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Biotechnology

Technology of Mineralized Fermented Milk Drink of High Biological Value Based on Georgian Bioresources

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(Presented by Academy Member Tinatin Sadunishvili)

Abstract. Milk composition was prepared to obtain fermented milk drink, for which drinking milk, demineralized whey, and milk permeate were selected. Their chemical compositions were studied. To maintain a stable consistency of fermented milk drink, the use of hydrocarbonate mineral water "Likani" was envisaged in the milk composition. Based on experiments, the optimal ratio of the selected ingredients in the milk composition was determined, which amounted to 0.2:1,0:0.5:0.3, respectively. Bacterial starter cultures of Matsoni and yogurt were selected for fermentation of the milk composition. To determine their optimal ratio, the activity of bacterial starter cultures in drinking milk, demineralized whey, and milk permeate was studied, for which titratable, active acidity and the number of viable cells of microorganisms were determined. The optimal ratio of bacterial starter cultures was 60:40 wt.%. Before fermentation, the bacterial culture composition, as fillers, natural mineral water "Sairme" with a high calcium content and oleaster fruit puree were added to the resulting milk mixture. The high content of pectin substances in the oleaster fruit (1.92% on a wet weight basis) provides stability of the ferment structure, and also acts as a sweetener. The optimal amount of oleaster puree was 5-7%. The new fermented milk drink has a tender consistency, a natural color, and the original aroma of oleaster fruit. © *2025 Bull. Georg. Natl. Acad. Sci.*

Keywords: demineralized whey, milk composition, bacterial starter culture, oleaster, fermented milk drink

Introduction

Recently, there has been a negative dynamics of population health around the world. Unwanted ecology, malnutrition, and stresses lead to decreased immunity, the development of pathological processes, and a dramatic increase in disease risks caused by metabolic disorders [1,2]. Correction of a nutritional status of society, i. e., providing the body with healthy food having a high biological value, is recognized by world medical organizations as a real step towards prevention of metabolic problems (http://www.who.int/nutrition/decade-of-action/workprogramme-2016 to 2025/en/). The diet of both healthy people and those with metabolic problems should be dominated by low-calorie, low-glycemic food

products with high bioavailability of biologically active substances. From this perspective, it is very promising to fortify the products produced on the basis of milk whey with full concentrations of essential macro- and micronutrients. In the world, including Georgia, milk whey is attracting special attention, the utilization factor of which remains low today [3,4]. As a low-calorie and low-glycemic product, whey is considered a dietary raw material for the production of functional food products [5-7]. Along with many positive properties, it is worth noting that the low glycemic index of whey contributes to the process of insulin release and regulates glucose levels in the blood, which prevents the which prevents the occurrence of type 2 diabetes [8].

The full utilization of secondary dairy raw materials in the production of functional fermented milk drinks is still a worldwide problem and remains very relevant [3].

Numerous methods for producing fermented milk drinks using whey are known. The disadvantages of these methods are that in some technologies the biological value of the product is not high, since its protein composition is not corrected, the growth of bifidobacteria is slowed down due to the lack of additional growth stimulants, and the low content of mineral substances in the finished product (P 2053676, 1996). Some beverages do not contain a heterogeneous phase (digestible fiber) and therefore are characterized by low stability and, accordingly, a short shelf life (P 2303877, 2007). Also, the technological process cannot achieve the formation of such properties that are required for prophylactic fermented products of high biological value (P 2413419, 2011). In addition, it is worth noting that in some cases the consistency of the drink is unstable, which is due to the instability of whey protein globules in the acidic environment. Protein precipitation and consistency delamination are caused by the side effects as a result of thermal denaturation during pasteurization, due to which protein flakes appear in the drink and are dispersed into liquid and solid fractions, which leads to a deterioration of the organoleptic properties of the drink.

Analysis of scientific publications and patent materials has shown that to increase the biological value, pre- and probiotic properties of fermented milk drinks, highly effective polycomponent bacterial cultures [9,10], products of modification of basic raw materials [11], fruit juices [4,12], non-traditional plant [13,14] and phyto-raw material extracts [5,15], semi-finished products of germinated grains [16], various cereals, legumes [7], algae [6], and others are used in world practice [P GEO No. 7334, 2021; 17].

Despite the growing acceptance and popularity of fermented milk drinks in recent years, which has led to the expansion of their production, Georgia's rich mineral resources remain not properly utilized. In this regard, the use of some still unexplored, fruit-berry raw materials and unique mineral waters of various mineralizations, widespread in western Georgia, seems very interesting.

The goal of the research is to develop a new fermented milk drink of high biological value through the rational use of Georgia's rich raw materials, which will ensure the enhancement of the preventive properties of functional fermented milk drink through the use of various highly effective supplements.

Research objects and methods. The research objects were secondary raw materials of milk processing, such as drinking milk, demineralized whey, milk permeate; bacterial starter cultures of Matsoni and yogurt; herbal supplement – puree of the oleaster fruit (*Elaeágnus angustifólia*); prophylactic fermented milk drink.

The above-mentioned secondary dairy raw materials were obtained in laboratory conditions, and the herbal raw materials were grown in the subtropical zone of western Georgia.

Demineralized whey with a demineralization level of 85-90% and a neutralization level of acidity pH 6.0-6.5, as well as milk permeate, was prepared

on a laboratory electrodialysis device using bipolar membranes [18, 19].

The modern standard and modified research methods were used to perform scheduled activities. The amount of dry matter in the samples was determined by the drying method using a RADWAG MA 50r thermometer, the total amount of protein – by the Kjeldahl method (ISO 8968-1:2014), fats – by the Soxhlet method, ash content – in accordance with ISO/CD 9877 | IDF 258; pectic substances – by titrimetric method (ISO 5773: 2023(E); titratable acidity – in accordance with ISO/TS 22113:2012 standard, and active acidity – using a Mettler Toledo pH meter (USA). The number of microorganisms was determined based on the SOP – Standard Operating Procedure.

An organoleptic examination of the fermented milk drink was carried out using a 10-point scale according to the following indicators: homogeneous, slightly viscous, characteristic color of the product, moderately sweet, and moderate flavor of the filler. The results were displayed on the profilogram.

Results and Discussion

To prepare a functional fermented milk drink, a milk composition was prepared using drinking milk, demineralized whey, and milk permeate.

In order to determine the ratio of the above raw materials in the milk composition, their chemical composition was initially determined, which is shown in Fig. 1.

To maintain the stable consistency of the drink, the use of hydrocarbonate mineral water "Likani" was envisaged in the milk composition, which provides a decrease in acidity and subsequently helps maintain a stable consistency during the fermentation process. The general chemical composition of mineral water "Likani" is as follows: mineralization – 5.0-7.5 g/l, hydrocarbonates – 3500-4500 g/dm^3, microelement – Na – 1000 µg, macroelements, in mg: Ca – 40, F – 10, Mg – 30; pH – 5.5-7.5; temperature – 38-40°C. The ratio of the selected raw materials was determined, which amounted to 0.2:1.0:0.5:0.3, respectively. For the fermented milk drink, bacterial starter cultures of Matsoni and yogurt were selected. The activity of their microflora development during the fermentation process was assessed by titratable active acidity and cell viability of microorganisms over the course of 12 hours. The studies were conducted at a dosage of 5% of the Matsoni and yogurt bacterial starter cultures (Table 1).

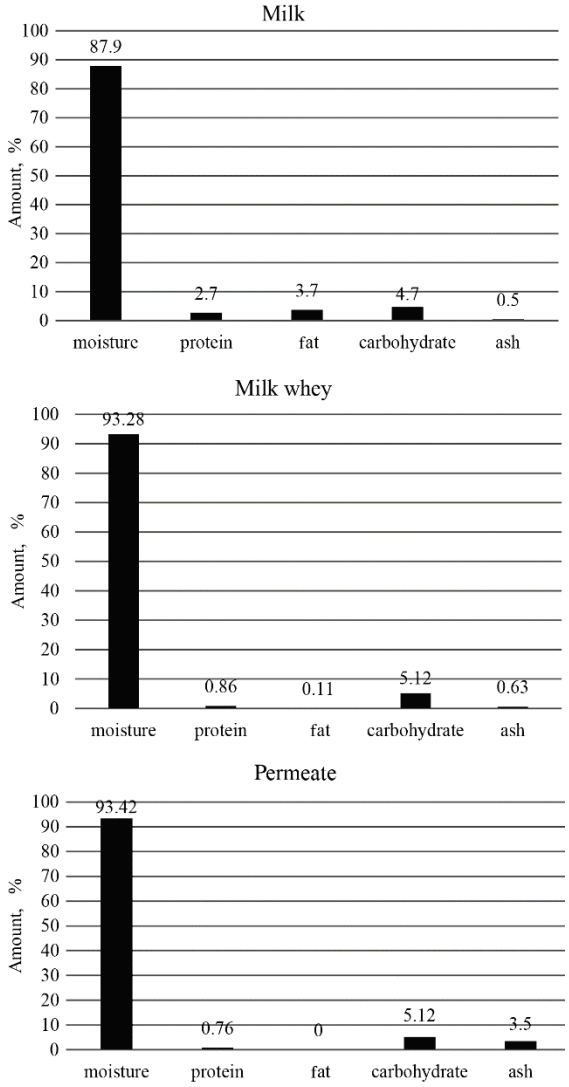

Fig. 1. Chemical composition of drinking milk and secondary dairy raw materials.

In the next phase of research, a composition was created from Matsoni and yogurt bacterial starter

Table 1. Comparative characteristics of bacterial starter cultures

Indicators	Bacterial starter cultures	
	Matsoni	Yogurt
Drinking milk		
No. of vital cells, CFU/cm^3	145±62	129±82
Titrated acidity, ^{0}T	87±2	69±2
Active acidity, pH	4.21±0.01	4.38±0.01
Demineralized cheese whey		
No. of vital cells, CFU/cm^3	118±38	102±62
Titrated acidity, ^{0}T	80±1	68±3
Active acidity, pH	3.62±0.02	4.35±0.01
Milk permeate		
No. of vital cells, CFU/cm^3	138±52	108±58
Titrated acidity, ^{0}T	75±2	62±3
Active acidity, pH	4.18±0.01	4.37±0.01

Table 2. Dynamics of changes in the formation of a ferment milk and acidity during the fermentation process of a milk composition

№	The proportion of starters in the bacterial composition (dosage – 5%)	Time required for curd formation, hr	Acidity	
			°T	°T
1	M : Y = 80 : 20	7.0	110±2	4.34±0.02
2	M : Y= 60 : 40	6.5	92±1	4.56±0.01
3	M : Y = 50 : 50	5.5	86±1	4.52±0.01
4	M : Y= 40 : 60;	10.0	72±3	4.71±0.02
5	M : Y = 20 : 80	12.0	75±2	4.68±0.01

cultures in their various ratios: 1. M:Y=80 : 20; 2. M:Y=60 : 40; 3. M:Y=50:50; 4. M:Y=40:60; 5. M:Y=20 : 80 (M – Matsoni starter culture, Y – starter yogurt culture).

There were determined the time of the creation and formation and final acidity of milk ferment (Table 2).

In order to achieve the predetermined final optimal acidity of the prophylactic fermented milk drink (80-100°T, pH – 4.5-4.6), the best option was considered to be the composition of bacterial starter cultures in the ratio: M:Y=60:40; M:Y=50:50.

In the new fermented milk drink technology, the natural mineral water "Sairme" with a high calcium content was used as a filler, the chemical composition of which is as follows: mineralization – 3.0-5.0 g/l, macroelements, in mg: K – 10, Ca – 150, Mg – 80, Na – 550; pH – 3.5-5.0; temperature – 43°C. Adding the calcium mineral water to the milk mixture before fermentation enriches the mixture with minerals, especially with calcium.

In the next phase of research, the fruit of oleaster was used as a sweetener and herbal supplement in the composition of the drink in the form of a puree. The oleaster fruit contains a large amount of pectin substances – total pectin – 1.92±0.21% on a wet weight basis (including soluble pectin 0.80±0.09% and protopectin – 1.12±0.05%), which is why it plays the role of a structure stabilizer during the fermentation process and delaying the ferment of milk composition, and the puree of this fruit also gives an original sweet taste to the finished product.

The oleaster fruit puree was introduced into the fermented milk drink in different percentages: 1%, 3%, 5%, 7%, and 9%. In order to determine the optimal amount, organoleptic examination was carried out. The best milk drink was considered to

be a milk drink with the addition of 5-7% oleaster puree. The results are displayed on the profilogram (Fig. 2).

On the basis of numerous experiments, the amount of filler and the technological parameters of making the drink were specified, which were reflected in the technology for the production of milk drink that we developed and proposed.

The technological process of fermented milk drink first involves preparing a milk composition using drinking milk, demineralized milk whey, milk permeate, and hydrocarbonate mineral water; then the mixture is homogenized at a temperature of 45-50°C and pasteurized at 60-65°C, with a delay of 20-30 minutes. Then the milk composition is cooled to the fermentation temperature (35-40°C), the bacterial starter culture composition is added, which consists of matsoni and yogurt bacterial starter cultures in 60:40 wt.%. ratio, as well as the addition of a filler – the natural mineral water with a high calcium content. Fermentation is carried out until the formation of ferment, reaching an acidity of 80-100°T. After that, a sweetener – oleaster fruit puree – is added to the mixture, followed by homogenization, pasteurization, cooling, and bottling.

Microbiological testing of the new fermented milk drink was performed at the Kutaisi Zonal Diagnostic Laboratory of the LEPL State Laboratory of Agriculture of Georgia. The following microbiological safety indicators were determined – coliform bacteria 0.01 g; Salmonella 25 g; coagulase-positive staphylococcus 1.0 g, Listeria monocytogenes 25 g. The test did not reveal the above indicators.

The new fermented milk drink has a tender consistency, a natural color, and the original aroma of the oleaster fruit. The selected ratio of ingredients ensures high nutritional and biological value of the drink, increasing the prophylactic properties due to the components of the drink.

Conclusions

The research resulted in developing technology for producing fermented milk drink with high biological value using Georgian bioresources. Milk composition was prepared to obtain fermented milk drink, for which drinking milk, demineralized whey, milk permeate, and hydrocarbonate mineral water "Likani" were selected, the optimal ratio of which was: 0.2:1,0:0.5:0.3, respectively. Bacterial starter cultures of matsoni and yogurt were selected

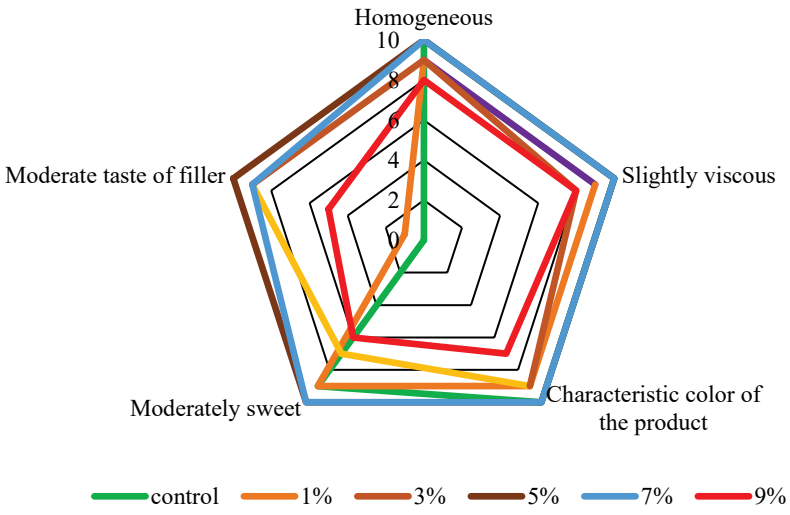

Fig. 2. The effect of oleaster puree doses on the organoleptic characteristics of fermented milk drinks.

for fermentation of the milk composition. To determine their optimal ratio, the activity of bacterial starter cultures in drinking milk, demineralized whey, and milk permeate was studied. Their optimal ratio was 60:40 wt.%, respectively. Before fermentation, the bacterial culture composition, as fillers, natural mineral water “Sairme” with a high calcium content and oleaster fruit puree were added to the resulting milk mixture. The new fermented milk drink has a tender consistency, a natural color, and the original aroma of oleaster fruit.

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ბიოტექნოლოგია

მაღალი ბიოლოგიური ღირებულების მინერალიზებული რძემჟავა სასმელის ტექნოლოგია საქართველოს ბიორესურსების ბაზაზე

ი. ბერულავა*, გ. ფხაკაძე**, მ. სილაგაძე*, ა. კალანდია§, გ. ხეცურიანი*, ს. გაჩეჩილაძე#

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(წარმოდგენილია აკადემიის წევრის თ. სადუნიშვილის მიერ)

რძემჟავა სასმელის მისაღებად მომზადდა რძიანი კომპოზიცია, რისთვისაც შეირჩა სასმელი რძე, დემინერალიზებული რძის შრატი და რძის პერმეატი. შესწავლილ იქნა მათი ქიმიური შედგენილობა. რძემჟავა სასმელის მდგრადი კონსისტენციის შესანარჩუნებლად რძიან კომპოზიციაში გათვალისწინებულ იქნა ჰიდროკარბონატული მინერალური წყლის – ლიკანის გამოყენება. ექსპერიმენტების საფუძველზე დადგინდა შერჩეული ინგრედიენტების ოპტიმალური თანაფარდობა რძიან კომპოზიციაში, რამაც შეადგინა 0,2:1,0:0,5:0,3, შესაბამისად. რძიანი კომ-

პოზიციის ფერმენტაციისათვის შეირჩა მაწვნისა და იოგურტის ბაქტერიული დედოები. მათი ოპტიმალური თანაფარდობის დასადგენად შესწავლილ იქნა ბაქტერიული დედოების აქტივობა სასმელ რძეში, დემინერალიზებულ რძის შრატსა და რძის პერმეატში, რისთვისაც განისაზღვრა ტიტრული, აქტიური მჟავიანობა და მიკროორგანიზმების სიცოცხლისუნარიანი უჯრედების რაოდენობა. ბაქტერიული დედოების ოპტიმალურმა თანაფარდობამ შეადგინა 60:40 მას.%. მიღებულ რძიან ნარევში ფერმენტაციამდე მოხდა ბაქტერიული დედოს კომპოზიციის, შემავსებლების სახით – კალციუმის მაღალი შემცველობის ბუნებრივი მინერალური წყლის – საირმის და ჭალაფშატის ნაყოფის პიურეს დამატება. ჭალაფშატის ნაყოფში პექტინოვანი ნივთიერებების მაღალი შემცველობა (1,92% ნედლ მასაზე გადაანგარიშებით) უზრუნველყოფს ნადედის სტრუქტურის სტაბილიზაციას, ასევე ის ასრულებს დამატკბობლის ფუნქციასაც. ჭალაფშატის პიურეს ოპტიმალურმა რაოდენობამ შეადგინა 5-7%. ახალ რძემჟავა სასმელს აქვს ნაზი კონსისტენცია, ნატურალური კოლერი, ჭალაფშატის ნაყოფის ორიგინალური არომატი.

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