страждають на лактазну недостатність. Дослідження технологічних аспектів процесу ферментації є важливим етапом у технології розроблення таких продуктів. Основною метою даної роботи був аналіз технологічних умов ферментаційного процесу при виробництві низьколактозних йогуртів із застосуванням сколотин. У дослідженнях використовувались молочні суміші на основі сколотин, нормалізовані за вмістом сухих речовин та гідролізованою лактозою, заквашувальні препарати, що містять молочнокислі бактерії *Streptococcus thermophilus* та *Lactobacillus delbrueckii* ssp. *bulgaricus*. Досліджено вплив температури сквашування, дози заквашувального препарату та тривалості процесу ферментації на органолептичні та фізико-хімічні показники готового продукту. Встановлено, що раціональними параметрами отримання кисломолочного згустку та зниження вмісту лактози є: температура сквашування 40…45 °C, доза заквашувального препарату – 2,6…2,8 мг/100 г та тривалість процесу ферментації – від 180 до 240 хвилин. Отримані результати показали, що у процесі ферментації вміст лактози в готовому продукті зменшився на 45 %, що дало змогу віднести його до категорії низьколактозних молочних виробів. Водночас зафіксоване зростання концентрації вітамінів, зокрема групи В, свідчить про підвищення харчової цінності продукту. Отриманий низьколактозний йогурт на основі сколотин мав щільний згусток, приємний кисломолочний смак та солодкість завдяки накопиченню моноцукрів – глюкози та галактози, в результаті гідролізу лактози. Визначені в роботі технологічні параметри процесу ферментації можуть бути використані у виробництві низьколактозних йогуртів для осіб із лактазною недостатністю та сприятимуть розширенню асортименту низьколактозних молочних продуктів українського виробництва

Ключові слова: вторинна молочна сировина; лактазна недостатність; заквашувальний препарат; ферментоліз; ферментовані продукти; кисломолочні напої; харчова цінність