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A STUDY OF THE PHYSICO-CHEMICAL COMPOSITION AND TECHNOLOGICAL PROPERTIES OF SHEEP AND GOAT MILK (SHGM) DEPENDING ON THE BREED OF THE ANIMAL

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Abstract

The aim of the study is to identify and substantiate the breed of sheep and goats for collecting milk for the purpose of producing yogurt. The milk of 14 breeds of sheep and 10 breeds of goats was considered for the production of yogurt. A statistical analysis is given and the choice of breed of goats and sheep for the selection of milk for the production of live yogurt is substantiated. Live yogurt is a product with live microorganisms for 14 days, in this case, the viability of bacteria is 28 days when stored in refrigerated conditions, in plastic cups sealed with a foil lid, using special equipment.

Probiotics stimulate the production of immunomodulatory substances by beneficial intestinal microflora, as well as normalize cholesterol and glucose levels in the blood, bind and remove some toxic substances from the body. Research in this direction will open up many hidden potentials of fermented milk products based on sheep and goat milk and live microorganisms. There are prerequisites for the creation of new original recipes for functional dairy products and these studies are of the greatest scientific interest. The laboratories of the Kazakh Research Institute of Processing and Food Industry also used their own living microorganisms – probiotics for the preparation of consortiums based on lactic acid and bifidobacteria. Milk was collected from 10 ewes and goats from each breed from June to August 2021. Milk sampling was carried out in the morning milking. Milk indicators were studied using standard methods in the laboratory "Biotechnology, quality and safety of food products" of the "Kazakh Research Institute of Processing and Food Industry" LLP.

Keywords: comparative analysis of milk of various breeds of sheep and goats, viability of bacteria during storage.

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1. Introduction

Studies by various scientists have shown that goat's milk, due to its composition, is more suitable to replace breast milk. Goat milk contains high levels of oligosaccharides compared to milk from other mammals and lower levels of αs1 casein. Since the beginning of the 20th century, goat's milk has been recognized as the best substitute for breast milk, since it has a significant homology of lactoferrin N-glycans with mother's milk. The oligosaccharides present in goat's milk

based infant formula have strong prebiotic and anti-infective properties and may provide protection to infants against gastrointestinal infections [1–4].

A larger range of works was revealed in the development of the technology of yoghurts from MRS milk, yogurts were developed taking into account changes in protein, with the selection of starter cultures, with a qualimetric approach, with different types of processing of raw milk, in order to prolong the shelf life.

Undoubtedly, the quality of the finished product is directly related to the quality of raw materials, so a variety of works are devoted to the study of the quality of milk in small cattle. The issues of selection of factors influencing the quality of milk were studied: the influence of lactation periods, the season on the quality of milk, the influence of nutrition of small cattle, the influence of breed on milk yield, etc. [5–7].

Goat milk has been extensively studied and characterized for the presence of biologically active peptides. They also contain the four major casein fractions (αs1-casein, αs2-casein, β-casein, and κ-casein), however, goat casein has been found to undergo a wide range of post-translational modifications resulting in the production of a wide range of casein molecules [8]. Goat milk whey proteins mainly consist of α-lactalbumin and β-lactoglobulin, the concentration of the latter is much higher than in cow's milk [9].

Fermented goat's milk more often showed the presence of antioxidant peptides. In this regard, Lactobacillus casei L61 was used for the fermentation of goat milk, after which the milk was subjected to the isolation and purification of antioxidant peptides [10]. They proved that these antioxidant peptides were quite stable during a simulated in vitro digestibility experiment. Commercial proteases, namely subtilisin and trypsin, have been used to produce microfiltration goat milk hydrolyzate [11].

Sheep milk protein is characterized by the content of 76–83 % of total casein and 17–24 % of the total amount of whey proteins [12].

Moreover, the technological properties (coagulation, clot compaction, syneresis) of milk from different species have rarely been compared [13], and it is not known whether taxonomic distance affects these traits. One of the problems that arise when evaluating the technological properties of milk of different types is that there is no methodology for evaluating milk of other types. The methods commonly used in both research and industry have been developed for testing cow's milk and may not always be reliable when applied to other species. A preliminary study was conducted on 6 major dairy species in their typical environments and dairy systems. Milk samples from different farms, each consisting of milk from many lactating females, were used to assess the variability in cheese production efficiency. The specific objectives of this study were to compare different types of milk. Evaluated in terms of (1) chemical composition; (2) coagulation, clot compaction and syneresis properties; (3) restoring milk nutrients to curds; and (4) cheese yield [14].

The scientific and technical information bases summarize the biochemical processes for the formation of aromatic compounds by lactobacilli including lycolysis, proteolysis and lipolysis, with a detailed description of some key compounds. The activity of lactic acid bacteria associated with taste mainly depends on the species used for the fermentation of yogurt. Several strategies have been developed to gain more control over the taste formation process. Metabolic engineering can be a powerful tool to redirect the metabolic flux towards the efficient accumulation of desired aromatic compounds [15].

Interest in the development of yogurts is increasing with varying degrees of success, the maximum number of articles on this topic was observed in 2021 according to the Scopus database. So, for example, an interesting direction is the preparation of whey protein concentrates from goat's milk. The concentrates were produced by membrane separation and the study of the effect of polymerized whey protein of goat milk on the physicochemical properties and microstructure of recombined goat milk yogurt [16]. The results indicated that polymerized whey protein made directly from raw milk could be a novel protein-based thickener for natural goat milk yogurt.

The development of a new probiotic yogurt with a mixture of cow's and sheep's milk and evaluation of these products in terms of physicochemical, textural and sensory parameters was carried out by a group of researchers [17].

An analysis of the market for the production of goat and sheep milk in the Republic of Kazakhstan shows an increased interest in both milk and processed products. The increased and stable growth of interest of the scientific community in the topic of small cattle milk and processed products is also justified.

The range of goat and sheep milk products is expanding every year. Sheep milk cheeses are popular in France and Spain, and Kashkaval cheese is popular in Bulgaria [18]. Cheese is known in Kazakhstan. In the world, yoghurts, butter, and fermented products are also produced from the milk of small ruminants. The change in the quality indicators of the listed products from combined raw materials is also being studied. Works are given that consider combined raw materials, camel milk-sheep, cow-sheep, cow-goat, goat-sheep, etc.

The direction in the development of products from the milk of small ruminants is also the use of secondary raw materials, the analysis of production modes, syneresis, quality indicators. The issue of lossless delivery of a group of bifidobacteria through the human gastrointestinal tract is being studied, both in vitro and in vivo. Many works are devoted to the enrichment of the composition with probiotics and prebiotics, synbiotics and metabiotics. There are many works devoted to the study of the milk of small cattle. The composition of milk of various breeds of sheep and goats, the influence of the lactation period, the lactation season on the quality indicators of milk, dairy products, and secondary raw materials were studied.

In this regard, most of the works are devoted to the direction of development of the technology of functional yoghurts. The composition and modes of processing of small cattle milk are also being studied. Basically, the comparison of milk of various animals is carried out with cow's milk.

2. Materials and methods

When accepting milk from sheep and goats, an analysis of the chemical composition of milk was carried out on the device "Laktan". The use of this instrumental method of express analysis allows to reduce time, improve accuracy and obtain effective indicators. The results of the analysis of raw milk were recorded in the laboratory workbook.

The mass fraction of protein and fat in the milk mixture was determined on a MilcoScan FT2 analyzer, the mass fraction of fat was determined by the Gerber arbitration acid method according to GOST 5867-90 with an error of 0.1 %. The density of sheep and goat milk was determined by the classical method – a milk hydrometer.

The dry matter content was determined on a Mettler Toledo HB43-S Classic plus moisture content analyzer with a measurement accuracy of 0.01 % in accordance with GOST R 54668-2011. SOMO was determined by calculation by subtracting the mass fraction of fat from the mass fraction of dry matter.

Titratable acidity was determined by the titrimetric method, with a NaOH solution with a concentration of 0.1 mol/dm^3 using a phenolphthalein indicator according to GOST 3624-92, active acidity was determined electrometrically on a Hanna pH meter with a measurement error of 0.01 units. pH.

For experimental studies, raw milk was selected from sheep of the Kazakh Research Institute of Sheep Breeding named after Medeubekov (Mynbaeva village, Almaty region). Also, raw milk was selected from the South-Western Research Institute of Animal Husbandry and Plant Growing (Shymkent, South Kazakhstan), the Birlik Breeding Plant, SKATU named after Zhangir-Khan (Uralsk) and from breeding farms of the Almaty region. In the south of Kazakhstan, sheep breeds such as the South Kazakh merino, meat merino, Kazakh fine-fleeced, Karakul, Gissar and the Ordabasy breed have found the greatest distribution. In the west of the country, milk samples from the Akzhaiyk and Edilbay breeds were taken. In central Kazakhstan, the fence was made from the Saryarka breed and foreign breeds adapted in Kazakhstan Don Merino, Ile de Franz and Hampshire. Goat milk was selected from the Boer breed of the Kazakh Research Institute of Sheep Breeding named after Medeubekov (Mynbaeva village, Almaty region), Zaanensky from goats LLP "Sarayshyk" (Saraishyk village, Atyrau region) and Nubian and Alpine breeds ("ShelekAgro", Shelek village, Almaty region). The diet of all sheep and goats is the same. In winter and spring, silage and hay are introduced into the diet. In summer, the basis of the diet is pasture grass [19].

Milk was collected from 10 ewes and goats from each breed from June to August 2021. Milk sampling was carried out in the morning milking. Milk indicators were studied using standard methods in the laboratory "Biotechnology, quality and safety of food products" of the "Kazakh Research Institute of Processing and Food Industry" LLP.

The physicochemical composition of milk determines its biological and nutritional value, which determines the yield of dairy products and their quality. Therefore, it is very important to study the influence of various factors on the physicochemical composition of milk and take them into account when processing milk. Particular importance is attached to the content of biologically valuable components of milk: protein, fat and DSMR. The presence of dry matter (DM) in milk makes it possible to judge the nutritional value of raw milk. Dry skimmed milk residue (DSMR) – makes it possible to judge the biological usefulness, as it contains all the necessary, indispensable substances for the human body.

In this regard, it is possible to set the task – to analyze the physicochemical and technological properties of sheep's milk, depending on the breed of the animal, lactation period.

For processing, raw milk was supplied from various farms and private farmsteads. The most common breeds of sheep in the South Kazakhstan region are Kazakh fine-fleeced, merino, Edilbay, Ile de Franz. Their diet is about the same. In winter and spring, silage and hay are introduced into the diet for sheep. In summer, the basis of the diet is pasture grass.

The organoleptic evaluation of milk was carried out by the commission profile method on a 5-point scale (0.3 and 5 points), in accordance with the tasting regulations. Under the organoleptic properties of milk understand the properties perceived by the senses: appearance, color, taste and smell, consistency, which depend on the content of all the constituent components of milk and its physico-chemical parameters.

3. Results and discussion

The purpose of the exploratory experiments was to describe the milk of small ruminants and to study its composition and characteristics. Organoleptic evaluation of sheep and goat milk is given in **Table 1**.

Table 1

Organoleptic characteristics of sheep and goat milk

Index	Actual result
Sheep milk	
Color	White, with a slightly yellowish tint
Smell	Sweetish, specific notes, characteristic of sheep's milk
Appearance and texture	Thick homogeneous liquid without flakes
Taste	Pleasant, sweetish, close to cow
Goat milk	
Color	Light cream
Smell	Clean, without foreign smells not characteristic of fresh goat's milk.
Appearance and texture	Homogeneous liquid without sediment and protein flakes
Taste	Slight specific aftertaste of goat's milk

Organoleptic studies of milk samples taken from the "Aksha" farm showed good results, corresponding to ST RK 1732-2007 "Milk and dairy products. Organoleptic method for determining quality indicators "and GOST 32940-2014" Raw goat's milk. Specifications".

The productivity of sheep and goats largely depends on the conditions of livestock (pasture, stall), the breed of the animal, and the diet. Information on the duration of lactation and milk yield per day are given in **Table 2**.

From the data in **Table 2** it can be seen that the daily milk production of queens ranges from 0.55 kg – for sheep of the IDF breed to 0.93 kg – for the Kazakh fine-wool breed. The highest milk yield for the entire lactation was noted in the Ile de France (169 kg) and Edilbay breeds, the mini-

mum milk yield was in the Kazakh fine-fleeced breed (112 kg). It should be noted here that with a short lactation duration of 95 days, the Edilbay breed gives milk exactly as much as the Ile de Franz breed gives in 178 days.

Table 2

The productivity of sheep and goats depending on the breed

Breed name	Duration of lactation, days	Milk yield per day, kg	Milk yield per lactation, kg
Sheep breed			
Kazakh fine-fleece	120	0.93±0.001	112.13±2.5
Merino	124	1.13±0.12	140±3.7
Edilbay	95	1.78±0.23	169±1.6
Ile de France	178	0.55±0.01	169±3.4
Goat breed			
Zaanensky	300	3.08±0.20	630.14±3086
Nubian	300	2.80±0.10	608.70±83.64
Alpine	300	2.63±0.4	534.17±43.64

The productivity of goats of different breeds was also studied, milk was taken from different collective farms. At the same time, data were obtained on the same conditions of detention and diet. All goats were kept in grazing conditions, in one area. In terms of productivity, the goats of the Zaanensky breed surpassed their peers of the Alpine and Nubian breeds in terms of milk yield for 300 days of lactation, and as the information from **Table 2** shows, the breed of Zaanensky goats gives 630 kg for the lactation period.

In the production of yoghurts, milk must be pasteurized at high temperatures and further heat treated at lower temperatures. Based on this, an assessment of sheep and goat milk for thermal stability and coagulability is given.

Milk obtained at the beginning of the lactation period and towards the end of lactation has a low resistance to heat. The thermal stability of the protein components of milk depends on many factors: the protein composition, its acidity and salt balance, the amount of DSMR in milk. The amount of DSMR, in turn, depends on the stage of lactation, the components of the diet, etc. The results of studies on the thermal stability and duration of curdling milk in the middle lactation period are presented in **Table 3**.

Table 3

Technological properties of sheep and goat milk

Name	The state of the rennet clot	Heat resistance group	Coagulation time, min	Thermal stability of milk, min
Sheep	dense	II	12.3–30	42.3±1.2
Goat	dense	II	15–40	42.8±1.2

As can be seen from Table 3, the state of rennet is dense, the coagulation of goat milk is not much different from that of sheep milk, and the total time can be adjusted, and also show the same heat resistance.

In this study, let's compare the milk of different breeds of sheep in terms of physicochemical parameters (**Fig. 1**).

As can be seen from **Fig. 1** in terms of density, the highest indicators of milk are in the Edilbay breed, the lowest in the Hampshire breed. In terms of dry matter, the picture shows the highest content in the milk of the Saryarka breed, the smallest amount in the milk of the Edilbay, SKM, IDF, Gissar, Hampshire breeds. Approximately the same indicators in all breeds for DSMR, protein, lactose, and in terms of fat content, the best indicator for the Saryarka breed.

Thus, it is possible to conclude that the values of fat, protein and somo, density and lactose differ in different breeds of sheep Wilks lambda=0.06520, $F(66, 578)=5.8299$, $p=0.0000$.

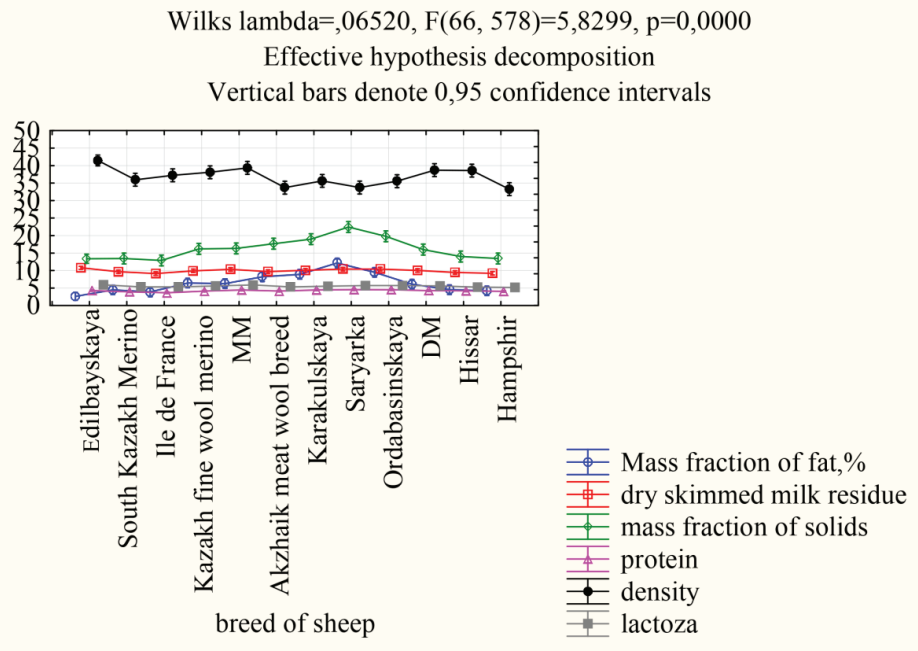

Fig. 1. Comparison of milk from different breeds of sheep

Also, differences in the composition of milk from different breeds of sheep can be seen using the Benferoni and Tukey criteria. In this study, both criteria showed the same result.

Comparison of milk of different breeds of sheep in terms of fat content, there are no breeds similar in terms of fat content of milk, they all differ, but slightly (P=0.000000–0.011). So, according to the content of lactose in milk, it is possible to see differences between the breeds Edilbay and SCM (p=0.0114), IDF and Edilbay (p=0.0088), AMWB and Edilbay (p=0.0132), MM and IDF (p=0.0458). Breeds Ordabasinskaya, Saryarka, Karakulskaya, DM, CT breeds are similar in terms of lactose content. Differences in milk density in the breeds of Edilbay and SKM (0.00087) are insignificant; Basically, it is possible to conclude that the differences in milk density are not significant in the context of breeds.

Analyzing the results of the Benferroni criterion, it is possible to conclude that the milk of the Kazakh fine-fleeced, Hampshire and Gissar breeds is similar in protein content. For other breeds, the protein content varies slightly (P=0.0103–0.000009). When comparing the content of solids in the milk of various breeds of sheep, it was found that the differences are not significant (P=0.00000 – 0.01421).

Comparison of milk of different breeds of sheep according to the content of SOMO, breeds of IDF and Saryarka (p=0.035322) IDF and Ordabasinskaya (0.03334) differ, in other breeds the differences in SOMO are insignificant (p=0.00046–0.00017).

Based on the analysis according to the Benferroni criterion, it can be concluded that milk from different breeds does not differ much in terms of fat content. According to Somo, there are no significant differences; in terms of protein content, the IDF breed is the most different. In terms of density, the Edilbay breed stands out the most.

Fig. 2 shows the desirability profile for the quality of sheep milk, which makes it possible to make an informed choice of sheep breed for milk collection in order to obtain high-quality milk for the production of yogurt.

According to **Fig. 2**, it is possible to conclude that the highest quality milk is in sheep of the Saryarka and Edilbay breeds. Based on the amount of milk during lactation, the Edilbay breed gives more milk in a shorter period. Also, this analysis showed that the Edilbay breed of sheep is a rational choice in terms of milk quantity and quality.

Also, the Benferroni criterion was used to evaluate differences in the physicochemical parameters of goat milk of different breeds. Three breeds of goats common in the Republic of Ka-

zakhstan were considered: Zaanensky, Alpine, Nubian. In terms of fat content, there are differences (p=0.012) between the Zaanensky and Alpine goat breeds, and in terms of average milk values (3.18), there are differences between the Alpine and Nubian breeds in terms of fat content (p=0.18).

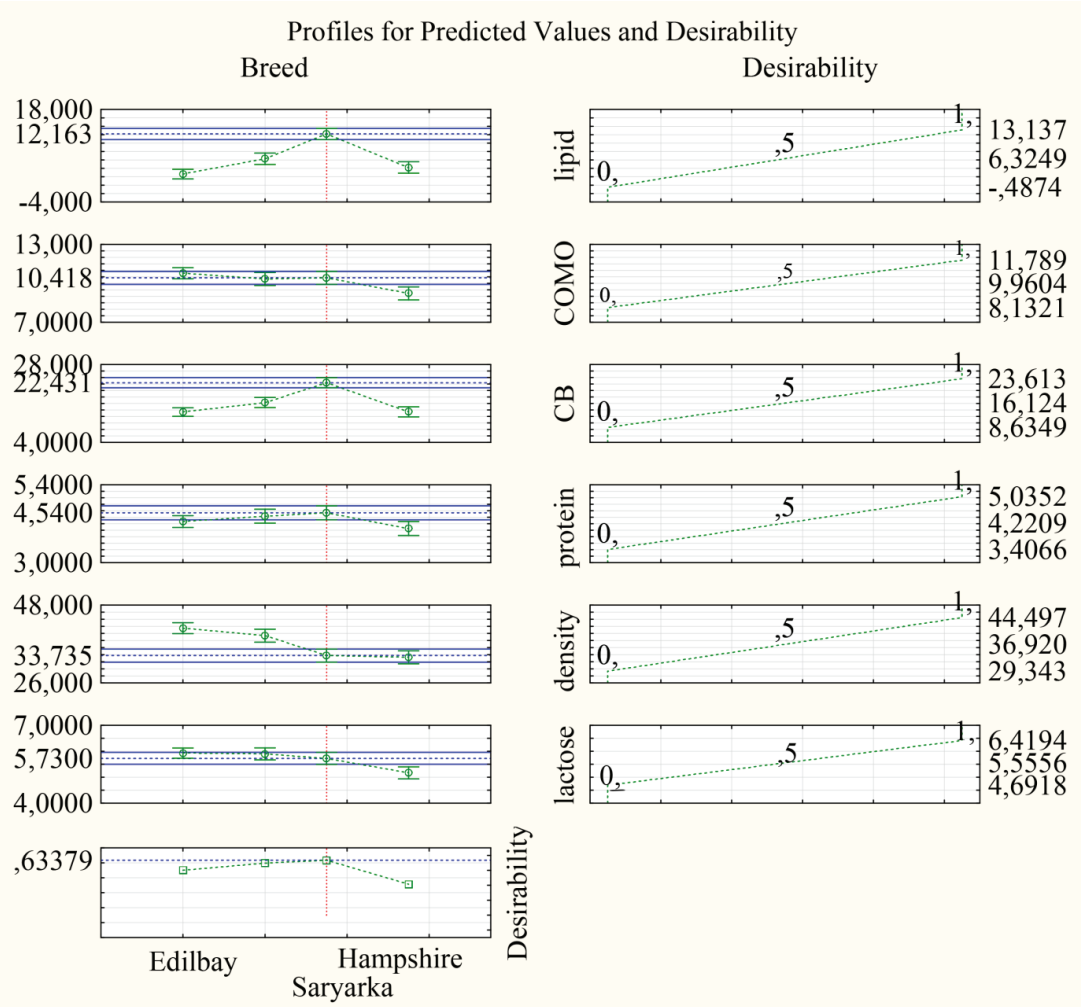

Fig. 2. Desirability profiles for the quality of sheep milk in the context of breeds

In terms of calorie content, content of mineral salts, lactose and solids, DSMR, density, the milk of these breeds does not differ from each other. According to the content of total protein and protein, there are differences in the highest indicator between the Zaanensky and Alpine breeds (p=0.0014).

Fig. 3 shows the desirability profile for goat milk quality.

Fig. 3 shows that Alpine milk is the best for most parameters. Alpine milk was chosen for the production of yogurt and further research.

The study revealed that the highest content of solids and dry skimmed milk residue of sheep's and goat's milk is observed in August – 8.86 % and 8.59 %, and the lowest – in July (12.58 and 12.34 %). This change can be explained by the fact that in the summer there is a change in the feed ration, which affects the course of metabolic processes occurring in the body of animals.

The quantitative content of protein and fat in the milk of sheep and goats varies depending on the months. The difference in protein content in summer periods does not exceed 0.2 to 0.5 %. The difference in the content of protein in milk by months of lactation is explained by a change in the diet of goats. A diet low in energy leads to a decrease in protein content, and a diet rich in energy leads to an increase in it. With a protein deficiency in animal nutrition, the protein content in milk decreases accordingly.

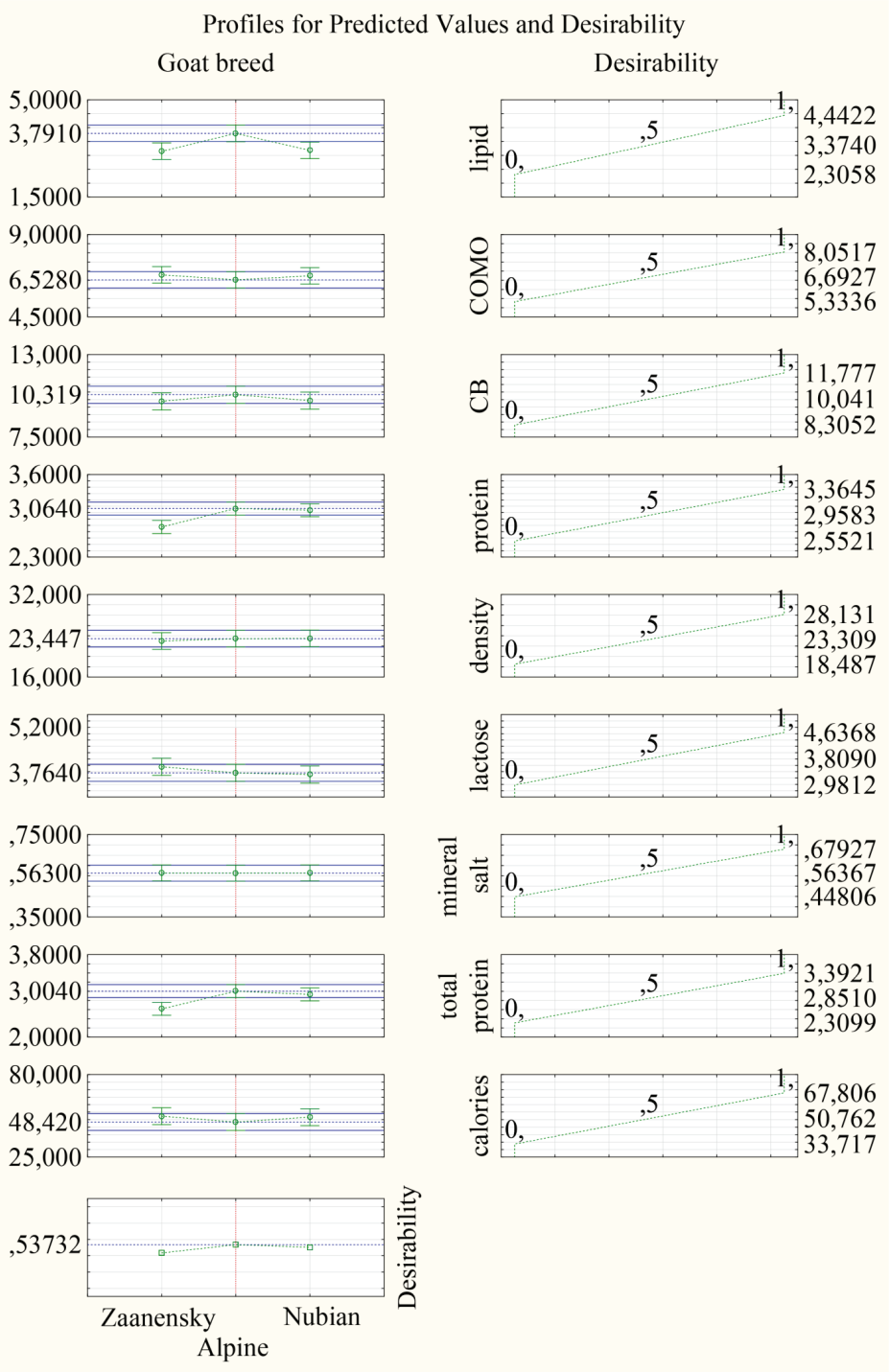

Fig. 3. Goat milk desirability profiles

The highest fat content was observed in the month of August (8.5 % for sheep and 4.3 % for goats). The lowest at the end of June (7.50 % for sheep and 4.0 % for goats), because during this period the weather is very hot, sheep and goats consume more water than feed.

In the summer periods of lactation of sheep and goats, there is a decrease in lactose milk sugar from 4.6 to 4.4 % for sheep's milk, respectively, for goat's milk, the indicator is from 4.36 to 4.48 %. The decrease in milk sugar in goat and sheep milk negatively affects the lactase enzyme (β-galactosidase) produced by the starter lactic microflora.

The density of sheep and goat milk in August slightly decreased from 1.026 to 1.024 kg/cm^3, respectively, the density of goat milk was in the range of 1.041 to 1.073 kg/cm^3. Titratable acidity in both animal species remains unchanged (22 °T for sheep milk) and (14 °T for goat milk).

The viscosity of sheep's milk in the summer months significantly decreases from $2.3 \cdot 10^{-3}$ to $2.1 \cdot 10^{-3}$, respectively, the viscosity of goat's milk decreases from $1.8 \cdot 10^{-3}$ to $1.4 \cdot 10^{-3}$. This is due to a decrease in the mass fraction of fat and casein, as well as a low degree of its dispersion.

The freezing point sharply decreases when sheep milk is acidified, when the pH changes from 6.6 to 6.8, this indicator changes from minus 0.533 to minus 0.494 °C, for goat milk, when measuring pH from 4.5 to 4.3, the indicator changes from –0.494 to –0.495.

The direction of improving the research is the standardization of milk by mass fraction of fat, the development of standards for goat and sheep milk in order to produce live yoghurts. It is also planned to investigate the viability of bacteria in yoghurts depending on the composition of combined milk, in models of the gastrointestinal tract (in vitro).

4. Conclusions

The milk of different breeds of sheep and goats is insignificant, but it has differences. It should be noted that the chemical composition and the ratio of milk components to each other practically does not change or changes slightly. The obtained results of the physicochemical properties and technological characteristics of sheep and goat milk indicate the expediency of using milk for the production of fermented milk products, in particular yogurts. Information about the composition and physico-chemical characteristics of goat and sheep milk is important for the successful development of the dairy industry of goat and sheep breeding, as well as for product marketing. Goat's milk differs from cow's milk in better digestibility, alkalinity, buffering capacity and certain therapeutic properties in medicine and human nutrition. Sheep's milk has a higher specific gravity, viscosity, refractive index, titratable acidity, and a lower freezing point than average cow's milk.

Conflict of interests

The authors declare no conflicts of interest in relation to this article, as well as the published results of the study, including the financial aspects of conducting the study, obtaining and using its results, as well as any non-financial personal relationships.

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