Evaluation of quality indicators of fermented milk product based on sheep's milk enriched with vegetable ingredients

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Abstract. The purpose of this study is a comprehensive assessment of the quality of yogurt enriched with vegetable ingredients. The object of research is a fermented milk product, the main ingredient of the formulation is sheep's milk. The unique composition of sheep's milk makes it a promising raw material for obtaining food products with high biological and nutritional value. Milk thistle meal, ground walnut and chokeberry syrup were selected as vegetable fortifiers for the yogurt under study. Experimental studies were conducted in the Don State Agrarian University. Traditional yogurt based on cow's milk without fillers was selected as control samples. When analyzing the results of studies of the fatty acid composition of the samples of the fermented milk product, it was revealed that the prototype in terms of the content of some fatty acids exceeds the values of the control, due to the replacement of cow's milk and the introduction of vegetable ingredients. The study assessed the quality indicators of yogurt samples, such as organoleptic, physico-chemical, biochemical and microbiological. Based on the results obtained, it can be concluded that it is advisable to enrich the fermented milk product with vegetable ingredients.

1. Introduction

Recently, consumers have been forming an increased demand for quality food products. The quality of food is characterized as a set of properties that determine its suitability to meet certain needs in accordance with its purpose. Quality control of manufactured products is a process of obtaining and processing information about the object of research in order to determine and find its parameters within the required limits [1, 2]. Medical studies conducted by researchers in Russia in recent years have shown that, on the one hand, there is a decrease in the consumption of food sources of energy and protein in the diet of the population, on the other hand, against the prevailing nutritional background, many people are obese, which is a consequence of metabolic disorders. Consequently, the optimization of the population's nutrition structure is inextricably linked with an increase in the production of mass-consumption products with high nutritional and biological value, including those enriched with high-quality protein, vitamins and minerals [3, 4]. As a rule, the technological process of production of any
fermented milk product, including yogurt, is controlled by organoleptic, physico-chemical, biochemical and microbiological indicators [5]. Organoleptic indicators are the main characteristics of consumer properties of food products, which are determined using the human senses. The main organoleptic indicators for fermented milk products are: appearance, taste and smell, consistency. The basis for the examination of the quality of fermented milk is the determination of physico-chemical indicators. These include temperature characteristics, the mass fraction of fat, protein and moisture. Biochemical methods are based on biochemical processes. As a rule, these methods are used to control the quality of raw materials used for production, as well as to assess the nutritional and biological value of products. Microbiological methods are based on the vital activity of microorganisms. These methods are used to control the quality of raw materials, to control technological processes, technological hygiene of equipment and finished products [6]. Guided by the above approaches, we have identified the area of our interests as the development of high-quality and healthy for human nutrition fermented milk products based on sheep's milk. Thus, the purpose of this study is a comprehensive assessment of the quality indicators of yogurt made from sheep's milk, enriched with vegetable ingredients, prepared according to the recipe developed by us.

2. Materials and methods
Most authors mainly use raw materials of animal and vegetable origin when developing the formulation of preventive products as a source of vitamins, protein and minerals, fats and carbohydrates. In some cases, a natural food component is used as a raw material, in others, the raw materials are enriched with special additives [7, 8].

The main ingredient in the formulation of the studied yogurt is sheep's milk. The unique composition of sheep's milk makes it a promising raw material for obtaining food products with high biological and nutritional value, with biologically active components that provide benefits to human health, since it contains 1.4 times more dry matter and 1.7 times more protein in its composition compared to cow's milk.

Milk thistle meal, ground walnut and chokeberry syrup were selected as vegetable fortifiers for the studied yogurt. Each of the listed vegetable ingredients contains a range of useful nutrients necessary for the normal functioning of the human body.

Experimental studies were conducted at the Department of Food Technology and Commodity Science of the Don State Agrarian University. Traditional yogurt based on cow's milk without fillers was selected as control sample, and yogurt based on sheep's milk enriched with vegetable ingredients was selected as experimental sample.

To implement the set tasks for the assessment of quality indicators, studies were conducted on the basis of standard and generally accepted methods:
- acceptance, sampling, preparation for the study – the State Standards GOST 3622-68, GOST 26809.1-2014;
- organoleptic indicators - the State Standard GOST ISO 5492-2014;
- mass fraction of fat - the State Standard GOST 5867-90;
- mass fraction of protein - the State Standard GOST 23327-98;
- mass fraction of dry skimmed milk residue - the State Standard GOST R 54668-2011;
- phosphatase or peroxidase - the State Standard GOST 3623-2015;
- titrated acidity - the State Standard GOST 3624-92;
- microbiological indicators - the State Standards GOST 10444.11-2013 (ISO 15214:1998), GOST 10444.12-2013 GOST 30347-2016, GOST 31659-2012 (ISO 6579:2002);
- mass fraction of fatty acids - the State Standard GOST 32915-2014, methodical instructions MU 4.1./4.2.2484-09. The triglycerides of fatty acids isolated from the samples were converted into methyl esters and the resulting mixture was analyzed on a chromatograph "Chromatek-Crystal 5000". The results were compared with the normative indicators presented in attachment A of the State Standard GOST R 52253-2004.

At the final stage of the experiment, an organoleptic analysis of the studied yogurt was carried out
using a quantitative descriptive method of analytical evaluation. Statistical processing was performed using the Microsoft Office 2013 software package (Microsoft, USA) and the Statistica7 application software package.

3. Results and discussions

The yogurt was produced by a thermostatic method, the sourdough was added individually to each container after bottling, the fermented clot was not mixed, which made it possible to achieve a denser structure of the product. Since the fermentation process is the most vulnerable stage of the technological process, the introduction of prepared plant components was carried out before pasteurization, in order to avoid bacterial contamination. At the initial stage, in accordance with the set goal, the organoleptic indicators of the control and experimental yogurt samples were evaluated according to the State Standard GOST 31981-2013 "Yogurts. General technical conditions", the results of which are presented in Table 1.

Table 1. Organoleptic quality indicators of control and experimental yogurt samples.

| Indicator                        | Control sample                              | Experimental sample                        |
|----------------------------------|---------------------------------------------|--------------------------------------------|
| Consistency and appearance       | Homogeneous, with a broken clot moderately viscous | Homogeneous, with a broken clot moderately viscous. The presence of inclusions of insoluble particles characteristic of the introduced components is visible |
| Taste and smell                  | Pure, fermented milk, without foreign tastes and odors | Pure, fermented milk, with the appropriate taste and aroma of the added components |
| Colour                           | Milky white                                 | Milk-cream                                 |

In terms of consistency, both samples were characterized by uniformity, and in appearance, the experimental sample was distinguished by the presence of inclusions of milk thistle meal and walnut. According to the taste range, the control sample can be characterized as having a characteristic pure, fermented milk flavor, the experimental sample is characterized by a fermented milk taste with a nutty flavor. The color of the control sample is marked as milky white, uniform throughout the mass, and the experimental sample is milk-cream.

Thus, the introduction of vegetable ingredients in the formula of the fermented milk product contributed to the appearance of a pleasant, harmonious taste and smell characteristic of the ingredients introduced.

The next stage was the evaluation of the physico-chemical quality indicators of yogurt samples, which are shown in Table 2.

Table 2. Physico-chemical parameters of samples.

| Indicator                          | State Standard GOST31981-2013 | Control sample | Experimental sample |
|------------------------------------|-------------------------------|----------------|---------------------|
| Mass fraction of fat, %            | 0.5-10.0                      | 2.5 ± 0.10     | 2.5 ± 0.13          |
| Mass fraction of protein, %        | 2.8-3.2                       | 3.1 ± 0.10     | 2.8 ± 0.10          |
| Mass fraction of dry skimmed milk residue, % | 8.5-9.5                      | 8.7 ± 0.10     | 9.4 ± 0.10          |
| Acidity, ° T                       | 75-140                        | 80 ± 0.10      | 85 ± 0.10           |
| Phosphatase or peroxidase          | lack of                       | -              | -                   |

The obtained values of physico-chemical indicators of the samples correspond to the requirements of the State Standard GOST 31981-2013 "Yoghurts. General technical conditions". Thus, the experimental
sample of the enriched fermented milk product has the most harmonious organoleptic characteristics, its titrated acidity is within the regulated limits.

At the final stage, the most important biochemical quality indicators, such as fatty acid and vitamin-mineral composition, were evaluated.

When analyzing the results of studies of the fatty acid composition of samples of fermented milk product (Table 3) it was found that the experimental sample in terms of the content of some fatty acids exceeds the values of the control sample. This, in our opinion, was the result of the use of a different dairy component instead of cow's milk and the introduction of vegetable ingredients.

**Table 3. Fatty acid composition of samples, %.

| Name of the fatty acid | Acceptable levels | Control sample | Experimental sample | Error rate (+/-) |
|------------------------|-------------------|----------------|---------------------|-----------------|
| **Saturated fatty acids** |                   |                |                     |                 |
| Butyric C4:0          | 2.0-4.2           | 2.4            | 1.0                 | 0.40            |
| Caproic C6:0          | 1.5-30            | 1.8            | 0.7                 | 0.40            |
| Caprylic C8:0         | 1.0-2.0           | 1.2            | 0.5                 | 0.40            |
| Capric C10:0          | 2.0-3.5           | 2.8            | 1.0                 | 0.40            |
| Lauric C12:0          | 2.0-4.0           | 3.2            | 1.2                 | 0.40            |
| Myristic C14:0        | 8.0-13.0          | 9.9            | 3.8                 | 0.40            |
| Palmitic C16:0        | 22.0-33.0         | 29.9           | 15.4                | 2.20            |
| Stearic C18:0         | 9.0-13.0          | 10.7           | 5.6                 | 2.20            |
| Begenic C22:0         | до 0.1            | 0.1            | 0.1                 | 2.2             |
| Arachinic C20:0       | до 0.3            | 0.2            | 0.3                 | 0.40            |
| **Monounsaturated fatty acids** |                     |                |                     |                 |
| Decenic C10:1         | 0.2-0.4           | 0.3            | 0.1                 | 0.40            |
| Myristoleic C14:1     | 0.6-1.5           | 1.4            | 0.5                 | 0.40            |
| Palmitoleic C16:1     | 1.5-2.0           | 1.3            | 0.5                 | 0.40            |
| Oleic C18:1           | 22.0-32.0         | 27.5           | 24.1                | 2.20            |
| **Polyunsaturated fatty acids** |                   |                |                     |                 |
| Linoleic C18:2        | 3.0-5.5           | 3.0            | 36.8                | 0.40            |
| Linolenic C18:3       | до 1.5            | 0.2            | 0.7                 | 0.40            |

Caprylic and capric acids together with butyric and caproic acids determine the organoleptic characteristics and quality of the finished dairy product under storage conditions.

The content of butyric acid in the control sample is at the level of 2.4%, in the experimental - 1.0%. No less important is caproic acid, it is contained in the control sample in an amount of 1.8%, and in the experimental - 0.7%.

The content of caprylic and capric acid in the control sample is 1.2% and 2.8%, respectively. In the experimental sample, the content of caprylic and capric acid is 0.5% and 1.0%, respectively.

One of the criteria for the naturalness of milk fat is the presence of decenic acid in its fatty acid composition. It is a minor component of milk fat, but its presence is mandatory. The content of decenic acid in the experimental sample ranges from 0.1%, in the control sample - 0.3%.

Methodical instructions MU 4.1.4.2.2484-09 sets the content of lauric acid in milk fat in the range from 2.0 to 4.4%. According to the data, the experimental sample of lauric acid contains 1.2%, and the control sample contains 3.2%.

The content of myristic acid, as well as lauric acid, characterizes the naturalness of milk fat. The range of its content in accordance with the requirements of MU 4.1.4.2.2484-09 should be 8.0-13.0% of the total of fatty acids. The data obtained indicate that the content of myristic acid in the experimental sample is relatively low – 3.8%. Its amount is reduced by the addition of vegetable additives, and hence other fats, since the proportion of any of the fatty acids in milk fat is related with to the content of other fatty acids that make up its composition. In the control sample, myristic acid is in the amount of 9.9%.
In accordance with the requirements of MU 4.1./4.2.2484-09, the content of myristoleic acid in milk fat should be within 0.6-1.6% of the total of fatty acids. In terms of the content of myristoleic acid, both samples meet the requirements of regulatory documentation. In the control sample it is 1.4%, and in the experimental sample it is 0.5%. According to the data obtained, the content of palmitic acid in the fat of the studied dairy products is equal to 15.4% in the experimental sample and 29.9% in the control. The content of palmitinoleic acid in the experimental sample varies within 0.5%, and in the control sample – 1.3%.

No less important as a fatty acid composition is the role of saturated milk fat acid – stearic acid. Stearic acid, together with other saturated acids, is responsible for the formation of the texture of finished dairy products made on the basis of milk fat. Its content in the experimental and control samples is 5.6% and 10.7%, respectively.

Oleic and linoleic acids are referred to the category of particularly important unsaturated milk fat acids. Their content generally determines the qualitative characteristics of finished dairy products. The content of oleic acid in the experimental and control samples is 24.1% and 27.5%, respectively. The content of linoleic acid, an essential polyunsaturated acid, in the experimental sample is 36.8%, and in the control sample – 3.0%. The composition of the product includes another essential polyunsaturated acid - linolenic acid. In the experimental sample, it is contained in an amount of 0.7%, in the control sample – 0.1%. Thus, the obtained values of fatty acids in the experimental sample compared the requirements, but differ significantly from their content level in the control sample, forming a higher-quality fatty acid composition.

The results of the study of the vitamin and mineral composition of the samples of the fermented milk product are presented in Table 4.

| Indicator      | Control sample | Experimental sample |
|----------------|----------------|---------------------|
| Vitamin A      | 0.046          | 0.37                |
| Beta-carotene  | 0.007          | 0.39                |
| Vitamin E      | 0.1            | 0.67                |
| Vitamin K      | 0.0003         | 0.11                |
| Vitamin B₁     | -              | 0.03                |
| Vitamin B₂     | 0.2            | 0.22                |
| Vitamin B₃     | 0.2            | 0.2                 |
| Vitamin B₄     | 14.3           | 15.9                |
| Vitamin B₅     | 0.4            | 0.43                |
| Vitamin B₆     | 0.005          | 3.09                |
| Vitamin B₁₂    | 0.0005         | 0.0005              |
| Vitamin C      | -              | 0.23                |
| Magnesium      | 15.0           | 31.8                |
| Zinc           | 0.4            | 1.2                 |
| Selenium       | 0.002          | 0.025               |
| Copper         | 0.01           | 0.03                |

The analysis of the results showed that when vegetable ingredients were added, the amount of vitamins increased: A by 0.324 mg, E by 0.57 mg, K by 0.11mg, B₉ by 3.085mg, beta-carotene by 0.383 mg, and the experimental sample is characterized by the presence of vitamins such as B₁ and C.

The analysis also showed that in comparison with the control sample, the experimental sample contains more minerals, for example, the control sample contains 15 mg of magnesium, and the experimental sample contains 61.8 mg. Zinc is contained in the control sample in an amount of 0.4 mg, and in the experimental sample – 1.21 mg. The silene in the experimental sample is contained in an amount of 0.025 mg, which is 0.023 mg more than in the control, and copper in an amount of 0.03 mg.
which is 0.02 mg more than the control.

The results of the studied microbiological parameters of the fermented milk product samples are shown in Table 5.

| Indicator | The value of the indicator according to Technical Regulations of the Customs Union TR CU 033/2013 | Actual value |
|-----------|------------------------------------------------------------------------------------------------|--------------|
| Lactic acid microorganisms, CFU/cm³ (g), not less | 1 × 10⁷ | 1.6 × 10⁷ | 1.6 × 10⁷ |
| Yeast, CFU/cm³ (g), no more | 50 | 20 | 35 |
| Mold, CFU/cm³ (g), no more | 50 | 25 | 30 |
| The amount of E. coli group bacteria (coliform), in 0.1g | Not detected | Not detected | Not detected |

According to the requirements of the Technical Regulations of the Customs Union TR CU "On the safety of milk and dairy products", the value of lactic acid microorganisms in the product should be at least 1 × 10⁷ CFU/cm³ (g), the data of the study results showed that both samples meet the requirements.

The yeast and mold content in the control sample is 20 CFU/cm³ (g) and 25 CFU/cm³ (g), respectively, and the experimental sample is 35 CFU/cm³ (g) and 30 CFU/cm³ (g). Both samples in terms of yeast and mold content correspond the requirements of the regulations.

Pathogenic microorganisms, such as bacteria of the E. coli group, were not found in the samples of fermented milk products.

4. Conclusion

Thus, in the course of the study, the quality indicators of yogurt samples, such as organoleptic, physico-chemical, biochemical and microbiological, were evaluated. Based on the results obtained, it can be concluded that it is advisable to use sheep's milk as the main composite and enrich the fermented milk product with vegetable ingredients.

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