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RESEARCH ARTICLE

Use of sorbents to improve water quality in the production of reconstituted dairy products

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ABSTRACT

Ensuring the safety of dairy products is one of the components of integrated food safety. The safety of dairy products is directly related to the organization of production control carried out when assessing the quality of water of the centralized drinking water supply system. The article discusses the feasibility of using natural and modified zeolites to ensure water safety. The physical and chemical properties of natural zeolites of the Taizhuzgen and Shankanai deposits of Kazakhstan, the possibility of their use to improve the quality of water in the production of reconstituted dairy products were investigated. The efficiency of water sample purification with modified zeolite of the Shankanai deposit for heavy metal ions was: Pb^{2+} – 79%, Cd^{2+} - 98%, Fe^{2+} - 77%, depending on the initial impurity concentration. It was found that the studied sorbents can be used to improve the quality of water in the production of reconstituted dairy products.

Keywords: Dairy products; Modification; Safety; Water; Water treatment; Zeolites.

INTRODUCTION

The world's population is expected to reach 9.7 billion by 2050, creating an urgent need to address global food safety in order to maintain global health (Garcia et al., 2019; Al Hamedi et al., 2021). In order to ensure the safety of food products during its production, the following procedures should be developed, implemented and maintained:

1) selecting technological processes of food production, necessary to ensure food safety;
2) selecting the sequence and flow of technological operations of food production in order to avoid contamination of food raw materials and food products (TR CU 021/2011).

Milk occupies a special place among food products, as it is the only product that nature produces specifically for the nutrition of humans and animals. (Kaskous, 2021).

Milk-based products provide a source of proteins, fats, mineral nutrients, prebiotics and probiotics and contribute significantly to food safety and human health (Hoppe et al., 2006). The developed and developing countries maintain high safety standards for dairy products, thereby ensuring the safety of consumer properties. It is commonly known that the health status cannot be improved without access to clean water, balanced nutrition and hygienic living conditions (Garcia et al., 2019). Over the past decades, the biosphere has been significantly polluted, including aquatic ecosystems. The health of the population depends on the quality of water resources, their rational integrated use and protection (Prosekov et al., 2016). In the food industry, only high-quality fresh water is used as an ingredient, as well as in the stages of processing raw materials: cooling, heating, transportation and purification. The amount of water used in a particular food processing plant will vary, depending on size, equipment efficiency, plant layout and culture. The dairy industry uses 1 to 60 liters of water per kg of processed milk (28% of the total water consumption) (Rad et al., 2013). The food hygiene regulations in force indicate that only potable water can be used to clean food contact surfaces and equipment (FDA, 2013).

To meet the needs of the population for dairy products in the off-season, it is common practice in Kazakhstan to use dried milk at dairy plants. Seasonality is one of the distinctive features of Kazakhstan dairy production. In the winter-spring period, there is a mass calving of cows, so there is a shortage of raw milk. But dairy production enterprises cannot afford losses due to seasonality, just

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as consumers are not ready to face a shortage of dairy products in the cold season. In addition, the use of dried whole and skim milk in the dairy production is complying with standards and recipes. It makes up for the lack of raw milk during the seasonal period of demand for dairy products. The milk powder neutralizes these fluctuations. Besides, the dried milk is used in the confectionery and dairy industry to enrich milk products with the components to increase dry substances in milk, while increasing the nutritional value of these products and improving the organoleptic characteristics of the finished product (Babenko, 2016).

The relevance of research in this direction is also dictated by the need to extend the shelf life of perishable dairy products and reduce its microbiological contamination, which depends on the state of surfaces, directly contacting with raw materials/milk and the finished product – that is, the inner surface of technological equipment, pipelines, containers and other reservoirs. (Belozerov, 2003).

The use of milk powder in the production requires the creation of certain conditions for the dissolution of milk powder and its reconstitution to the fullest extent (Popova and Potoroko, 2014). Occupying a large share (up to 88%) in the reconstituted milk processing product, water affects the quality and consumer properties of the final dairy product (Popova, 2014). In addition, according to the results of the research, it was found that the properties of water have a significant impact on the organoleptic properties of reconstituted milk. Considering the level of modern development of water treatment technologies and a wide range of appropriate equipment, it is reasonable to recommend that milk powder processors equip enterprises with water treatment plants, the choice of which is based on the results of water studies directly at the enterprise (Gevorkyan, 2018).

The water coming from the water supply network is not quite suitable for its consumption for food purposes. However, despite this, most food enterprises use tap water without additional high-quality purification. Additional water purification in order to provide food industry enterprises and the population with environmentally friendly water can be carried out by adsorption, membrane and distillation methods. (Kalimullin et al., 2013).

Nowadays activated carbon is used as a filter medium for most adsorption filters, which is less effective in water purification than zeolites and artificial sorbents. Possessing a high specific surface, the zeolite filter material adsorbs low and high molecular weight organic compounds, dissolved gases. The use of such filters makes it possible to remove the side effects of reagent treatment and improve organoleptic characteristics (taste, smell, color) (Frolov et al., 2008; Krasnova, 2018).

The nature of the adsorbent determines the porous structure and composition of functional groups on the surface of the adsorbent, which, in turn, affects the type of interaction between the extracted substance and adsorbent (Krasnova and Timoshchuk, 2014).

Many years of research under the guidance of Professor S.I. Khorunzhina and production practice showed that natural zeolite-containing tuffs – a promising sorbent for improving the quality of raw materials, semi-finished products and finished products in the beverage industry. The main materials for research: zeolites of the Pegas deposit – pegasine (Kemerovo region), Khonguruu – khongurin (Republic of Sakha (Yakutia)), Shivyrtui – shivyrtuin and Kholin deposit (Chita region). Materials were used both in natural and modified form. (Pushmina et al., 2009; Pushmina et al., 2008).

The use of Sakhapta and Kholin zeolites for water treatment in the dairy industry makes it possible to obtain reconstituted milk with higher hygienic safety indicators (Pushmina, 2010).

The use of adsorption filters based on natural minerals is currently a promising and cheap method of water purification from microbiological contaminants (Plotnikov et al., 2015).

The authors (Park et all., 2021) have developed a method for obtaining a filter for water purification, including: mixing additives with a positive charge, glass fiber, binder fiber, cellulose, zeolite powder and water to form the resulting mixture. Due to the positive charge additive, cellulose and zeolite, the effect is found that various contaminants in water including hardness-causing substances can be effectively removed.

The methods of special water treatment imply the purposeful imparting of certain properties to it. For example, the milk powder in such water can be dissolved better, acquiring better organoleptic, physical and chemical properties, and the system itself – a solution obtained in the result of the reconstitution of dry components – can acquire a structure similar to that of natural dairy products (Gerassimova et al., 2013). We have proposed the sorption water treatment at the stage of the dried milk reconstitution, in particular, the water treatment before adding the milk powder to it, as a factor in the intensification of the production processes of reconstituted dairy products.

The purpose of the research is studying the effect of zeolites from Kazakhstani deposits on adsorption capacity to improve the quality of tap water in the production of reconstituted dairy products by reducing the content of toxic metals (Pb^{2+}, Cd^{2+}, Fe^{2+}).

MATERIALS AND METHODS

For obtaining sorbents, zeolites of the Taizhuzgen and Shankanai deposits of Kazakhstan were used. Various fractions in the range of 0.1. 1.0 mm were obtained mechanically.

The modification of minerals was carried out in the following way: a portion of a mineral weighing 5 grams was placed in a glass, poured with a 4% hydrochloric acid solution at the ratio of 2:5 and stirred for 1 hour at room temperature, then the zeolite was separated from the acid, washed with water and dried at 60^0C in a drying cabinet. (Alimardanova and Khamzina, 2021).

X-ray diffraction analysis of the zeolite was carried out on DRON-3 automated diffractometer with $Cu_{K\alpha}$ -radiation, β-filter.

In order to determine the characteristics of the sorbent surface, tests were carried out on Sorbtometer-M analyzer by thermal nitrogen desorption (BET). During the tests, the values of the specific pore volume, BET surface area and average pore size were determined. The sample parameters were determined according to (ISO 287:2017).

The obtained sorbents were studied in the process of purification of a model solution with ion content, identical to the quality indicators of main water used in dairy production. The model solution was purified under the following conditions: water to be purified was fed into an adsorption column with a mass of 4 g at a speed of 2.4 cm^3/h. The content of impurities of metal ions was determined in KVANT-Z.ETA-T spectrometer by the atomic absorption method.

Reconstituted milk was obtained by dissolving milk powder in water with constant stirring and heating up to 65-75^0C, after which it was kept for 30-90 minutes with cooling due to natural heat exchange with the environment to the temperature of 20-24^0C (WO, 2012). The mass fraction of protein in reconstituted milk was determined according to (ISO 8968-1:2014, IDF 20-1:2014). The lactose in reconstituted milk was determined according to (ISO 22662:2007, 198:2007). The mass fraction of fat in the reconstituted milk was determined according to (ISO 2446:2008, IDF 226:2008). The acidity in reconstituted milk was determined according to (ISO/TS 22113:2012, IDF/RM 204:2012).

Photographic documentation

Photographs of the experiments performed are shown in Fig. 1

RESULTS AND DISCUSSION

In the practice of the dairy industry, water supply to enterprises is carried out from a public water supply network or from an artesian well (Frolov et al., 2008; Borissov et al., 2014). Being the main source of drinking water, natural water contains a significant amount of pollutants of natural and anthropogenic origin, including organic pollutants. Moreover, the water treatment process creates the risk of more hazardous secondary toxic pollutants. The water from natural reservoirs is mainly disinfected with chlorine-containing reagents. In water, chlorine interacts with natural organic substances, including humic ones, forming toxic (carcinogenic) organohalogen compounds (Krasnova et al., 2017). As the WHO suggests, “the most efficient means of maintaining a safe drinking-water supply at all times is using a comprehensive risk assessment and risk management approach” (Kelly et al., 2021). The water used in the production of milk and dairy

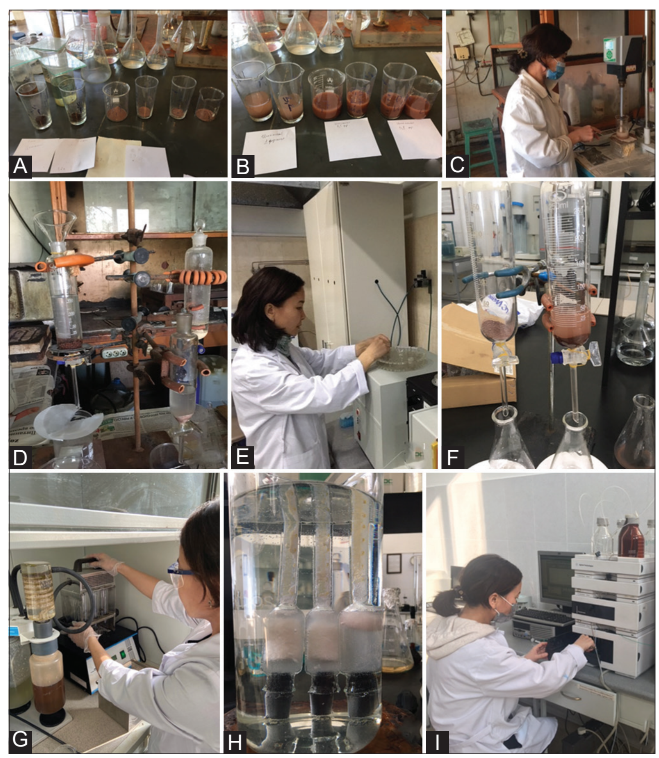

Fig 1. Photo collage of some experiments carried out in this study A) various zeolite fractions B) preparation of sorbents (zeolites) for operation C) mixing of zeolites for modification on PE-8300 device D) passing model solutions through the adsorption column E) determination of metal ions in KVANT-Z.ETA-T spectrometer by atomic absorption method F) water filtration through natural and modified zeolite G) protein determination according to Kjeldahl H) fat determination I) lactose determination.

products and in direct contact with food raw materials and packaging materials, must comply with the requirements of the technical regulations of the Eurasian Economic Union (EAEU) "On food safety" (TR CU 021/2011), "On safety of milk and dairy products" (TR CU 033/2013), as well as the Technical Regulations of the Republic of Kazakhstan "Requirements for the safety of drinking water for the population" dated May 13, 2008, i.e. meet all the usual requirements for drinking water, and, in addition, be notable for a higher degree of bacteriological purity, low hardness and absence of iron, which can cause even in minimal quantities undesirable changes in the smell and taste of finished products (TR TS 033/2013, TR TS 021/2011, Babkina, 2017).

Taking into account the above-mentioned provisions of the regulatory documents, we have established that water from the drinking water supply system, as well as used by various enterprises producing dairy products, is characterized by a fairly high content of a number of impurities. In the water samples, the iron content was 11% higher than the normalized value, the lead content was 1.3 times higher; the cadmium content was 3 times higher; the arsenic content was 1.2 times higher than the MAC (Alimardanova et al., 2021). Therefore, after conducting preliminary studies, the authors decided to use natural zeolites as adsorption filters to remove impurities from water.

Nowadays there are many ways of water decontamination (chemical treatment, membrane purification, sorption method), but their applicability is limited due to the economic inexpediency. The use of adsorption filters based on natural minerals at present is a promising and cheap method of water purification from impurities.

In the matter of water treatment and water purification, natural materials (quartz sand, shungite, expanded clay, granite sand, burnt rocks, zeolites, etc.) remain the main ones due to better knowledge, availability, and relatively low cost. Their reserves in Kazakhstan are significant: a large deposit of natural zeolites Tayzhuzgen (Tarbagatai district of the East Kazakhstan region, approved reserves – 7 million tons, forecasted – 215 million tons) and Shankanai (Kerbulak district, Almaty region, approved reserves – 5.5 million tons, forecasted – 120 million tons), both deposits are prepared for commercial development. In South Kazakhstan, the Altyn-Emel (41 million tons), Karzhantau and Daubabin zeolite deposits have been preliminary estimated (Vassilyanova et al., 2016).

The modern outlooks of the composition of silicate structures are based on the principles developed by Pauling. The primary unit is a tetrahedral complex, consisting of the Si^{4+} cation, tetrahedrally coordinated with four oxygen ions. Isomorphic substitution of Al^{3+} for Si^{4+} causes a negative charge density in the zeolite lattice. Zeolites belong to the group of framework aluminosilicates, the infinite aluminosilicate framework of which is formed by joining through the common cavities of the $[AlO_4]^{5-}$ and $[SiO_4]^{4-}$ tetrahedras (Breck, 1974; Jiang et al., 2020). The frameworks have a regular system of cavities, communicating with each other by channels, in which metal cations and water molecules are located, which can be freely removed and absorbed by the structure, due to which ion exchange occurs. The structural formula of a zeolite can be represented as follows: $M_{m/n}[(AlO_2)_x(SiO_2)_y]\cdot zH_2O$, where x+y is the sum of tetrahedras in a unit cell, m – is a number of cations M (potassium, sodium, calcium, magnesium), n is the cation valence (Nazarenko et al., 2011).

Only some zeolites of the more than 40 mineral species and varieties of zeolites known in nature, meet the requirements for practical use, namely: they form large almost monomineral concentrations and at the same time have the appropriate consumer properties (adsorption, ion exchange, acid and heat resistance, etc.) (Breck, 1974).

Zeolites are characterized by favorable technological parameters for the creation of filtration materials on their basis: they are not water-swellable, they are easily mechanically processed with subsequent fractionation, possess molecular-sieve, absorption (ion-exchange) and other useful properties, while being environmentally safe. The authors (Novgorodov et al., 2012) developed technical conditions and made a sanitary and hygienic conclusion on the zeolite of the Khonguruu deposit as a filtering and sorbing material for the purification of natural and waste waters. The countries that have experience in using natural zeolites include Bulgaria, Hungary, the USA, Turkey, Czech Republic, Japan, etc. (Savchenkov, 2017). The main indicators of zeolites from Kazakhstan deposits are identical to the known deposits of Ukraine (Sokirnitsa), Georgia (Tedzam) and Russia (Kholin, Kulikov, Vangin) (InfoMain, 2016).

The problem of removing iron and other elements from water can be solved by using zeolite filters. Natural zeolites are widespread and cheap mineral raw materials, having a unique spectrum of physical and chemical, adsorption and ion-exchange properties, due to which they have found wide application in wastewater purification and potable water treatment technologies (Wang et al., 2010). Natural zeolites can soften water, make it free from metal ions, organic impurities, colloids, and retain microorganisms. The use of zeolites of various modifications will make it possible to obtain microbiologically pure water of the required composition (Pushmina, 2010).

At the first stage of research, in order to increase the exchange capacity of natural zeolite and improve its sorption properties, we subjected natural zeolites of the Taizhuzgen and Shankanai deposits to a "hard" modification. For the modification we used 4% solution of hydrochloric acid 1N, which is prepared from a concentrated 37% hydrochloric acid solution with a density of 1.198 g/cm3. The choice of the acid is due to the fact that when using hydrochloric acid as a modifier of the zeolite, insoluble salts are not formed on its surface, unlike other acids, which eliminates the clogging of the surface of the zeolite structure. Table 1 shows the indicators of the composition of the samples of zeolites from Kazakhstan deposits used in the work before and after their HCl-modification.

We found that these zeolites comply with the radiation safety standards (RSS-99) for the content of toxic elements and radionuclides.

Using XRF analysis, the mineralogical composition of the zeolite rock was determined (Fig. 2).

The tested sample of the Taizhuzgen zeolite contains clinoptilolite $(Na,K,Ca)_{2.5}Al_3(Al,Si)_2Si_{13}O_{36}\cdot 12H_2O)$-34,3%, montmorillonite $(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2\cdot xH_2O)$ – 27.9, quartz SiO_2 – 21.7%, albite $(Na(AlSi_3O_8)$ – 12.7% and orthoclase $K(AlSi_3O_8)$ – 3.4%. The Shankanai zeolite sample contains clinoptilolite $(Na,K,Ca)_{2.5}Al_3(Al,Si)_2Si_{13}O_{36}\cdot 12H_2O)$ – 46,9%, quartz SiO_2 – 13.1%, montmorillonite $(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2\cdot xH_2O)$ - 13.1, lamontite $(Ca_{0.89}(Al_2Si_4O_{12})(H_2O)_{1.88})$ – 9.5 %, albite $Na(AlSi_3O_8)$ - 7.8%, hematite Fe_2O_3 – 6.3%, orthoclase $K(AlSi_3O_8)$ – 3.4%.

The surface characteristics of the tested samples after modification showed that the maximum values of the specific surface area and specific pore volume are achieved in the modified zeolite sorbents (Table 2).

At the next stage, we studied the sorption of a number of heavy metals from aqueous solutions of their salts by the zeolites of the Taizhuzgen and Shankanai deposits. These studies are due to the presence of these elements – cadmium, lead, iron in tap water used in dairy plants. For this, we used test solutions of lead, cadmium, and iron salts in distilled water, which were passed through a column filled with the Shankanai or Taizhuzgen zeolites in natural and in H^+ forms (after HCl-modification). The experimental results are shown in Table 3.

Table 1: Average chemical composition of zeolites from Kazakhstan deposits before and after their HCl-modification

Composition, concentration, % by weight	Zeolitic material			
	Taizhuzgen		Taizhuzgen	
	Natural	Modified	Natural	Modified
Na_2O	2,07	1,53	2,45	3,14
MgO	1,81	0,91	2,62	3,25
Al_2O_3	17,92	15,53	16,94	17,03
SiO_2	70,07	73,34	62,54	62,72
K_2O	4,34	4,57	2,67	2,00
CaO	2,42	2,38	5,49	4,54
TiO_2	-	-	0,83	0,69
MnO	-	-	0,17	-
FeO	1,38	1,73	6,29	6,63

As can be seen from our data, the extraction of ions of various metals by zeolites is ambiguous. It is known from the literature (Antonova, 1991; Santos, 2018) that the maximum capacity for divalent cations is not achieved under these physical and chemical conditions. However, the following regularity is observed for them: the smaller the radius of the divalent cation is and, accordingly, the higher its hydration capacity, ionic potential and the ratio of charge to coordination number, the lower the capacity. It follows that large size ions of heavy metals Pb^{2+}, Cu^{2+}, Zn^{2+}, Fe^{2+}, Cs^{2+} should be effectively adsorbed by zeolite tuffs.

In our case, the sorption of cadmium occurs to the greatest extent, regardless of the deposit and modification of the mineral, and to the lesser extent – lead ions. The modification of minerals helps to increase the exchange capacity of zeolite and allows passing a larger volume of water until the concentration of ions at the inlet and outlet of the column is equalized., The Shankanai zeolite in a modified form among the studied zeolites is more efficient in extracting heavy metals, which, apparently, can be explained by the more rigid crystal structure of the mineral and its chemical composition (Table 3).

The data in Table 3 showed that the use of zeolite filter for water treatment made it possible to reduce the concentration of toxic elements in the test solution to 98%.

The pretreatment of zeolite with a 10% aqueous solution of NaCl promoted the saturation of zeolite with exchangeable sodium ions. This is a simple and inexpensive way of preparing zeolite for water purification and its regeneration, as a result of which the efficiency of removing pollutants from water increases significantly. The regeneration can be carried out multiple times, i.e. zeolites can be used for water purification many times, for a long time, which increases the economic efficiency of this method.

The sorption capacity of zeolite minerals in the treatment of natural waters depends on the size of the fractions. With a decrease in the size of the fraction, the total surface of active sites and the number of direct contacts of the main channels with iron cations increase (Savchenko, 2009). In this regard, the sorption properties of zeolites increase. At the same time, the carried out experiments revealed that the use of a fraction ≤0.1 mm for water treatment under dynamic

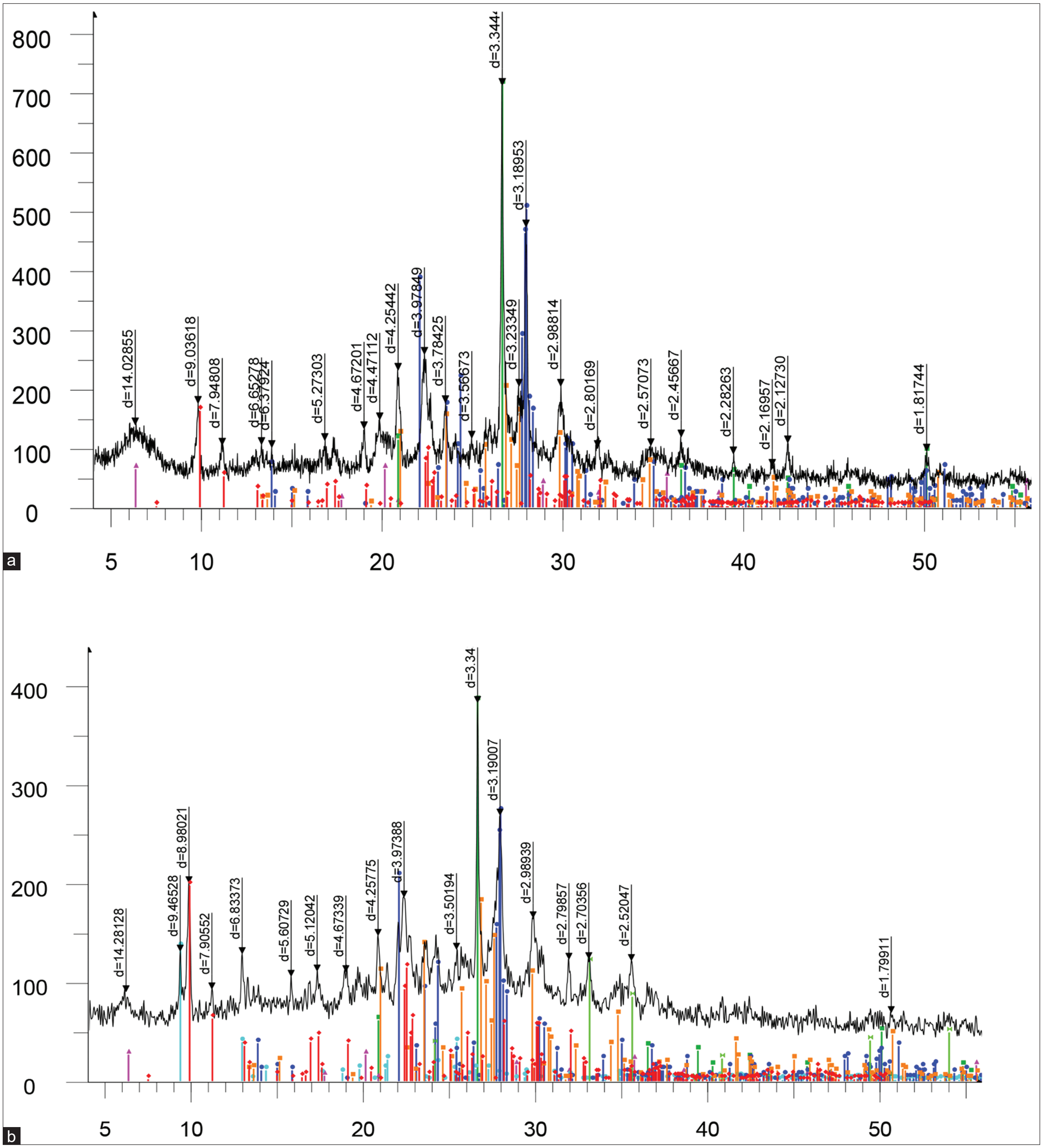

Fig 2. Diffraction pattern of zeolite a) Diffraction pattern of the Taizhuzgen zeolite sample b) Diffraction pattern of the Shankanai zeolite sample.

conditions of zeolite is impractical because of the problem of separating a fine dispersed phase from an aqueous medium.

The assessment of the zeolite safety (Savchenko, 2009) witnesses the absence of biochemical morphological and histochemical changes in the human body. Moreover, the use of zeolites at waterworks showed (Savchenko, 2009) that the finely dispersed fraction of zeolites with a filter loading layer of up to 50 cm has a high ability to purify water from intestinal viruses, therefore, helps to reduce the risk of transmission of viral gastrointestinal diseases by water. The work (Plotnikov et al., 2017) confirms the possibility of using modified zeolites as a load for purifying water from bacteria only when the sorbent fraction is less than 0.1 mm. Despite the absence of toxicity of zeolite, it is proposed to use a fraction of zeolite with a size of 0.1. 1.0 mm to improve the quality of drinking water, which is more resistant to mechanical abrasion under dynamic conditions. All the above experimental results were performed with fractions 0.1.1.0 mm.

Further, we proceeded to the next stages of the study in this work. For the production of reconstituted milk, skimmed milk powder with a fat content of 0.5% and water were used:
- tap water;
- water purified through natural zeolite;
- water purified through modified zeolite.

Table 2: Surface characteristics of mineral zeolites

Material	Fraction, mm	Specific surface area, m^2/g	Specific pore volume, cm^3/g	Average pore size, nm.
Natural zeolite of the Shankanai deposit	1	7.78	0.009	1.715
Modified zeolite of the Shankanai deposit	1	11.13	0.010	1.715
Natural zeolite of the Taizhuzgen deposit	1	18.75	0.010	1.716
Modified zeolite of the Taizhuzgen deposit	1	22.43	0.011	1.715

Table 3: Comparative data on the purification of the test solution with natural and modified zeolites

Heavy metals, mg/l	Before filtration	After filtration
Natural zeolite of the Taizhuzgen deposit		
Pb^{2+}	2.412±0.082	2.022±0.046
Cd^{2+}	293.864±22.334	17.811±0.802
Fe^{2+}	40.666±1.789	15.972±0.831
Modified zeolite of the Taizhuzgen deposit		
Pb^{2+}	2.412±0.082	1.565±0.011
Cd^{2+}	293.864±22.334	26.233±0.709
Fe^{2+}	40.666±1.789	20.016±1.461
Natural zeolite of the Shankanai deposit		
Pb^{2+}	2.412±0.082	1.872±0.097
Cd^{2+}	293.864±22.334	27.570±1.709
Fe^{2+}	40.666±1.789	5.48±0.284
Modified zeolite of the Shankanai deposit		
Pb^{2+}	2.412±0.082	0.493±0.0099
Cd^{2+}	293.864±22.334	3.667±0.097
Fe^{2+}	40.666±1.789	9.124±1.141

We studied the quality of reconstituted milk in respect of the indicators and content of heavy metals in it as provided for by the technical regulations of the EAEU "On safety of milk and dairy products". It was found that the physical and chemical indicators in three cases were at the required level, however, in terms of the content of heavy metals, milk reconstituted with untreated water was not suitable for consumption and processing (Table 4). This, in turn, will adversely affect the indicators of hygienic safety of milk and milk-containing products reconstituted with such water.

The data in Table 4 showed that the use of the zeolite filter for water treatment according to the developed technology allowed significantly reducing the concentration of toxic elements in the treated water. The content of heavy metals was well below the limits established by the technical regulation of the customs union "On safety of milk and dairy products". At the same time, its composition has improved qualitatively (Table 5).

The results of the study of heavy metals in the product show that, in milk reconstituted with tap water, the lead content was above the permissible level, the content of cadmium and iron did not exceed the threshold value, and arsenic was not detected. Milk reconstituted with purified water and passed through natural zeolite contains heavy metals, the amount of which does not exceed the permissible level. In milk reconstituted with purified water and passed through modified zeolite, no lead or cadmium were found, and the content of arsenic and iron does not exceed the permissible level (Table 4).

The analysis of Table 5 shows that the content of protein (3.75%) and lactose (4.85%) in milk reconstituted with purified water and passed through modified zeolite is significantly higher compared to the content of protein and lactose in milk reconstituted with tap water or purified water and passed through natural zeolite (3.57% and 4.8%; 2.86% and 4.28%, respectively).

Table 4: Content of some elements (mg/l) in dried and reconstituted milk

Element	Skimmed milk powder	Milk reconstituted with water			Technical Regulations of the Customs Union "On safety of milk and dairy products"
		Tap water	Purified water after passing through natural zeolite	Purified water after passing through modified zeolite	
Lead	None	0.2490±0.0092	0.0207±0.0004	None	0.02
Cadmium	None	0.0008±0.0001	0.0004±0.00004	None	0.02
Arsenic	None	None	0.0032±0.0003	0.0024±0.0001	0.05
Iron	None	0.292±0.025	0.258±0.0075	0.241±0.014	0.3

Table 5: Physical and chemical indicators of reconstituted milk

Indicators	Milk reconstituted with water		
	Tap water	Purified water after passing through natural zeolite	Purified water after passing through modified zeolite
Mass fraction of protein, %	3.57	2.86	3.75
Mass fraction of fat, %	0.05	0.04	0.05
Mass fraction of lactose, %	4.8	4.28	4.85
Acidity, ^{0}T	16	17	17

CONCLUSION

The research of drinking water from different regions of Kazakhstan, carried out by the authors, have led to the conclusion that iron, lead and cadmium in drinking water present in an amount, exceeding the permissible regulatory limits. The possibility of using zeolites of the Taizhuzgen and Shankanai deposits of Kazakhstan for water purification has been established. The possibility of improving the quality of drinking water with the help of the Shankanai zeolite has been proven. As shown by the results of the experimental studies, zeolite of the Shankanai deposit, modified with hydrochloric acid (HCl), significantly improves the quality of water. The purification efficiency, depending on the initial concentration of impurities, was Pb^{2+} - 79%, Cd^{2+} - 98%, and Fe^{2+} - 77%. Thus, it has been proven that the use of zeolites for the water treatment in the dairy industry will allow obtaining reconstituted milk with higher quality and hygienic safety indicators, and, consequently, high-quality final dairy products.

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Author contributions

Alimardanova Maria – contributed to research direction, literature review, selection of references and preparation of the manuscript.

Khamzina Zhulduz – performed laboratory experiments, participated in the selection of journals and contributed to the preparation of the manuscript.

Belopukhov Sergey – contributed to conceptualization, assisted in the data analysis and drafting of the manuscript drafting.

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