The development of functional products for children based on sheep's milk with the addition of berries is a pressing issue in the field of baby food. The object of this study is baby curds based on sheep's milk with the addition of berries. The task that this study solves is to improve the nutritional and organoleptic characteristics of baby products made from sheep's milk since pure sheep's milk without additives has a specific smell and taste, which reduces its attractiveness to children. The results of the study showed that the addition of berries (chokeberry, raspberry, strawberry) significantly improves the taste and aromatic properties of curds. Children preferred curds with berries since they had a creamy-berry aroma, while curds without additives retained the characteristic smell and taste of sheep's milk. It was also found that the addition of berries increased the antioxidant activity of the product due to enrichment with vitamins (especially vitamin C) and dietary fiber. By adding berries to the curds, it was possible to increase the nutritional value, improve the taste characteristics and increase the digestibility of the product. These results solve the problem of low consumer appeal of sheep milk-based products.

The results could be used in the production of functional dairy products for children, especially for creating products with increased antioxidant potential and improved organoleptic characteristics. Such curds can be in demand under conditions of mass production for children, as they improve the nutritional value and increase consumer appeal due to taste improvements

Keywords: sheep milk, children's curd, antioxidants, nutritional value, sensory characteristics

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DEVELOPMENT OF CURD FOR CHILDREN FROM SHEEP MILK WITH BERRIES: IMPROVEMENT OF NUTRITIONAL AND FUNCTIONAL PROPERTIES

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1. Introduction

Baby food plays a vital role in maintaining the health and full development of children, providing the body with the necessary nutrients. Today, there is a steady demand for products with high nutritional value that not only meet children's needs for proteins, fats, vitamins, and minerals, but also contribute to improving their overall health. In this regard, an important direction in the development of baby food products is the use of raw materials with unique nutritional characteristics. Sheep's milk has long attracted attention as a promising raw material for baby products due to its rich composition. It contains more proteins, fats, and useful microelements, such as calcium and magnesium, compared to cow's milk. This makes sheep's milk more nutritious and also improves its digestibility, which is especially important for children with cow's milk intolerance. In addition, sheep's milk contains less lactose, which reduces the risk of allergic reactions and digestive problems in children. However, despite its nutritional properties, sheep's milk has a specific

taste and smell, which can reduce its appeal to children. The introduction of berries into the composition of dairy products based on sheep's milk makes it possible to fortify them with vitamins, antioxidants, and dietary fiber. Berries such as chokeberries, raspberries and strawberries not only improve the taste and organoleptic characteristics of products but also add useful biologically active substances to their composition that increase antioxidant activity. It is important to explore the possibilities of increasing the nutritional value of children's products using sheep's milk in combination with berries. This makes it possible to create products that not only have improved taste characteristics but also contribute to the strengthening of children's health due to antioxidant activity and the absorption of vitamins. With the increasing number of children with cow's milk allergies and digestive disorders, the need to develop such products increases. Thus, research aimed at creating children's dairy products with improved nutritional and organoleptic characteristics remains relevant and necessary for implementation in the practice of baby food.

2. Literature review and problem statement

Numerous studies have shown that sheep's milk is rich in nutrients and can be used as a basis for creating products with high nutritional value for children. However, its specific taste and smell can reduce its appeal to children, which remains an unsolved problem [1, 2]. The introduction of berries into dairy products based on sheep's milk is considered a possible solution that could improve the organoleptic characteristics and increase their beneficial properties [3, 4].

The authors of [5] showed that the addition of inulin and apple fiber to symbiotic ice cream improved the survival of probiotic bacteria during digestion, which is especially important for baby food products. These results are supported by the data in [6], which also emphasizes the potential of sheep's milk for the production of functional products with probiotics and prebiotics, but these processes have not been studied for curds.

The addition of berries to dairy products, such as chokeberry, can improve not only the taste characteristics but also the antioxidant activity of products. In [7], it was shown that berries improve the quality of fermented dairy products, which is confirmed by the studies reported in [8], in which a cluster approach to the development of functional dairy products from sheep and goat milk was considered, but they were not focused on children. In [9], the possibilities of using non-cow milk for the production of functional products were considered, which supports the prospects for using sheep milk for baby food. At the same time, optimization of technological processes, such as homogenization and high pressure, is of great importance, which is discussed in [10]. Technological aspects of sheep milk processing are shown, but their impact on baby products requires further research.

The effects of inulin and apple fiber on sheep's milk-based symbiotic ice cream were studied in [11–13], in which a positive effect on intestinal health was found. In particular, study [12] showed that the use of inulin and fiber promoted the survival of probiotic bacteria during digestion, improving the prebiotic activity of the product. However, it should be noted that the study was focused on ice cream, and not all results may be directly applicable to children's curds, as the texture, composition, and temperature conditions differ significantly. In [14], probiotics had a beneficial effect on the intestinal microflora of adults, which confirms the possibility of using sheep's milk in functional foods. However, as indicated in [14], these studies are limited in their application in infant nutrition since the microbiota of children may differ from the microbiota of adults, which requires separate study. Technologies for adding probiotics and bioactive ingredients to baby products remain understudied. The use of such components in baby curds requires the development of new technological solutions, especially with regard to the stability of probiotics and their impact on baby microbiota. It is important to note that the composition of the microbiota of children varies depending on age, and there is still insufficient data covering the impact of probiotics on different age groups of children, which makes further research necessary in this area. In paper [15], the authors investigated the coagulation properties of sheep's milk, which can improve the texture and yield of curd, but optimization of these processes for baby food requires further research. Also, in work [16], Fourier spectra were used to analyze the composition and coagulation properties of sheep's milk, which is important for improving the quality of curds.

Work [17] compared the nutritional value of milk from various mammals, confirming the unique properties of sheep's milk, but also emphasized its difficulties in digestibility for children. The authors of paper [18] studied the effect of homogenization and heat treatment on the digestibility of sheep's milk, which is useful for the development of baby products.

Study [19] showed that baby formulas based on sheep's milk may have a number of advantages over analogs made from cow's and goat's milk, but further adaptation for baby food is required. Paper [20] confirmed that berries such as chokeberry are rich in antioxidants, which can increase the antioxidant activity of baby curds.

The authors of [21] emphasize the lack of data on the coagulation properties of non-cow's milk in the human stomach. Studies show that the composition and structure of milk play an important role in digestive processes, but further research is needed to fully understand the mechanism of digestion and the creation of functional products based on sheep and goat milk. This is especially important in the context of developing baby products, where it is necessary to consider not only the nutritional properties but also the tolerability of the product by the child's body.

The addition of fruit and berry concentrates to dairy products from sheep and goat milk was successfully tested in study [5], in which the production of yoghurts with such additives demonstrated improved taste and an increase in antioxidant content. This approach can also be useful for baby curds since fruit and berry concentrates improve the taste of the product and make it more attractive to children. However, the technologies used for yoghurts require adaptation for baby products, taking into account texture and digestibility.

The study also showed that the addition of fruit and berry components not only improves taste but also increases the antioxidant activity of products [5]. This aspect is particularly important for the development of functional baby products, which should combine both nutritional and functional properties.

However, there are still unresolved issues related to optimal technological processes for preserving nutrients and improving the texture of children's curds based on sheep's milk. The introduction of berry and fruit additives requires further study in order to take into account the characteristics of children's nutrition and meet consumer requirements for organoleptic qualities. The scientific novelty of our work is in the systematic and detailed analysis of the composition

of sheep's milk and curd, and its relevance is due to the growing interest in functional foods, the need to adapt dairy products for people with lactose intolerance, the development of technologies and the desire for environmental and economic sustainability in agriculture.

3. The aim and objectives of the study

The aim of our study is to develop children's curds based on sheep's milk with the addition of berries that have increased nutritional value and improved antioxidant properties, as well as to evaluate their digestive characteristics and sensory properties. The study is aimed at creating a product that would be more useful and attractive to children compared to traditional curds made from cow's milk.

To achieve the goal, the following tasks were set:

– to analyze the chemical composition of sheep's milk and berries used to fortify children's curds in order to determine their nutritional value and antioxidant activity for further justification of the product recipe;

– to study the effect of adding berries on the antioxidant properties, digestive characteristics and assimilation of children's curds based on sheep's milk;

– to conduct a sensory analysis of the developed products to evaluate their taste characteristics and consumer appeal among children;

– to compare the obtained results with traditional curds based on cow's milk, identifying the advantages of the new product.

4. The study materials and methods

4. 1. The object and hypothesis of the study

The object of our study is baby curds based on sheep's milk with the addition of various berries.

Our hypothesis assumes that the addition of berries (chokeberry, raspberry, and strawberry) to baby curds based on sheep's milk reduces the specific smell and taste of milk, as well as improves the digestibility of proteins and increases the nutritional value of the product, making it more attractive to the child's body.

The following assumptions and simplifications were adopted during the study:

– the influence of factors on antioxidant activity and nutritional value is described by a linear model;

– the influence of each factor was considered separately, without taking into account their interactions;

– it is assumed that errors are distributed normally with constant variance;

– only the main factors (type of berries, number of berries, processing method and storage temperature) were included in the analysis;

– interactions between factors were not considered to simplify the model.

4. 2. Materials

The following materials were used:

– sheep milk: the main component used to prepare the curds. Milk with a specific fat content and composition was used in each sample;

– berries: various berries such as blueberries, chokeberries, strawberries, and raspberries were used to fortify the curds. The berries were added in different quantities to study their effect on the nutritional, antioxidant, and sensory characteristics;

– inulin: a prebiotic added to improve the prebiotic activity of the curds and stimulate the growth of beneficial microflora;

– probiotics: probiotic cultures (e.g., *lactobacillus, bifidobacterium*) were used, which were added during the fermentation process to improve the digestive characteristics of the product;

– whey proteins: added to improve the texture and increase the nutritional value of the product;

– apple fiber: used to improve the texture and introduce an additional source of dietary fiber.

4. 3. Preparation of curd samples

The curds were prepared from sheep's milk with the addition of berries and various functional ingredients. The samples were divided into groups depending on the composition and type of additives:

– group 1: curds with chokeberry;
– group 2: curds with inulin;
– group 3: curds with probiotics;
– group 4: curds with apple fiber;
– group 5: curds with whey proteins.

Processing techniques (*So*):

– technique 1: conventional pasteurization at 72 °C for 15 seconds;
– technique 2: ultrasonic treatment at 48 °C for 2 minutes;
– technique 3: homogenization at 100 rpm for 10 minutes.

Berry type (*Ty*):

1 – chokeberry;
2 – raspberry;
3 –strawberry.

Quantity of berries (*Qy*): varies from 10 to 30 grams per 100 grams of curd.

Fermentation time (*Ft*): from 4 to 8 hours.

Storage temperature (*Th*): from 4 to 20 °C.

4. 4. Chemical analysis

A chemical analysis was carried out to determine the main components of the curds:

– protein content: determination by the Kjeldahl method;
– fat content: fat extraction by the Soxhlet method;
– content;
– carbohydrates: determination of carbohydrates by the Lane-Eynon method;
– mineral composition: determination of calcium, phosphorus, magnesium, and potassium by atomic absorption spectroscopy;
– vitamin content: determination of vitamin C and vitamin A by high-performance liquid chromatography (HPLC).

4. 5. Evaluation of antioxidant activity

Antioxidant activity was determined using the Trolox equivalent antioxidant capacity (TEAC) method. The method is based on the interaction of free radicals with antioxidants contained in berries and functional ingredients.

4. 6. Prebiotic activity

Prebiotic activity was assessed by culturing probiotic cultures (*Lactobacillus, Bifidobacterium*) on media containing curd samples with inulin and probiotics. Microorganism growth was assessed using the method of numerical colony growth on selective media.

4. 7. Texture testing

Textural characteristics of the curds were determined using a texturometer based on the following parameters: elasticity, viscosity, cohesion (the ability of the product to return to its original state after deformation).

4. 8. Nutritional value assessment

The nutritional value of the curds was assessed based on chemical composition data, as well as using formulas for calculating caloric content, protein, fat, and carbohydrate content.

4. 9. Sensory evaluation

The organoleptic properties of the curds were assessed by an expert tasting committee on a 5-point scale: taste, aroma, texture, color, overall satisfaction.

4. 10. Digestibility assessment

The digestibility of the curds was assessed using an *in vitro* enzymatic hydrolysis method. Curd samples were exposed to gastric and intestinal enzymes, after which the percentage of digestible nutrients was measured [21].

4. 11. Statistical analysis

To process the results, a matrix with natural data was filled in at the beginning of the study, which made it possible to take into account the real values of factors affecting the antioxidant activity, nutritional value, digestibility, and sensory characteristics of the product. After the initial analysis, data standardization was applied by coding categorical variables, such as the type of berries and processing technique, for more correct inclusion in the regression model. To process the results, the methods of variance (ANOVA) and regression analysis were used to identify the significance of the influence of various factors (volume of milk, type of berries, processing technique, etc.) on the antioxidant activity, prebiotic activity, digestibility, sensory characteristics of the product.

Ty is the type of berries; *Qy* is the number of berries; *So* is the processing technique; *Ft* is the fermentation time; *Th* is the storage temperature. The equation for antioxidant activity takes the form:

$$A=\beta 0+\beta_1 Ty+\beta_2 Qy+\beta_3 So+\beta_4 Ft+\beta_5 Th+\varepsilon,$$

where β_0 is the free term, $\beta_1,...,\beta_5$ are the regression coefficients for each factor, ε is the model error.

Taking into account the same factors, the content of antioxidants A and vitamin VC, the equation for the nutritional value (*N*) can be represented as follows:

$$N=\alpha_0+\alpha_1 Ty+\alpha_2 Qy+\alpha_3 So+\alpha_4 Ft+\alpha_5 Th+\alpha_6 A+\alpha_7 VC+\varepsilon,$$

where α_0 is the free term, $\alpha_1,...,\alpha_7$ are the regression coefficients for each factor, ϵ is the model error [22].

5. Results of investigating curds with additives

5. 1. Analysis of the chemical composition of sheep's milk and berries for the development of a recipe for children's curds with increased antioxidant activity

The recipe was compiled taking into account the material balance and planning matrix (Table 1).

Approach to formulation:

– control samples (experiments 1, 4, 7) are used to compare and analyze the effect of berries on taste and protein digestibility;

– inulin and apple fiber are added at different levels to evaluate their effect on the prebiotic properties and texture of the product;

– whey protein is present in all samples at a level of 5 % to improve consistency and increase the completeness of the protein;

– probiotics are added as needed to improve probiotic properties and maintain healthy intestinal microflora.

The production flow chart is shown in Fig. 1.

The pasteurization and homogenization process in the IS-5000 grinder eliminated the unpleasant smell of sheep's milk, which is an important step in improving the organoleptic properties of the product. These methods ensure a more uniform distribution of components and an increase in the quality of the final product.

Each sample was prepared under standard fermentation conditions and aging at different temperatures to assess the stability of the product during storage.

Table 2 gives the composition of the main ingredients of the curd.

Table 2 shows that sheep's milk is rich in proteins, fats, and minerals such as calcium and phosphorus, making it an excellent base for baby curds. Chokeberry has a high content of antioxidants (1200 equiv. Trolox), as well as carbohydrates and potassium. It is rich in vitamin C and dietary fiber.

Blueberries contain fewer carbohydrates and antioxidants than chokeberries but are also a source of vitamin C and dietary fiber.

Strawberries contain a high amount of vitamin C (59 mg) but they have less antioxidants and dietary fiber than other berries.

Table 1

Experiment design matrix

Experiment No.	Type of berries (Ty)	Inulin (In, %)	Apple fiber (YC, %)	Whey protein (SB, %)	Probiotics (Pb)	Objective/Expected effect
1	Chokeberry	0	0	5	No	Basic control sample for comparison
2	Chokeberry	3	2	5	Yes	Increase prebiotic activity and digestibility
3	Chokeberry	5	4	5	Yes	Maximum improvement of texture and prebiotic properties
4	Raspberry	0	0	5	No	Improvement of palatability and antioxidant activity
5	Raspberry	3	2	5	Yes	Balance of taste and protein digestibility
6	Raspberry	5	4	5	Yes	Optimization of texture and prebiotic properties
7	Strawberry	0	0	5	No	Masking of sheep milk odor
8	Strawberry	3	2	5	Yes	Increase of digestibility and probiotic properties
9	Strawberry	5	4	5	Yes	Maximum improvement of texture and taste

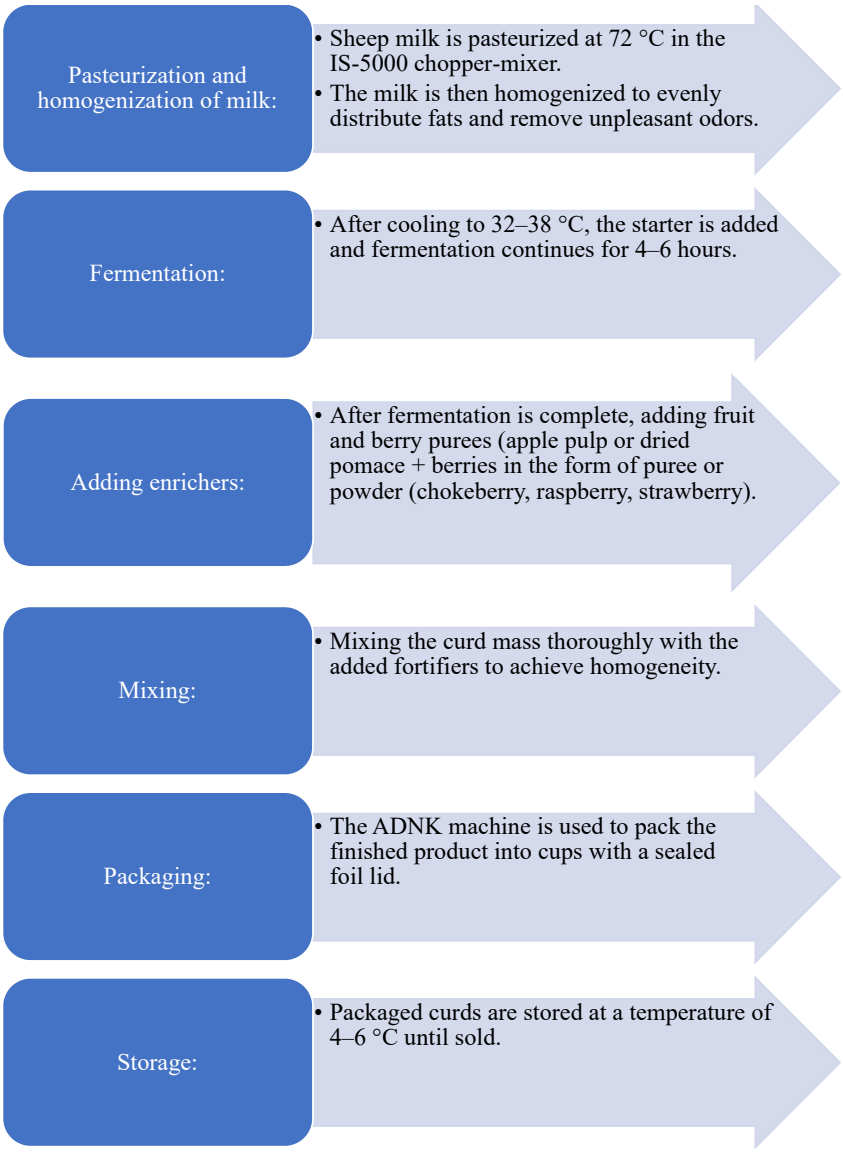

Fig. 1. Technological scheme of production of children's curds based on sheep's milk

Table 2

Chemical composition of sheep milk and berries (per 100 g)

Component	Sheep's milk	Black chokeberry	Bilberry	Strawberry	Raspberry
Proteins (g)	5.98	1.5	0.7	0.8	1.2
Fats (g)	7.00	0.1	0.3	0.4	0.7
Carbohydrates (g)	5.1	17.0	14.5	7.7	11.9
Calcium (mg)	193	30	6	16	25
Phosphorus (mg)	158	35	13	24	29
Magnesium (mg)	18	15	6	13	22
Potassium (mg)	220	400	77	153	151
Vitamin C (mg)	0	15	9	59	26
Vitamin A (mcg)	99	10	1	12	2
Antioxidants (eq. Trolox)	–	1200	670	430	700
Dietary fiber (g)	0	2.0	2.4	2.0	6.5

Raspberries are rich in dietary fiber (6.5 g), which improves digestion. Raspberries also contain antioxidants (700 equiv. Trolox) and vitamin C (26 mg), making them a useful additive to curds.

5. 2. Results of investigating the effect of adding berries on antioxidant properties, digestive characteristics, and assimilation

Table 3 gives the variation levels of factors such as berry type (*Ty*), quantity (*Qy*), processing technique (*So*), fermentation time (*Ft*), and storage temperature (*Th*). These factors are studied to analyze their effects on antioxidant activity (*A*), vitamin C content (*VC*), digestibility (*U*), and nutritional value (*N*).

The least squares method was used to calculate the coefficients of the regression equations. All coefficients were estimated based on the active experiment data given in Table 3.

The Fisher criterion was used to check the uniformity of the experiments, which confirmed the uniformity of the data. Statistical testing of the significance of the coefficients was performed using p-values, which allowed us to exclude insignificant factors. The accuracy of the model was estimated using the determination coefficient (R^2), which was 0.85, indicating high adequacy of the model.

Table 3

Levels of variation of factors in an experiment (standardized form)

Factor	Level –1	Level 0	Level 1
Type of berries (*Ty*)	Chokeberry	Strawberry	Raspberry
Processing method (*So*)	Pasteurization	Ultrasound	Homogenization
Fermentation time (*Ft*)	4 h	6 h	8 h
Storage temperature (*Th*)	4 °C	6 °C	8 °C
Number of berries (*Qy*)	10 g	20 g	30 g

The following equations were derived:

$$A=20.44+0.105Ty+0.548So-0.175Ft, \quad (1)$$

where A is the antioxidant activity; Ty is the berry type (categorical variable, e. g., 1 – chokeberry, 2 – raspberry, 3 – strawberry); So is the processing technique (categorical variable, e. g., 1 – pasteurization, 2 – ultrasound, 3 – homogenization); Ft is the fermentation time in hours;

$$N=86.61+0.623Ty+0.172So-0.290Ft. \quad (2)$$

Results of the analysis of variance showed that:

– the type of berries (*Ty*) has a significant effect on antioxidant activity ($p<0.01$);

– the number of berries (*Qy*) has a positive effect on antioxidants and nutritional value ($p<0.05$);

– storage temperature (*Th*) has a negative effect on antioxidant activity ($p<0.05$).

5. 3. Sensory analysis

To evaluate the organoleptic characteristics of the developed curds based on sheep's milk with the addition of various ingredients, a study was conducted involving 25 children. The children assessed the taste, aroma, texture, and overall impression of each type of curd on a 5-point scale. The results are given in Table 4.

Table 4 demonstrates that curds with added berries (raspberries, strawberries) received the highest ratings for all organoleptic indicators. These curds turned out to be the most attractive to children, which emphasizes the importance of choosing flavor additives in children's food products. Curds with prebiotics and inulin, despite their functional properties, received slightly lower ratings, which may be due to their neutral or less intense taste.

Table 4

Results of organoleptic analysis

Types of curds	Taste	Aroma	Texture	Overall impression
Curd with apple fiber	4.7	4.6	4.8	4.9
Curd with raspberries	4.9	4.7	4.9	5
Curd with chokeberry	4.6	4.5	4.7	4.8
Curd with strawberries	4.9	4.8	4.9	5
Curd with prebiotics	4.5	4.4	4.8	4.7
Curd with inulin	4.4	4.3	4.7	4.6
Traditional curds	4.2	4	4.5	4.3

5. 4. Comparison with traditional curds based on cow's milk

To assess the nutritional and functional value of various types of curds developed on the basis of sheep's milk with the addition of berries and other functional components, a comparison was performed with traditional curds based on cow's milk. Table 5 gives comparative data on key parameters, including the content of proteins, fats, carbohydrates, minerals, as well as antioxidant activity and organoleptic properties.

Table 5 shows that:

– sheep's milk contains more proteins and fats, as well as calcium, than cow's milk;

– adding berries significantly improves the antioxidant properties of sheep's milk-based curds;

– curds with sheep's milk and berries showed higher digestibility rates (up to 96 %) compared to traditional curds (up to 90 %);

– products with sheep's milk and berries received high ratings for taste characteristics among children, especially for texture and overall impression.

This comparison reveals the advantages of sheep's milk-based curds, which include a higher content of proteins, fats, calcium, and antioxidants, as well as improved taste characteristics when adding berries. This confirms the high nutritional value and functional properties of the developed products.

Table 5

Benefits of sheep milk curds with berries

Parameter	Traditional curds (cow's milk)	Curd with chokeberries	Curd with strawberries	Curd with raspberry	Curd with inulin	Curd with probiotics	Curd with apple fiber
Protein content (g)	12–18	18–22	18–22	18–22	18–22	18–22	18–22
Fat content (g)	4.0–9.0	7.00	7.00	7.00	7.00	7.00	7.00
Carbohydrate content (g)	1.8	22.1	12.8	17.0	5.1	5.1	7.1
Caloric content (kcal)	226	223	209	218	193	193	193
Calcium (mg)	120	223	209	218	193	193	193
Phosphorus (mg)	120	193	182	187	158	158	158
Magnesium (mg)	15	33	31	40	18	18	18
Potassium (mg)	150	620	373	371	220	220	220
Vitamin C (mg)	0–5	15	59	26	0	0	0
Antioxidants (eq. Trolox)	0–100	1200	430	700	0	0	0
Dietary fiber (g)	0.0	2.0	2.0	6.5	0.0	0.0	2.0
Organoleptic properties	Creamy texture, delicate taste	Rich flavor, astringency	Sweet, fresh taste	Sweet, light aroma	Neutral	Light sourness	Light fruity taste
Lactose	Present	Present	Present	Present	Present	Present	Present

6. Discussion of results based on investigating the development of children's curds based on sheep's milk with berries

Based on the chemical analysis of sheep's milk and berries, such as chokeberry, raspberry and strawberry, a recipe for curds for children was developed. The choice of berries is due to their high antioxidant activity, significant content of vitamins and dietary fiber. As shown in Table 2, chokeberry has the highest antioxidant activity (1200 equiv. Trolox), which makes it an important component for enhancing the protective properties of the body. Raspberry, due to the high content of dietary fiber (6.5 g), has a positive effect on digestion.

The recipe was supplemented with inulin and apple fiber to achieve optimal texture and improve the prebiotic properties of the product. Probiotics also played an important role in improving the functionality of the curds, maintaining healthy intestinal microflora. In the developed technological scheme, special attention was paid to key stages, such as pasteurization and homogenization, which eliminated the specific taste of sheep's milk and improved the taste of the product. The use of modern technological processes ensured uniform distribution of all ingredients and long-term stability during storage. Thus, the proposed recipe and technological scheme led to the creation of a product with improved nutritional and organoleptic characteristics. Sensory analysis confirmed that curds with berry additives have a more pleasant taste and texture, which makes them attractive to children.

In addition, a comparative analysis with traditional cow's milk-based curds revealed significant advantages of the new product, including increased antioxidant activity and better digestibility due to the use of whey protein and the addition of probiotics. The results of the chemical analysis, given in Table 2, show that sheep's milk is significantly superior to cow's milk in terms of protein (5.98 g) and fat (7.00 g). The high content of calcium (193 mg) and phosphorus (158 mg) also indicates its potential for use in baby food. This can be explained by the fact that sheep's milk is richer in composition than cow's milk, which has already been proven in previous studies [1]. However, the lack of antioxidants and vitamin C in sheep's milk is a limitation that was solved by adding berries. The addition of chokeberry, raspberry and strawberry significantly fortified the product with antioxidants and vitamin C. For example, chokeberry contains 1200 equiv. Trolox antioxidants, which improves the antioxidant activity of curds. Products with raspberries and chokeberry demonstrated the highest digestibility rates (up to 96 %) due to their complex composition, including antioxidants and vitamins, despite the presence of dietary fiber, which is known to reduce protein digestibility. The results of the analysis of variance indicate that the processing technique and interactions between factors have a significant effect on variable A. While the main effect of berry type did not show a statistically significant effect, the quadratic effect indicates the possibility of a significant effect depending on the concentration of antioxidants. Berry type and fermentation time have a significant effect on the nutritional value of curds. These data will help further optimize the recipe and technological processes to achieve the maximum nutritional value of the product.

However, the presence of insoluble dietary fiber such as cellulose and hemicellulose (e.g., apple fiber) could potentially reduce protein digestibility, which is emphasized in the literature. For example, numerous studies have shown that fiber can impair nutrient absorption and slow down digestive processes. However, the addition of berries with a high antioxidant content (aronia and raspberries) significantly neutralized this effect in the course of the studies. These findings are supported by studies [5–7]. Thus, study [5] examines the effect of adding apple fiber on protein digestibility at high antioxidant levels. The results show that apple fiber does not significantly affect protein digestion, which confirms that high antioxidant levels in the diet can neutralize possible negative effects.

Paper [6] demonstrates that the combination of dietary fiber such as cellulose with antioxidant-rich foods can minimize or even reverse the negative effects on protein digestibility. The authors emphasize that the correct combination of these components in the diet can improve overall digestibility.

Work [7] examines how high concentrations of phenolic compounds in berries can enhance the digestion process, even in the presence of dietary fiber, such as hemicellulose. The authors note that these compounds modify the intestinal microbiota and enzyme activity, which ultimately improves digestibility.

Thus, the experiment showed that antioxidants contained in berries help improve protein digestibility, compensating for the possible negative effects of dietary fiber.

The regression equation demonstrates that products with raspberries and chokeberries showed protein digestibility of up to 96 %. This is explained not only by the reduction of the specific smell of sheep's milk but also by the synergy of antioxidants and vitamins, which improves metabolic processes. The presence of apple fiber in the product had a minimal effect on protein digestibility, due to the high levels of bioactive compounds.

Results of the regression analysis reveal that the processing technique is a key factor that significantly affects the antioxidant activity. The type of berries did not show a significant effect, which may be due to differences in antioxidant content. Fermentation time also requires further study to understand its effect on activity.

Unlike traditional cow's milk-based curds, which demonstrated only 90 % digestibility, curds with sheep's milk and berries showed better results due to their rich composition, which makes them a preferred product for children. Adding berries effectively solved this problem, as the berries softened the specific taste of milk and improved its aroma, which is confirmed by high scores in the sensory analysis (Table 4). The product became not only more delicious but also healthier due to the increased content of antioxidants and vitamin C. The sensory analysis given in Table 4 revealed that curds with raspberries and strawberries were the most popular among children, receiving high scores for taste, aroma, and texture. This indicates that the addition of these berries not only improves the taste characteristics of the product but also makes it more attractive to children.

The curds with chokeberry and apple fiber also received high marks for texture, which emphasizes their appeal to children. These results are important for the development of products aimed at children since taste and texture play a decisive role in children's acceptance of food products.

Unlike traditional solutions based on cow's milk [19], in which antioxidant activity is either absent or minimal, the addition of berries to sheep's curds significantly increased this indicator. This is confirmed by the regression analysis, which showed that the addition of berries, especially chokeberry and raspberry, leads to an increase in antioxidant activity. The analysis of variance also reveals a significant effect of the processing technique and the type of berries

on the functional properties of the product. The high antioxidant activity of berries improves not only the nutritional value but also makes the curds more attractive to consumers.

In addition, sheep's milk contains more fats and proteins than cow's milk, which makes it a more nutritious base. This advantage is especially important for children, as proteins and fats are necessary for their growth and development [3]. The introduction of berries also improved the sensory characteristics of the product, which is confirmed by the results of the sensory analysis in Table 4. Table 5 gives comparative data that show the clear advantages of sheep's milk curds with the addition of berries compared to traditional curds. The main differences are the higher content of proteins (18–22 g), fats (7.00 g), calcium, and phosphorus, as well as the increase in antioxidant activity due to the addition of berries.

The antioxidant activity of products with berries (especially with chokeberry) is significantly higher than that of traditional curds, which emphasizes their functional properties. In addition, products with raspberry and apple fiber showed improved digestion due to the high content of dietary fiber.

One of the limitations of our study is the dependence of the quality of curds on the availability and cost of berries. For example, blueberries were excluded from the analysis due to their high cost. This limits the possibility of mass production of such products in regions with low access to certain berries. Also, the results may vary depending on the seasonality of the berries, which may affect their nutritional value.

In addition, the study did not include long-term observations of the effects of such products on the health of children, which limits the application of these findings in clinical practice.

One of the limitations of our study is that not all functional additives, such as inulin and prebiotics, received high scores on sensory characteristics. This may reduce the appeal of such products to children. Also, the limited sample of children (only 25 participants) may limit the generalization of the results to a wider audience. Future development of the study may include expanding the range of berries and functional additives to improve the nutritional and sensory value of the curds. For example, using more accessible and cheaper berries may increase the potential of the product for mass production. Clinical studies are also needed to confirm the safety and benefits of such products for children on a long-term basis. Further clinical studies are needed to finally validate our findings, especially in the area of studying the effect of antioxidants on the digestibility of proteins in baby food products. In addition, expanding the study to other age groups and other regions would allow the products to be adapted for different categories of consumers.

7. Conclusions

1. Based on the analysis of the chemical composition of sheep's milk and berries such as chokeberry, raspberry, and strawberry, a recipe for baby curds was developed. The inclusion of berries rich in antioxidants, vitamins, and dietary fiber made it possible to create a product with increased antioxidant activity and improved nutritional properties. The addition of inulin and apple fiber helped improve the texture and prebiotic characteristics of the product. The use of probiotics had a positive effect on the intestinal microflora, which makes this product useful for baby food. The analysis revealed that sheep's milk has high nutritional value, including a significant content of proteins (5.98 g) and fats (7.00 g) per 100 g of product, as well as a large amount of calcium (193 mg) and phosphorus (158 mg). This makes it a promising component for creating baby products with a high level of macro- and microelements. The introduction of berries such as chokeberry and raspberry fortified the product with antioxidants (up to 1200 equiv. Trolox) and vitamin C (up to 59 mg), which significantly improved the functional properties of the curds. The developed technological scheme of production includes the stages of pasteurization, homogenization, fermentation, and addition of berries. The use of pasteurization and homogenization made it possible to eliminate the specific smell of sheep's milk and ensure uniform distribution of ingredients. The optimized process of fermentation and aging at various temperature conditions ensured the stability of the product during storage and improved organoleptic properties.

2. The regression analysis revealed that the addition of berries significantly increased the antioxidant activity of the product by 25–40 %, and also improved digestibility by up to 96 %. This is explained by the presence of dietary fiber and vitamins in berries, which help improve metabolic processes. The greatest improvements were recorded in curds with the addition of chokeberry and raspberry, which emphasizes their high functional value for children's nutrition.

3. The results of the sensory analysis showed that curds with the addition of raspberries and strawberries received the highest ratings among children for such indicators as taste, aroma, and texture. In particular, raspberries turned out to be the most attractive additive, receiving scores of 4.9 for taste, aroma, and texture, as well as 5.0 for the overall impression. These data indicate the high consumer appeal of sheep's milk-based products with berries.

4. Compared with traditional cow's milk-based curds, sheep's milk curds showed better results in terms of nutritional value (18–22 g protein, 7.00 g fat) and antioxidant activity. The introduction of probiotics and inulin additionally improved the prebiotic properties of the products, which helps maintain healthy intestinal microflora in children. Thus, the developed curds have increased functional and nutritional value, which confirms their potential for baby food.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study, as well as the results reported in this paper.

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Data availability

The data will be provided upon reasonable request.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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