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Development of Formulation and Technology of Low-lactose Dairy Beverage Made from Goat Milk

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Abstract

The concept of lactose intolerance and solution approaches of this problem using modern dairy processing technologies are considered in this study. The protein and lipid constituents were calculated to select the basis of a low-lactose milk beverage. The β-galactosidase preparation was chosen and enzymatic hydrolysis conditions were optimized to obtain a dairy drink that meets the requirements for low-lactose products. To determine the residual amount of lactose in fermented milk, the method for determining whole blood glucose by enzymatic colorimetric method using Shimadzu UV-1800 spectrophotometry was adopted. The influence of technological factors on the dairy low-lactose drink properties was studied. The formulation has been developed and the manufacture process for obtaining a range of low-lactose beverages was adopted, the protein and lipid constituents in the finished product were calculated. The results of this study are considered to be socially significant since the low-lactose products are intended for people suffering from lactase deficiency.

Keywords: dairy industry, low-lactose products, low-lactose milk, milk, lactase, β-galactosidase

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1. Introduction

The market of milk and dairy products, being one of the largest segments of the food industry, is characterized by large volumes of production and consumption [15]. The main raw material for dairy production is cow's milk. However, milk obtained from other animal species is not inferior to cow's in nutritional value. To prove this, a number of studies have been carried out [16--20].

Due to dairy product consumption, people can obtain animal fats, proteins, carbohydrates, vitamins, macro- and microelements in an easily digestible form. However some of the people have been forced to eliminate their dairy product consumption due to the content of milk sugar in its composition - lactose.

Lactose intolerance is a pathological condition caused by decreased lactase level in the body, the enzyme necessary for the proper digestion of lactose [5, 6]. To avoid symptoms of lactose intolerance, people suffering from hypolactasia need to reduce the amount of lactose consumed [3, 7]. It is possible without the exception of dairy products from the diet consuming lactose-free and low-lactose products [2, 4].

To solve the problem of lactose intolerance when consuming milk, modern dairy processing technologies provide a number of techniques to reduce the lactose content or completely remove it from milk and dairy products [8--10]. The most common of them include:

- traditional;
- membrane filtration;
- enzymatic degradation of lactose.

In order to meet the nutrient requirements of people with lactose intolerance, dairy products with a low lactose content are produced worldwide [11--14]. Based on the science information that is studied, it can be concluded that the problem of expanding the range of lactose-reduced dairy products is highly relevant.

2. Results and Discussion

2.1. Milk base selection

In this research work, the protein and lipid constituents were calculated to select the basis of a low -lactose milk beverage. It is proposed to use cow or goat milk as the basis of dairy low-lactose beverage.

Cow milk contains 3.2% protein; goat milk contains 3.0% protein. Cow milk contains more isoleucine, lysine, threonine, tryptophan, phenylalanine and tyrosine. Goat milk contains more amino acids such as valine, histidine, leucine, methionine, and cysteine. The coefficient of difference for amino acid score of cow's and goat's milk are 48.65% and 30.90%, respectively. The biological value of goat milk is higher than that of cow milk and was determined at 69.10% and 51.35%, respectively.

The fatty acid balance coefficient of cow milk, calculated based on the content of saturated, monounsaturated and polyunsaturated fatty acids, is higher than that of goat and ranges from 0.49 to 0.52. The coefficient of fatty acid balance of goat milk in this study varied from 0.45 to 0.48. The coefficient of fatty acid balance of milk in this

calculation, which includes the content of omega-3 and omega-6 fatty acids ranged from 0.31-0.34 for cow milk and 0.14-0.41 for goat milk.

Consequently, to expand the range of low-lactose products based on the calculation of protein and lipid constituents, goat milk was chosen as the basis for the beverages.

2.2. Enzyme hydrolysis

Carbohydrate content in whole goat milk was determined by the iodometric method and showed value of 4.6%. The acidity of goat raw milk was determined by the potentiometric method and was 6.53. Therefore, in the test milk, partial removal of lactose by β-galactosidase products will be effective.

In this study the method of enzymatic cleavage of lactose using a preparation of β-galactosidase produced by yeast of the genus *Kluyveromyces lactis* has been presented. For the experimental production of low-lactose milk samples, the technology of enzymatic hydrolysis was adopted for laboratory conditions. The enzyme preparation Lactasis 6500K was chosen for the production of low-lactose milk showing the maximum hydrolysis efficiency when using manufacturer's recommended dosage amount at 40˚C for 4 hours.

To determine the residual amount of lactose in goat's fermented milk, the method for determining the glucose concentration in whole blood by the enzymatic colorimetric method has been adopted [1]. This determination was carried out using Shimadzu UV-1800 spectrophotometer. The results showed 98.13% of lactose hydrolysis in milk, reducing the lactose content to 0.09%.

2.3. Formulation development

The formulations of treatment samples with various vegetable fillers stabilized with agar in the amount ranged from 0.05 to 0.25 g / 100 g were developed. Oat, almond, peanut, bird cherry and chickpea flours were used as vegetable fillers. The mass fraction of plant compounds varied from 2 to 10%. The developed beverage samples were subjected to organoleptic evaluation.

In order to determine the mass fraction of the filler, test samples with oat flour in the range of 2 to 10% were produced and their organoleptic evaluation was carried out. According to the organoleptic assessment, the mass fraction of the vegetable filler in the amount of 5% is preferred. The concentration increase of the filler led to the mild

taste and smell of the treatment samples. In the manufacture of the sample with the filler of more than 5% significant sedimentation was observed.

To determine the appropriate filler for dairy low-lactose beverage production of treatment samples with various vegetable fillers in an amount of 5% were obtained. Taste, smell, colour, consistency and appearance were subject to evaluation. Each of the indicators was evaluated using 5-point scale. If the treatment sample gained the mean score equals to 2 points for at least one of the indicators then the product is not subject to further evaluation. A group of experts analysed the low-lactose beverage samples for compliance with the developed assessment scale for organoleptic characteristics based on a digital discrete interval scale.

According to the resultant mean scores of organoleptic evaluation, descriptive sensory profile was obtained and presented in Figure 1. The results of comparative analysis of all samples are presented in Figure 2.

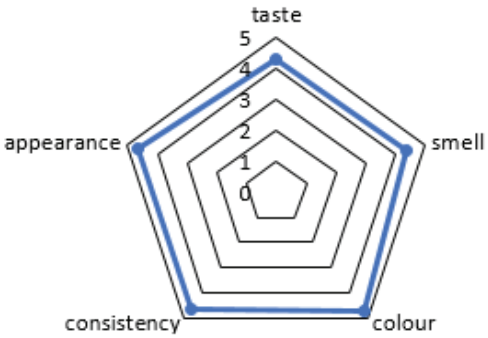
According to the results of organoleptic evaluation, samples with bird cherry and chickpea flour received low mean scores as they had a bitterish taste. When using peanut flour and chickpea flour, significant sedimentation of the filler is observed during the storage period. Therefore, for the production of the assortment group of dairy low-lactose beverages oat and almond flours are recommended. The combination of oat and almond flour in the ratio of 1 : 1 was used to expand the assortment group.

Based on the results of the current study, the proper amount of stabilizer sufficient to stabilize the system for a long period of time was determined. An acceptable amount of agar is 0.2 g / 100 g of the beverage weight. The concentration decrease of the stabilizer does not allow obtaining a stable system, increased concentration of stabilizer is impractical because it does not provide improvement in the obtained result.

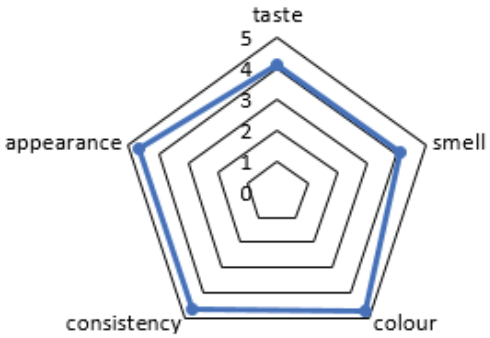
Consequently, the assortment group composition of the low-lactose goat milk-based beverages has been established.

2.4. Development of manufacture procedure

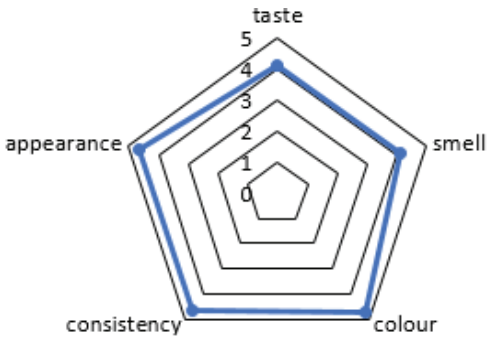
The general manufacturing procedure corresponds to the traditional technology of milk drinking production and the only difference is in the necessity of the filler preparation and enzymatic hydrolysis. The production of the low-lactose milk beverage combines the unit operations of homogenization, pasteurization, cooling, Lactasis 6500K enzyme introduction, enzymatic hydrolysis of lactose while holding the mixture with gentle stirring at 40 $\pm$ 2°C, followed by heating the resultant low-lactose milk to a temperature of 40 - 45°C, separation of 25 % of milk for agar activation and hydration of plant



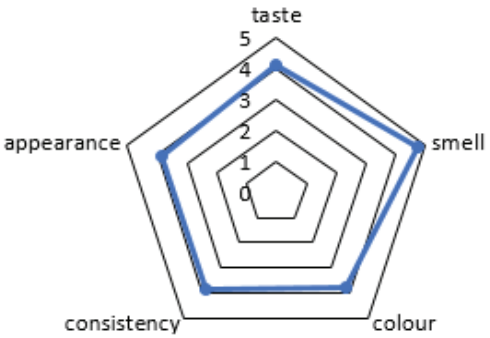
Spider plot of the sample 1
(compound of plant origin – oat flour)



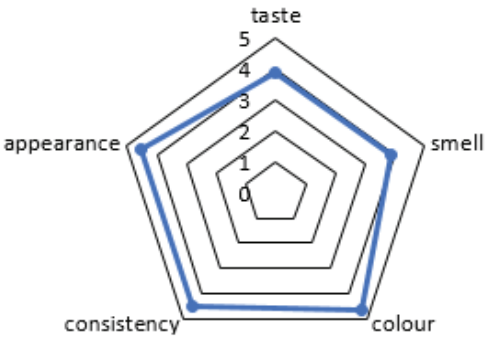
Spider plot of the sample 2
(compound of plant origin – almond flour)



Spider plot of the sample 3
(compound of plant origin – peanut flour)



Spider plot of the sample 4
(compound of plant origin – bird cherry flour)



Spider plot of the sample 5
(compound of plant origin – chickpea flour)

Figure 1: Descriptive sensory profile of test samples.

components (oat and almond flour) at 90 ± 2°C for 15 minutes, mixture preparation using the residual 75% of low-lactose milk, stirring at 40 - 45°C for 2 hours, cooling to 4 ± 2°C and filling. The preparation of plant components includes sieving, setting of mixture of stabilizer and low-lactose milk, which is added to the bulk low-lactose milk in a ratio of 1: 3.

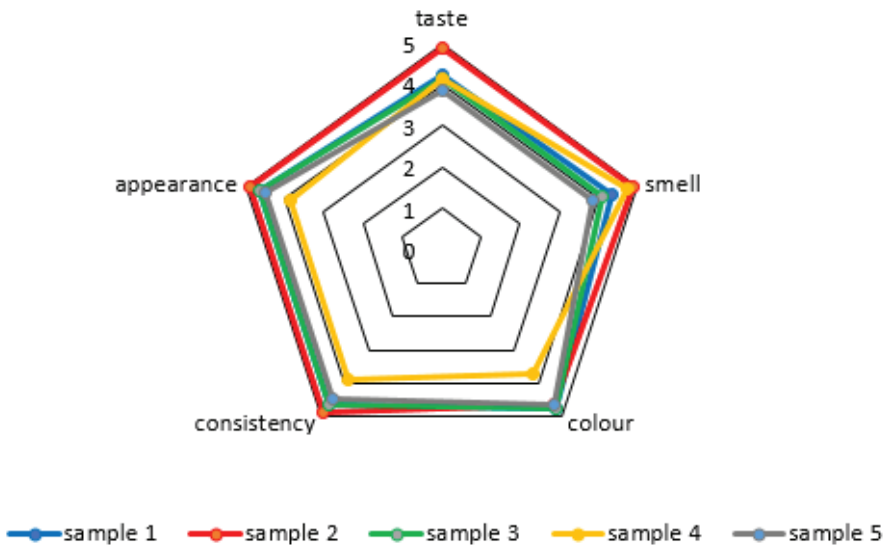


Figure 2: Comparative characteristic: sample 1 contains oat flour; sample 2 -- almond flour; sample 3 -- peanut flour; sample 1 -- bird cherry flour; sample 1 -- chickpea flour.

2.5. Product investigation

In the course of this research, the protein and lipid constituents of the developed milk beverages were calculated. The content of carbohydrates, the vitamin and mineral constituents of the product were determined.

The sample containing oat flour in its composition has the highest content of all amino acids except histidine. The histidine content is higher in the sample containing almond flour. The coefficient of difference for amino acid score in low-lactose milk beverages is in the range from 29.58% (sample with almond flour) to 29.73% (sample with oat flour). The biological value varies from 70.27% (sample with oat flour) to 70.42% (in a sample containing almond flour).

The fatty acid balance coefficient of low-lactose milk beverages calculated based on the content of saturated, monounsaturated and polyunsaturated fatty acids is from 0.49 to 0.53.

3. Conclusion

In this study, the formulation of low-lactose milk beverages was developed and the effects of technological factors on properties of these beverages were investigated.

To determine the residual lactose content in goat fermented milk, the method for determining the glucose concentration in whole blood by the enzymatic colorimetric method using the Shimadzu UV-1800 spectrophotometer was adopted. The enzyme

preparation Lactasis 6500K that hydrolysed up to 98.13% of lactose during 4 hours at 40°C was chosen to develop the low-lactose beverage.

The general manufacturing procedure corresponded to the traditional technology for the production of drinking milk. The additional required steps were plant compounds preparation and enzymatic hydrolysis.

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