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EFFECT OF ENTEROSORBING DIETARY FIBERS ON THE QUALITY AND SAFETY OF FERMENTED MILK PRODUCTS

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This paper considers the possibility of using rice husks as enterosorbing fibers in the production of fermented milk products. The results of studying the fermented milk product using L. diacetylactis, L. bulgaricus, and Bacteriumbifidum microflora with the introduction of enterosorbing dietary fibers (ESDF) are reported. The technology of processing and preparation for the introduction of rice husks is described. Rice husks were studied for different particle sizes, the optimal option in the form of powder was selected. The behavior, influence on the shelf life, and viability of lactic acid bacteria in the finished product were investigated. The study of the chemical composition showed that in the examined samples the protein content increased by 25 %, carbohydrates – by 1.6 %, and dry matter – by 18 %; the content of dietary fiber (2.3 g) is 9 % of the daily value. An organoleptic assessment was also analyzed, based on which it was revealed that the rational dose of rice husks is 12 %. The dose of ESDF introduction varied from 0 to 5 %, in increments of 1 %. The optimization method revealed the area of the optimum, based on which repeated studies of the fermented milk product, produced according to the optimal formulation, were carried out. To assess safety, such indicators as QMAFAnM (the quantity of mesophilic aerobic and facultative anaerobic microorganisms), titrated acidity and pH, as well as the content of heavy metals in the resulting samples were investigated. Enriching the fermented milk product with dietary fiber has made it possible to obtain a product with higher organoleptic properties and increased nutritional value while maintaining the consumer properties of the product

Keywords: fermented milk product, rice husks, lactic acid bacteria, shelf life, safety

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1. Introduction

Given the rapid pace of life and environmental concerns, the importance of functional food products has been increasingly recognized in recent years [1].

The trend of expanding the range of functional products opens up a wide range of added ingredients. The composition of products includes enzymes, polyphenols, drugs, etc. In different cultures, prevention and therapy against viruses are traditionally based on the combination of several functional foods and nutraceuticals with active immunomodulators, polyphenols, and anti-inflammatory and antioxidant components. Among such components, probiotics have become widespread, which have proven to be useful components of functional foods [2]. Accordingly, nutrition should include not only the consumption of proteins, fats, and vitamins as the main macronutrients but also a sufficient amount of dietary fiber. It is worth noting that this component is not produced by the human body on its own, so it is necessary to include foods rich in dietary fiber in the diet. The recommended daily intake is 25 g [3]. At least half of them should be coarse dietary fiber (cellulose, hemicellulose, lignin), and the second half of the daily norm should come in the form of soft dietary fiber (pectins, gums, mucus) [4].

Dietary fiber is made up of plant-based carbohydrates that cannot be metabolized by digestive enzymes encoded in the human genome, such as amylase. Instead, fiber can only be metabolized by certain types of gut microbiota through anaerobic fermentation [5].

Enterosorption is a very promising method of removing toxins of various nature both in emergencies and in planned detoxification of the body. This is a simple and effective method of cleansing the body with sorbents, used in the prevention and treatment of certain diseases, poisoning, correction of pathological conditions associated with endoprosthesis, and exotoxicosis [6, 7].

It was shown that the introduction of enterosorbents led to a decrease in the manifestations of oxidative stress and a partial restoration of the native molecular conformation of serum albumin [8].

The inclusion of enterosorbents in anti-inflammatory therapy increases the effectiveness of treatment of patients with the chronic obstructive pulmonary disease during an exacerbation [9]. Restorative pathogenetic therapy in patients with opisthorchiasis (liver and biliary tract disease) with the inclusion of enterosorbent in the treatment protocol made it possible to achieve a significant improvement in the patient's condition [10]. Studies reported in [11] show the possibility of using biopolymer (chitosan) and inorganic (silica) components as hybrid enterosorbents for binding bile salts.

Therefore, the use of enterosorbents in the technology of fermented milk products to improve their functional properties is of interest. One of the sources of enterosorbents is rice husks – waste obtained in significant volumes during rice processing in Republic of Kazakhstan. Hence, it follows that it is relevant to study the possibility of introducing rice husks into food products, namely as enterosorbent fibers. Thus, one can obtain a product of therapeutic and prophylactic action.

2. Literature review and problem statement

With the deepening of research, other functions of dietary fiber have been discovered, including reducing the toxicity of heavy metals, and the risk of cardiovascular and female diseases [12]. In this review, it remains an unsolved task to determine the optimal dosage and type of dietary fiber in the prevention of diseases, as well as to determine their optimal intake. That is why the therapeutic and prophylactic (including immunotropic) properties of live cultures of lacto- and bifidobacterial (probiotics) and dietary fiber (prebiotics) are considered today in the inseparable context of the restoration of intestinal eubiosis. That led to the development and intensive research of a new promising class of products that combine both pre- and probiotics and called synbiotics. And, as the results of studies show, synbiotics in many cases are much more effective compared to pre- or probiotics used separately. Moreover, the increase in efficiency is achieved not due to a simple cumulative effect but due to a complex synergistic interaction [13, 14]. In [14], the addition of amaranth flour to yogurt had an undesirable effect on consistency, increased syneresis and general acidity during storage. In addition, amaranth products are allergenic. Probiotics have antimicrobial properties and can suppress various pathogens, such as *EschericEscherichia ColilStaphylococcus aureusllasonnei*, *Shigellaflexneri*, *Campylobacterjejuni* and *Salmonellatyphimurium* [15].

Research, supplementing dairy formulations with dietary fiber, plant polysaccharides, starter cultures, vitamins, antioxidants, is the main approach when creating functional foods. Studies of daily consumption of fermented milk have shown that fermented milk has a positive effect on cellular immune function and oxidative stress [16]. Probiotic yogurt provided a significant source of bioavailable protein but, for improved nutrient intake, dietary fiber can help.

When processing rice in large volumes, rice husks (about 30 %) are obtained, which are not used and are discarded as waste. In Kazakhstan, rice is produced in large volumes, the main rice growing regions are Kyzylorda (78.4 thousand hectares), Almaty (11.1 thousand hectares), and Turkestan (3 thousand hectares). According to the Ministry of Agriculture of the Republic of Kazakhstan, in 2020 alone, 199.4 thousand tons of processed rice were produced in Kazakhstan. In this regard, there is a problem with processing secondary raw materials from rice production.

Rice husks contain 60–80 % of organic substances such as cellulose, hemicellulose (mainly pentosans), lignin, a small amount of protein, fat, vitamins, and minerals [17, 18]. In the composition of dry substances of rice husks there are organic acids: acetic, citric, fumaric, malic, oxalic, succinic, as well as aromatic acids and amino acids. Depending on the isolation technique, about 20 % of amorphous silicon can be obtained from rice husks [19, 20]. These studies consider a wide market for spent husks and ashes but did not consider the possibility of using rice husks as a plant additive in food.

Rice husk is a fibrous substance that contains moisture, lignin, cellulose, pentosans, a small amount of protein, vitamins, and minerals in the amount of 10–20 %, consisting of 92–97 % of silicon dioxide. The content of dietary fiber in rice husks is 78 % [21]. In the cited work, the authors used rice husks to manufacture flour products; in therapeutic and prophylactic nutrition, greater preference is given to dairy and fermented milk products.

Interestingly, rice husks differ in their chemical composition from all other cereals, primarily by the high content of amorphous silicon dioxide in straw and husks [22]. Silicon refers to conditionally essential trace elements and performs several important functions in the human body; the development of its deficiency is fraught with very unpleasant consequences. The most studied function of silicon is its participation in the synthesis of collagen. With silicon deficiency, the formation of connective tissue, including the organic skeleton of bones, is disturbed [23].

As can be seen from the review, the trend is the association of food intake with the prevention of gastrointestinal diseases. As can be seen from the review of sources [13–16], the introduction of plant components into fermented milk products is safe; an important task is to determine the optimal dose and type of dietary fiber. In addition, based on the analysis of works [19–23], it can be seen that rice husks are an attractive raw material for enriching the body with dietary fiber, silicon, and organic acids. However, its use to expand the range of products in therapeutic and prophylactic nutrition has not been studied in sufficient volume. In this regard, it seems appropriate to conduct a study to identify the effect of rice husks on the quality and safety of the fermented milk product.

3. The aim and objectives of the study

The purpose of this study is to identify the effect of enterosorbing dietary fiber (ESDF) on the quality and safety of fermented milk products. This will provide an opportunity to expand the range of products of functional orientation, which can help in the work of the gastrointestinal tract and reduce the level of heavy metals and aflatoxins in the human body.

To accomplish the aim, the following tasks have been set:

– to investigate the qualitative characteristics of the fermented milk product with ESDF in the process of maturation and storage;

– to determine the rational doses of the introduction of ESDF into the fermented milk product;

– to study the impact of ESDF on the safety indicators of the product;

– to conduct an organoleptic evaluation of the finished product.

4. The study materials and methods

4. 1. This study's object and research base

The object of this study was enterosorbing dietary fibers of pre-prepared powder from rice husks; a fermented milk product from cow's milk, with the introduction of enterosorbing dietary fiber.

In this experiment, cow's milk was used, which was obtained from local traders. The milk had an approximate composition: 3.2 % protein, 3.5 % fat, and 4.6 % carbohydrates. Other components were 1 % (w/w) sucrose (Central Asian Sugar Corporation LLP) and a yogurt starter culture containing *Lac. diacetylactis*, *Lactobacteriumbulgaricus*, and *Bacteriumbifidum* (1:1:1).

The main hypothesis of the study assumed that the use of rice husks as a plant additive in a fermented milk product can provide specified indicators of consistency, taste, and safety of the product.

ESDF was administered in different doses and different fractions. Particle sizes introduced into the fermented milk product varied between $30{\cdot}10^{-3}$ and $10{\cdot}10^{-3}$ cm.

Experimental studies were conducted at the "Research Laboratory for Assessing the Quality and Safety of Food Products", JSC "Almaty Technological University", the "Institute of Combustion Problems" (Republic of Kazakhstan).

4. 2. Preparation of enterosorbing dietary fiber for application

Rice husks were selected in the Almaty region (Republic of Kazakhstan) at the rice processing plant of Magzhan and K LLP. Rice husks were washed first with tap water, then with distilled water to remove dirt and dust.

To the washed and dried rice husks, 5 % of nitric acid is poured in a ratio of 1:3, they are placed in a 3-liter measuring cup, and stirred with a glass stick, the solution is then left for 12 hours. We boiled it at a temperature of 75–85 °C for 3 hours, cooled it to room temperature, and washed it.

Next, the rice husks are subjected to alkalinization. As part of the study, 100 g of rice husks were boiled in 1 liter of 8 % sodium hydroxide NaOH for 40 minutes; this procedure was carried out until the solution was clarified. Then we washed the rice husks with distilled water in a neutral medium. Rice husks were dried in a muffle oven (PDP-LAB, Tomyanalit) for 4 hours at a temperature of 90 °C (until the water evaporated completely).

Rice husks crushed in a laboratory mill (Grindomix, GM 200, Germany) with a particle size in the range of $30{\cdot}10^{-3}$–$10{\cdot}10^{-3}$ cm were used to be applied to the test sample.

Fig. 1 shows the rice husks and powder prepared for application to a fermented milk product.

a *b*

Fig. 1. Enterosorbing dietary fiber: *a* — rice husks; *b* — prepared enterosorbent from rice husks

Milk: 1 – heat treatment of milk, 90 °C/15 min, 2 – addition of sugar (1 %), 3 – cooling to fermentation temperature of 45 °C, 4 – addition of yogurt starter culture, 5 – addition of ESDF (1, 2, or 3 %), 6 – fermentation phase at 45 °C 6 h.

The results were presented as the average ±SD for three-time analyses of each quality from the processing repeats.

The total dry matter content was determined by the standard method of drying the sample at a temperature of (102±3) °C for 7 hours.

The fat content was determined by Gerber's acid method in accordance with ISO 488:2008.

The protein content was determined by the Kjeldahl method from the mineralization of the sample and subsequent distillation.

The carbohydrate content was determined in accordance with ISO 5548:2004.

Active acidity was measured at the pH meter Testo-206 (TestoSE & Co.KGaA, Germany).

The content of heavy metals was determined by atomic absorption spectrometry (AAS) on the device "QUANTUM-Z. ETA" (Kortek).

A method for determining the quantity of mesophilic aerobic and facultative anaerobic microorganisms (QMAFAnM), based on the counting of QMAFAnM colonies growing on a solid culture medium QMAFAnM at a temperature of (30±1) °C for 72 hours.

The method for determining the bacteria of the *Escherichia coli* group is based on the ability of *Escherichia coli* to ferment lactose on a nutrient medium with the formation of gas and acid at a temperature of (37±1) °C for 24 hours.

The method for determining yeast and mold fungi is based on the ability of yeast and mold fungi to form separate colonies after 3–5 days at a temperature of (24±1) °C.

Sensory analysis was performed in accordance with ISO 11036:2020.

Statistical processing was performed according to [24].

The factors that most affect the quality indicators and organoleptic properties are particle size (*r*, μm) and the dose of application (*D*, %) of rice husks. The method of descriptive statistics reveals that all factors obey the law of normal distribution. At each point, 3 parallel experiments were conducted ($p>0.05$). The model was obtained using correlation-regression analysis. The dose of application (*D*, %) varied in the range of 1–5 % in increments of 1, the particle sizes (*r*, μm) varied in the range of 50–3000 μm. The response surfaces obtained from the regression analysis were optimized to construct the response surfaces of the desirability function.

For the organoleptic characteristics of the fermented milk product with ESDF, an extended tasting board was assembled from tasters, as well as technologists – dairy industry workers, a standard five-point evaluation system was used, including the main organoleptic indicators: appearance, color, smell, taste, and consistency. The total score was based on the sum of all assessments of organoleptic indicators (25 points).

The primary consumer assessment is formed mainly by the color and smell of the product. The color of milk is determined by the stability of the water-protein-fat emulsion, depending on the original color of the raw material (raw milk), fat content, milk powder, stabilizers, for example, starch, and changes during the technological processing.

All indicators of the score evaluation by tasters were summed up to derive averages for all organoleptic indicators.

Currently, there are instrumental methods for assessing the organoleptic parameters of milk – the "electronic nose", for determining color by computer colorimetry, which are more objective, but in these studies, preference was given to the opinion of experts in the dairy industry. After all, the ultimate goal of developing new functional products is the introduction at dairy enterprises and implementation for the consumption of the population.

5. Results of studying the enterosorbing dietary fiber and the developed fermented milk product

5. 1. Qualitative characteristics of fermented milk product with ESDF in the process of maturation and storage

The main effect of dietary fibers is determined by the process of enterosorption, i. e., they can bind exogenous and endogenous substances in the gastrointestinal tract (GIT) by adsorption. At the same time, the enterosorbent does not enter a chemical reaction with the sorbed substance and does not cause biochemical changes in the blood. At the same time, the process of intoxication of the body takes place.

For the study of the safety and possible use of ESDF as an additive to the fermented milk product, the content of heavy metals was determined (Table 1).

Table 1

Heavy metal content in ESDF

Indicator name	Actual results, mg/kg
Cd	0.12±0.002
As	0.05±0.002
Pb	0.5±0.002
Zn	2.79±0.002

The results of the research proved the safety of ESDF since the content of heavy metals is within the permissible norm, according to the Technical Regulations of the Customs Union TR CU 021-2011 "On the safety of food products".

Microbiological studies (presence of BHEC, yeast, and mold) have not detected BHEC, molds, or fungi in ESDF.

These data showed that by adding rice husks, it is possible to obtain and develop safe fermented milk products.

5. 2. Determining rational doses of enterosorbing dietary fiber in a fermented milk product

Fig. 2 shows the dependence of the color of the fermented milk product on the introduction of ESDF. When adding a greater percentage of the dose of ESDF, the results of the correlation analysis revealed a close negative relationship. At the same time, the smaller the ESDF, the more uniform the color.

The following regression formulas were derived:

$$Color=-0.4936+1.6228*r-0.3058*D-0.382r^2+0.0141rD+0.0186*D^2, \quad (1)$$

$$consistency=5+0.0034*r+0.4915*D+0.0002*r*D-0.5D^2, \quad (2)$$

$$taste,\ point=-0.6447+1.6034*r-0.0047*D-0.376r^2-0.0171*rD-0.0298*D^2. \quad (3)$$

Thus, as the dose of ESDF increases in model systems milk-ESDF fermented milk product-ESDF, the organoleptic characteristics change: consistency, taste, the color of model systems, and not for the better.

Fig. 3 shows the dependence of consistency on the dose and size of applied ESDF.

As can be seen from Fig. 3, when the maximum amount of ESDF is applied, the fermented milk product becomes dense. In terms of particle size, the larger the ESDF particles, the less they affect the consistency of the fermented milk product.

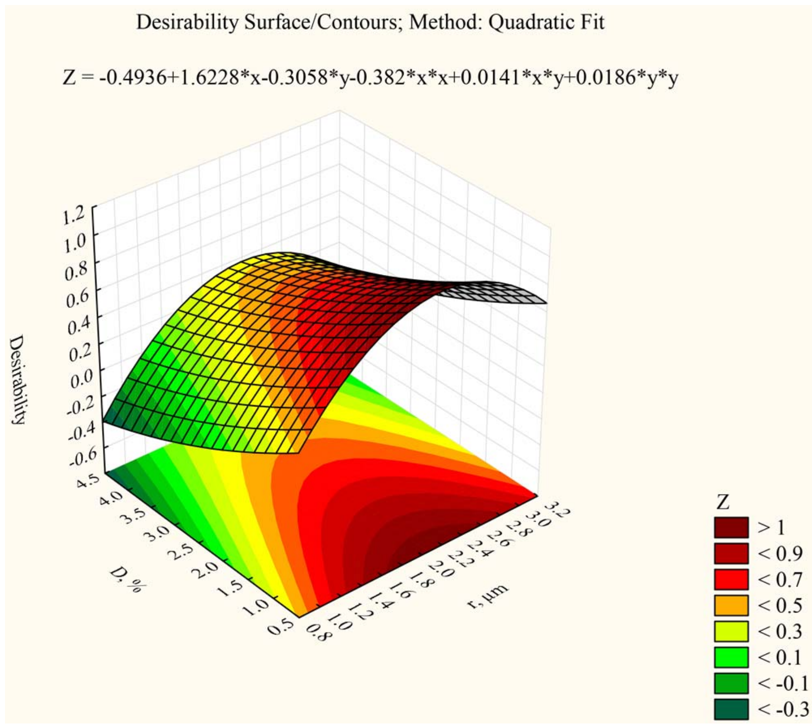

Fig. 2. Response surface of the desirability function for color depending on the dose and particle size of the introduced enterosorbing dietary fiber

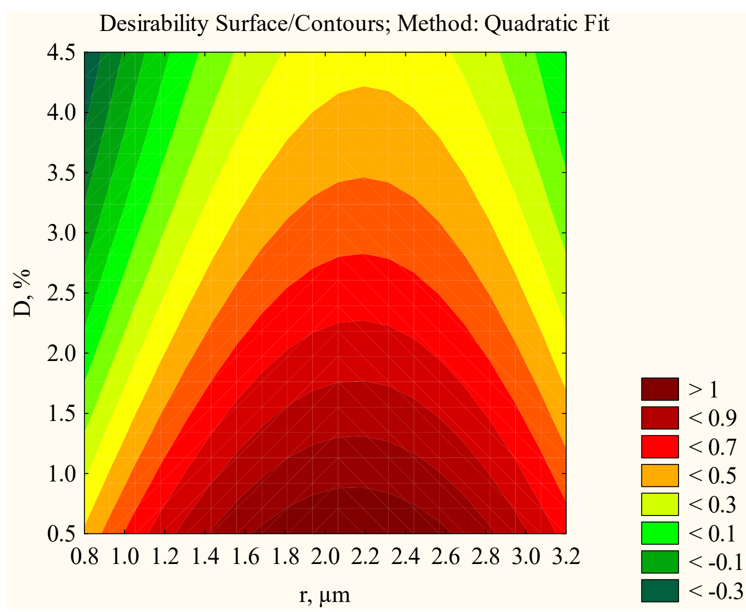

Fig. 3. Projections of cross-sections of response surfaces onto the plane r–*D* of desirability according to the consistency of the fermented milk product

5. 3. Safety indicators of fermented milk products with the introduction of enterosorbing dietary fiber

A comparison of controls and prototypes showed that the introduction of ESDF contributes to an increase in the protein content from 3.13 to 4.46 %, carbohydrates from 5.13 to 5.21 %, and most importantly, the introduction of ESDF contributed to an increase in the dry matter; while in the control sample, the dry matter volume is 12.57, in the prototypes, it increased to 14.11, 14.3, and 14.84 (1, 2, and 3 % of ESDF, respectively), which confirms the increase in the nutritional value of the developed prototypes. At the same time, the high sorption properties of ESDF lead to a decrease in the amount of fat, which must be taken into consideration during the technological processes of milk normalization.

Active acidity and pH differ slightly compared to controls, which is confirmed by the results of our microbiological studies.

The presence of toxic elements Pb, As, and Cd in prototypes was detected in the permissible norm, according to the Technical Regulations of the Customs Union TR CU 021-2011 "On the safety of food products". The physical and chemical indicators of the studied samples are given in Table 2.

Table 2

Quality indicators of finished products

Name of indicators, units of measurement	Control	1 % ESDF	2 % ESDF	3 % ESDF
Physical and chemical indicators				
Mass fraction of protein, %	3.13	3.93	4.11	4.46
Mass fraction of fat, %	3.20	3.10	3.10	3.18
Mass fraction of carbohydrates, %	5.13	5.18	5.2	5.21
Acidity, °T	110	100	106	106
pH	4.35	4.46	4.42	4.42
Dry matter, %	12.57	14.11	14.3	14.84
Heavy metals, mg/kg				
Pb	Not detected	0.06	0.01	0.02
As	Not detected	0.01	0.03	0.02
Cd	Not detected	Not detected	0.02	Not detected

In the course of our study, the conditions for the introduction of ESDF were developed. ESDF, during preparation at drying, should be dried to an equilibrium state, in the case of failure to reach a state of equilibrium, ESDF sorbs moisture from the external environment. Thus, the fermented milk product, in which ESDF was added without an equilibrium state, loses quality on the third day, as a result of which mold develops. With properly prepared ESDF, the fermented milk product is stored without loss of quality for 28 days under refrigerated conditions; the information is given in Table 3.

Table 3 demonstrates that when stored for 28 days at a temperature of ±4 °C, the fermented milk product with ESDF is stored without loss of quality and the bacteria are viable. Due to the introduction of ESDF into the composition of the fermented milk product, the proportion of proteins, fiber, etc. has increased.

Table 3

Physicochemical and microbiological parameters of fermented milk products in the process of storage

Name of indicators, units of measurement	Control			Experiment (1 % ESDF)		
	Day 0	Day 16	Day 28	Day 0	Day 16	Day 28
Mass fraction of protein, %	3.13	3.9	3.4	3.93	4.32	4.35
Mass fraction of fat, %	3.20	3.20	3.2	3.20	3.20	3.2
Mass fraction of carbohydrates, %	5.13	5.15	4.9	5.18	8.04	7.8
Mass fraction of fiber, %	0.16	0.16	0.16	0.45	0.45	0.45
Microbiological indicators						
Lactic acid microorganisms, CFU/g	$2*10^7$	$5*10^7$	$1*10^6$	$6*10^7$	$8*10^7$	$5*10^6$

5. 4. Organoleptic analysis of the finished product

The following samples were presented at the extended tasting:

a) Control.

b) Fermented milk product with 1 % ESDF.

c) Fermented milk product with 2 % ESDF.

d) Fermented milk product with 3 % ESDF.

The organoleptic assessment of the indicators of the fermented milk product with the introduction of ESDF from 1 **%** to 3 **%** provided an opportunity to obtain finished products without loss of consumer properties. According to the results of the studies, the optimal dose of application of ESDF was established, 1–3 %, which received the highest scores of tasters.

The organoleptic parameters of fermented milk products with ESDF were tasted and evaluated according to the following indicators:

– appearance and consistency – homogeneous with inclusions, with an undisturbed clot, moderately viscous;

– taste and smell – pure fermented milk with inclusions, moderately sweet;

– color – milky yellow.

The organoleptic indicators (Fig. 4) of the studied samples showed the possibility of obtaining a product while maintaining consumer attractiveness.

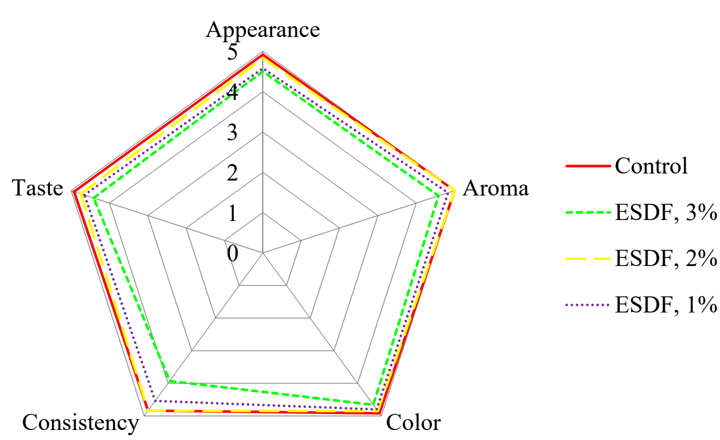

Fig. 4. Profilogram of the organoleptic parameters of fermented milk product

The data shown in Fig. 4 demonstrated that the best organoleptic parameters were characteristic of a prototype with an ESDF of 1 % and 2 %. This is because the dietary fiber in the indicated dosage is not intrusive when using the product. The Pareto diagram is shown in Fig. 5.

Fig. 6 shows a response surface that confirms that for better taste and digestibility, the experimentally established particle size should be $30 \cdot 10^{-3}$–$10 \cdot 10^{-3}$ cm, and the optimal dose of ESDF application should be within 12 %.

An extended tasting of the developed fermented milk products was held with the participation of leading scientists from Zhalyn SPTC LLP and ATU JSC. Fig. 7 shows a profilogram of the desirability function for the taste of a fermented milk product with ESDF.

Desirability profiles are an effective means of optimizing processes. Fig. 7 shows the optimal desirability profile. Fig. 7 consists of two lines of plots: the plot in the upper right corner displays the desirability function; the plots in the upper line, in addition to the desirability function, display slices of the adjusted function of the dependence of taste on the dose of ESDF and particle size when fixed at their optimal levels.

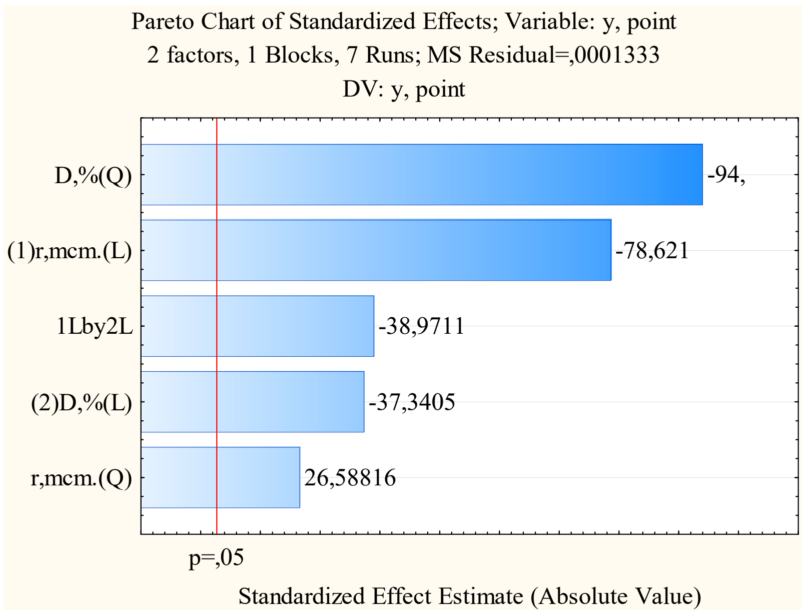

Fig. 5. Pareto diagram for assessing the quality of processed experimental results

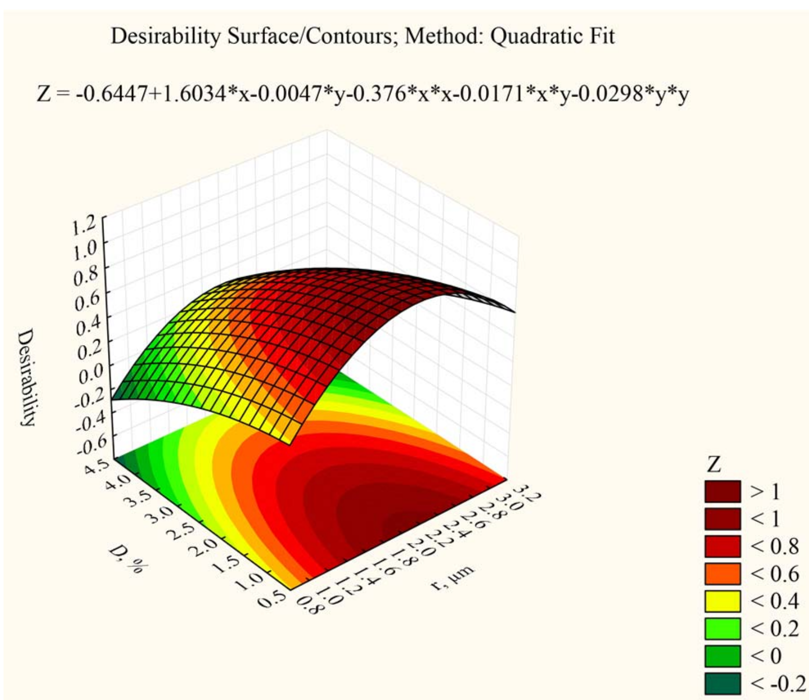

Fig. 6. The response surface of the desirability function for taste

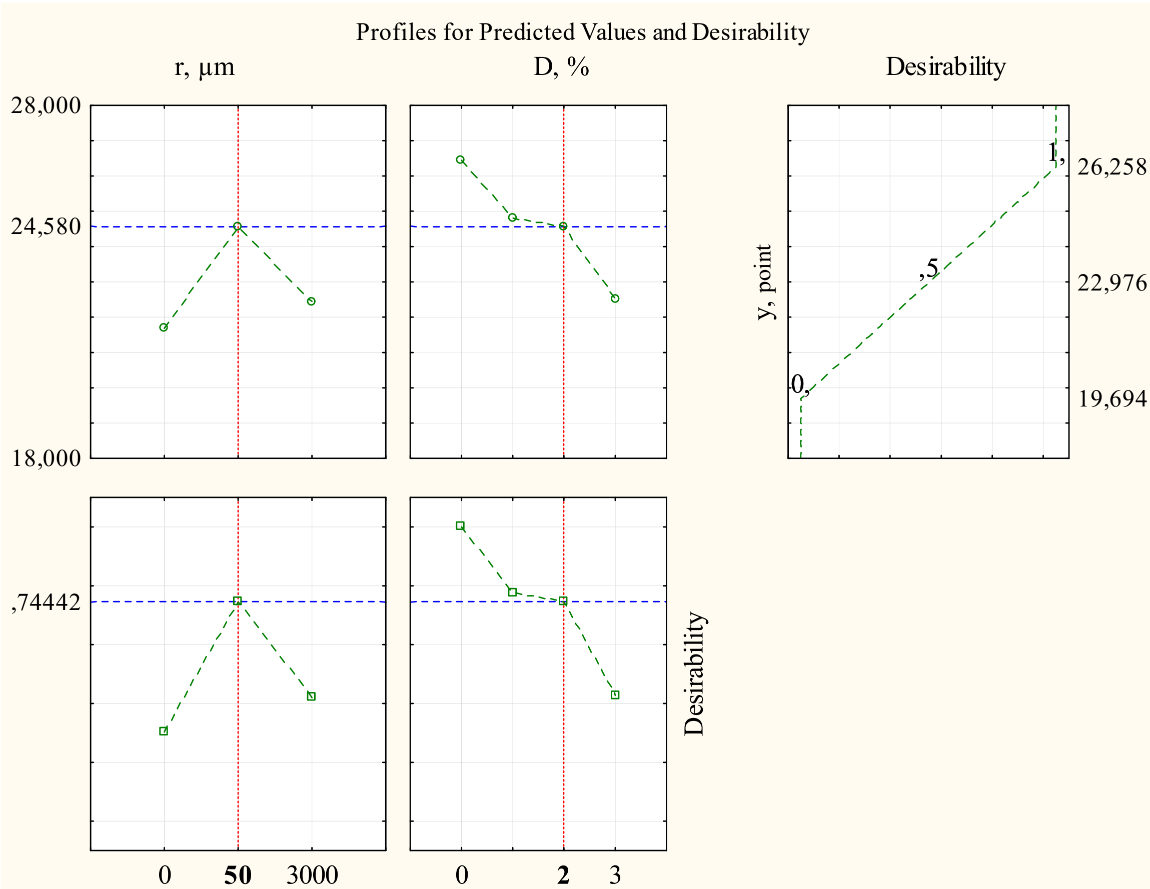

Fig. 7. Profiles of desirability function for the taste of fermented milk product with ESDF

6. Discussion of results of studying the developed fermented milk product with enterosorbing fibers

The obtained negative results of the effect of ESDF on microbiological parameters (the presence of BGCP, yeast, and mold) can be explained by the fact that ESDF were subjected to prolonged boiling, then drying. It is very important to control the full drying of ESDF since, with insufficient drying, ESDF can provoke the formation of mold in the fermented milk product on the third day of storage.

The presence of heavy metals in ESDF (Table 1) was detected in small quantities, within the permissible norm according to the Technical Regulations of the Customs Union TR CU 021-2011 “On the safety of food products”. Their presence can be explained by the ability of the plant to absorb heavy metals from the soil.

At the stage of determining the rational dose of the introduction of ESDF into a fermented milk product, special attention was paid to the consumer properties of the product (Fig. 2, 3). Initially, the dose administered correlated from 1 to 10 % but a larger amount of ESDF did not have the best effect on the taste and color of the fermented milk product. The dose of ESDF of 1–3 %, determined during the experiment, has an unobtrusive taste and a more pleasant yellow color.

Similar studies of safety indicators of fermented milk products with the introduction of ESDF and control were also carried out. Microbiological indicators for the presence of BGKP, yeast, and mold were not detected, the presence of heavy metals within the permissible norm, according to the Technical Regulations of the Customs Union TR CU 021-2011 “On the safety of food products” and TR CU033/2013 “On the safety of milk and dairy products”. Contamination of the fermented milk product with ESDF was possible from manufactured raw materials (ESDF, milk).

The results of the organoleptic evaluation of the fermented milk product with ESDF showed that when ESDF is added, the structure of the fermented milk product is compacted, as well as a close relationship was found between the applied ESDF and the color, the taste of the fermented milk product (Fig. 4–7). In addition, the choice of the rational dose of ESDF application is influenced by the particle size of the introduced ESDF. The larger the particle, the less it affects the structure and consistency of the fermented milk product (Fig. 2, 3).

Even though the introduced enterosorbent strongly correlates with the organoleptic properties of the fermented milk product, it also reduces the number of aflatoxins in milk and reduces the level of heavy metals.

A feature of this study is the use of pre-prepared rice husks in mass consumption products. From the literature [22, 23], it can be concluded about the usefulness and validity of the choice of ESDF but the effect on organoleptic parameters has not been studied; yogurt as a food product has not been considered. Sources [12–16] justify the usefulness of consuming fermented dairy products with plant components. In those works, rice husks were not considered an enterosorbent for introduction into fermented milk products. The current study examines the quality, safety, and storability of fermented milk products with ESDF.

Limitations for this study can be both raw materials for a fermented product, since the quality of the finished product is primarily affected by the quality of raw materials, and the technology of producing a fermented milk product. In addition, rice husks were prepared in different ways; an important factor is a quality of processing rice husks. With improper preparation and moisture content, the growth of mold and yeast for 3 days of storage is likely. With the correct technology for applying ESDF, the finished product is stored for up to 28 days under refrigerated conditions without loss of quality.

The disadvantage of this study is the use of cow's milk. Our plans include a study of the effect of ESDF on fermented products from combined milk. Goat's milk in many sources is marked by similarity with breast mother's milk, its usefulness is noted, and, unlike cow's milk, it does not cause allergic reactions. Since ESDF increases the amount of protein in fermented foods, it makes sense to test its effect on fermented products from goat and combined milk.

7. Conclusions

1. ESDF can be used in the production of fermented milk products, preserving consumer properties. Based on the data obtained, the safety indicators of rice husks as an enterosorbent are within the normal range, heavy metals are less than normal levels; BGKP, mold, and fungi are not detected.

2. Our studies have shown that in the process of maturation and storage of the fermented milk product, sorption processes are intensified with the active participation of even 3 % of ESDF. The content of the amount of ESDF should be reduced to 1–2 %. A study of the chemical composition showed that the introduction of ESDF into the fermented milk product increased the protein content by 25 %, carbohydrates by 1.6 %, dry matter by 18 %; and the content of dietary fiber (2.3 g) is 9 % of the daily value. Most importantly, the introduction of ESDF will expand the range of products for mass consumption in therapeutic and prophylactic nutrition.

Fermented milk products have a partially positive effect due to the stabilization of cell membranes and lysosomes, as well as the neutralization of toxic free radicals. Fermented milk product with crushed rice husks is useful in that, penetrating the intercellular space, crushed rice husks in the composition of a fermented milk product bind toxic metabolic products.

3. The studied fermented milk product with the introduction of enterosorbing dietary fiber is safe since the content of toxic metals was found within the normal range, according to the Technical Regulations of the CU. When stored under refrigerated conditions, the viability of bacteria remained stable for 28 days at 10^6 CFU/g.

4. Factors such as particle size and dose of ESDF are closely related to the resulting ones, the dose of ESDF affects both the taste and color and consistency of the fermented milk product. According to the results of the processed data of our experiment, the recommended dose of application to fermented milk products is 1–2 % ESDF from rice husks.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

References

1. Nigam, D. (2018). Probiotics as Functional Foods in Enhancing Gut Immunity. Functional Food and Human Health, 59–82. doi: https://doi.org/10.1007/978-981-13-1123-9_4
2. Alkhatib, A. (2020). Antiviral Functional Foods and Exercise Lifestyle Prevention of Coronavirus. Nutrients, 12 (9), 2633. doi: https://doi.org/10.3390/nu12092633
3. Bozhkova, S. E., Pogorelets, T. P., Gaivoronskaya, N. S., Pilipenko, D. N., Surkova, S. A. (2019). Technology of production of granulated cottage cheese with usage of dietary fiber. Agrarian-And-Food Innovations, 5 (1), 77–83. doi: https://doi.org/10.31208/2618-7353-2019-5-77-83
4. Stambekova, A. K., Elemesova, A. A., Bayakhan, A. A., Alimardanova, M. K., Petchenko, V. I., Levochkina, N. A. (2022). Development of the recipe, technology of a functional fermented milk product with dill greens and "Dzhusay." BIO Web of Conferences, 43, 03043. doi: https://doi.org/10.1051/bioconf/20224303043
5. Cronin, P., Joyce, S. A., O'Toole, P. W., O'Connor, E. M. (2021). Dietary Fibre Modulates the Gut Microbiota. Nutrients, 13 (5), 1655. doi: https://doi.org/10.3390/nu13051655
6. Oripova, M. Z., Kuzieva, Z. N., Oshchepkova, Y. I., Salikhov, S. I. (2022). Obtaining Chitosan from Artemia Cysts and Studying its Sorption Properties. Pharmaceutical Chemistry Journal, 55 (11), 1234–1239. doi: https://doi.org/10.1007/s11094-022-02563-9
7. Fatullayeva, S., Tagiyev, D., Zeynalov, N. (2021). A review on enterosorbents and their application in clinical practice: Removal of toxic metals. Colloid and Interface Science Communications, 45, 100545. doi: https://doi.org/10.1016/j.colcom.2021.100545
8. Sarnatskaya, V., Mikhailenko, V., Prokopenko, I., Gerashchenko, B. I., Shevchuk, O., Yushko, L. et. al. (2020). The effect of two formulations of carbon enterosorbents on oxidative stress indexes and molecular conformation of serum albumin in experimental animals exposed to CCl4. Heliyon, 6 (1), e03126. doi: https://doi.org/10.1016/j.heliyon.2019.e03126
9. Kucher, S. V., Lototska, O. V. (2021). Inclusion of enterosorbents in anti-inflammatory therapy improve treatment effectiveness in copd patients during exacerbations. The Ukrainian Biochemical Journal, 93 (2), 107–114. doi: https://doi.org/10.15407/ubj93.02.107
10. Tsukanov, V. V., Vasyutin, A. V., Tonkikh, J. L., Gorchilova, E. G., Rzhavicheva, O. S., Borisov, A. G. (2020). Possibilities of application of enterosorbent in combined therapy of opistorchosis patients with skin syndrome. Meditsinskiy Sovet = Medical Council, 5, 70–76. doi: https://doi.org/10.21518/2079-701x-2020-5-70-76

11. Budnyak, T. M., Vlasova, N. N., Golovkova, L. P., Slabon, A., Tertykh, V. A. (2019). Bile acids adsorption by chitoan-fumed silica enterosorbent. Colloid and Interface Science Communications, 32, 100194. doi: https://doi.org/10.1016/j.colcom.2019.100194
12. He, Y., Wang, B., Wen, L., Wang, F., Yu, H., Chen, D. et. al. (2022). Effects of dietary fiber on human health. Food Science and Human Wellness, 11 (1), 1–10. doi: https://doi.org/10.1016/j.fshw.2021.07.001
13. Alimardanova, M. K., Baybolova, L. K., Dzhetpisbaeva, B. Sh., Bakieva, V. M., Bayysbaeva, M. P., Mutushev, A. Zh. et. al. (2019). Pat. No. 4406 RK. Sposob proizvodstva yogurta. No. 2019/0316.2.
14. Shunekeyeva, A. A., Alimardanova, M., Albertovich, M. A. (2021). Chemical Composition, Texture and Sensory Evaluation of Yogurts Supplemented with Amaranth Flour. American Journal of Animal and Veterinary Sciences, 16 (2), 136–143. doi: https://doi.org/10.3844/ajavsp.2021.136.143
15. Tavakoli, M., Habibi Najafi, M. B., Mohebbi, M. (2019). Effect of the milk fat content and starter culture selection on proteolysis and antioxidant activity of probiotic yogurt. Heliyon, 5 (2), e01204. doi: https://doi.org/10.1016/j.heliyon.2019.e01204
16. Irvine, S. L., Hummelen, R., Hekmat, S. (2011). Probiotic yogurt consumption may improve gastrointestinal symptoms, productivity, and nutritional intake of people living with human immunodeficiency virus in Mwanza, Tanzania. Nutrition Research, 31 (12), 875–881. doi: https://doi.org/10.1016/j.nutres.2011.10.005
17. Sarangi, M., Bhattacharyya, S., Behera, R. C. (2009). Effect of temperature on morphology and phase transformations of nano-crystalline silica obtained from rice husk. Phase Transitions, 82 (5), 377–386. doi: https://doi.org/10.1080/01411590902978502
18. Muntohar, A. S. (2002). Utilization of uncontrolled burnt rice husk ash in soil improvement. Dimensi Teknik Sipil, 4 (2), 100–105. Available at: https://tekniksipil.umy.ac.id/wp-content/uploads/2011/06/CIV02040207.pdf
19. Sapei, L., Suseno, N., Riadi, L., Padmawijaya, K. S., Wurarah, T. S., Dewi, V. (2018). Biosilica recovery from pulped rice husk by acid precipitation. In: Chemeca 2018: Chemical Engineering in Autralasia. Available at: http://repository.ubaya.ac.id/34069/
20. Todkar, B. S., Deorukhkar, O. A., Deshmukh, S. M. (2016). Extraction of Silica from Rice Husk. International Journal of Engineering Research and Development, 12 (3), 69–74. Available at: http://www.ijerd.com/paper/vol12-issue3/Version-2/H12326974.pdf
21. Karavay, L. V., Levochkina, L. V. (2008). Gidrolizovannaya risovaya shelukha dlya proizvodstva muchnykh izdeliy. Pischevaya promyshlennost', 11, 53. Available at: https://cyberleninka.ru/article/n/gidrolizovannaya-risovaya-sheluha-dlya-proizvodstva-muchnyh-izdeliy
22. Kruglova, A. S., Selina, A. A., Minakova, P. S. (2020). Issledovanie aktivnogo kremniya v otkhodakh plodovykh obolochek risa i solomy. Eurasian Scientific Association, 9-3 (67), 168–170. Available at: https://www.elibrary.ru/item.asp?id=44122569
23. Galchenko, A. V. Sherstneva, A. A., Levina, M. M. (2021). Conditionally essential trace elements in nutrition of vegetarians and vegans: fluorine, silicon, bromine, boron. Trace elements in medicine, 22 (1), 32–43. doi: https://doi.org/10.19112/2413-6174-2021-22-1-32-43
24. Alimardanova, M., Tlevlessova, D., Bakiyeva, V., Akpanov, Z. (2021). Revealing the features of the formation of the properties of processed cheese with wild onions. Eastern-European Journal of Enterprise Technologies, 4 (11 (112)), 73–81. doi: https://doi.org/10.15587/1729-4061.2021.239120