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Rheological, texture and sensory properties of kefir from mare's milk and its mixtures with goat and sheep milk

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Abstract

The aim of this study was to conduct lactic acid-alcoholic fermentation using mesophilic lactic acid bacteria (LAB) for mare's milk and its mixture with goat and sheep milk, followed by instrumental and sensory characteristic of the texture profile in the produced kefirs. It was shown that kefirs made from a mixture of goat and sheep milk are firmer, have greater values of consistency and the viscosity index than those produced from mare's milk alone. Kefir storage for 3 weeks causes changes in their mechanical properties. Exceptions are found for firmness of kefirs made from both mixtures and the viscosity index of kefir made from sheep milk, which remained stable. The most divergent texture profile of the tested kefirs was reflected in the sensory examined descriptors of prickling, dense and mouth-coating sensation.

Key words: mares, goat, sheep, milk, kefir

Introduction

Modern consumers are constantly increasing their requirements modern related to dairy products. On the one hand, they concern quality, attractiveness and packaging of milk products (Singh et al., 2012). On the other hand, they are connected with functional characteristics, contents of bioactive compounds, as well as new sensory attributes (Cais-Sokolińska et al., 2015a). The willingness of producers to meet these expectations is a driving force for innovations in the dairy industry. These consist in the modification of the raw material composition of dairy products, combinations of various raw materials, introduction of novel technologies or improving those already applied on the commercial scale (Arora et al., 2015; Cais-Sokolińska et al., 2015b). Examples reported in literature on the subject concerning combining milk of different mammals in one product in the industrial practice also result from economic considerations and seasonal availability of the raw materials (Kűcűkcetin et al., 2003; Uysal et al., 2003; Wójtowski et al., 2003; Cagno et al., 2004; Stelios and Emmanuel, 2004; Vargas et al., 2008).

One of the examples of innovations in the dairy industry is related to the use of mare's milk which is usually not collected on a large scale and as such it is not commercially processed (Pikul et al., 2008). For this reason it may be an excellent supplement for other types of milk, particularly as it contains many bioactive components, such as lactoferrin, lysozyme, valuable whey proteins, etc. Contents of selected bioactive components in mare's milk are much greater than in milk of other mammalian

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species (Markiewicz-Kęszycka et al., 2013). Such mixtures typically include milk of small ruminants, i.e. sheep and goats, in contrast to mare's milk containing large amounts of the so-called rumenic acid (conjugated linoleic acid, CLA), a particularly valuable, polyunsaturated fatty acid (Wójtowski et al., 2003; Cabiddu et al., 2005; Decandia et al., 2007; Ceballos et al., 2009). Conjugated isomers of linoleic acid (CLA) are ascribed e.g. a reduction of both the level of low-molecular lipoproteins (LDL) and the ratio of low- and high-molecular lipoproteins, thus decreasing the risk of atherosclerosis (Sieber et al., 2004).

When designing the composition of milk mixture of different mammalian species it is also necessary to consider the technology of its further processing. It is attempted not only to retain the bioactive compounds contained in the components used in production, but also to enhance the health-promoting value of the final product. Production of fermented milk is such a technology. In the opinion of consumers mare's milk is most frequently associated with a fermented product, kumis (Nassal and Rembalski, 1980; Kűcűkcetin et al., 2003; Cagno et al., 2004; Bornaz et al., 2010). However, an equally valuable product may be obtained by lactic acid-alcoholic fermentation, in which thermophilic lactic acid bacteria (LAB) are replaced with mesophilic LAB.

Most literature data on rheology of fermented milks concern the counts and type of acidifying microflora (Shihata and Shah, 2002) as well as application of various thickeners and/or stabilizing agents (Sandoval-Castilla et al., 2004). However, there are only few studies concerning mechanical properties of fermented mare's milk, particularly its mixtures containing milk of ruminants. In the present study it was hypothesized that kefirs produced from a mixture of goat or sheep milk and the mare's milk will exhibit better firmness and consistency as well as greater values of the viscosity index than those made from mare's milk alone. It was also assumed that the share of goat and sheep milk in the produced kefirs would have a positive effect on their mechanical properties during 3-week storage.

The aim of this study was to conduct instrumental and sensory analyses of the texture profile for kefirs produced from mare's milk and its mixtures with goat and sheep milk.

Materials and methods

Mare's milk and its mixtures

The raw material for analyses was bulk milk collected from Polish Cold-blooded multiparous mares reared on an equine dairy farm in the Wielkopolska region (Western Poland). At the time of milk collection for analyses they were in their fourth month of lactation. Mares with foals spent most of the days on the pasture foraging.

Mixtures were prepared by adding bulk goat milk from morning and evening milkings (of the Polish White Improved goats) and milk from sheep with an over 90 % share of East-Friesian sheep in their genotype (Gut et al., 2008). Bulk milk from each of the above-mentioned species at 5 L per day was collected at the same time of the day for three successive days, collecting a total of 15 L milk from each species. After cooling down, the milk was transported and stored in accordance with the binding veterinary standards.

Ruminants, from which milk for analyses was collected, were fed with a mixture of concentrates and roughage (green lucerne forage and meadow hay) administered in the total mixed ration system (TMR). Farms, on which all these animal species were kept, were located within a distance of approx. 30 km in Western Poland.

The production of the mixture was started immediately after the collection and cooling of the last, third sample of bulk milk from all the three animal species. Raw whole mare's milk contained 15.1 ± 0.5 $g \cdot kg^{-1}$ fat. For this reason the other types of milk were corrected to the same fat content by centrifugation, followed by double homogenisation (1°-15 MPa, 2°-4 MPa). Next, a 1:1 mixture of mare's milk with goat milk and a 1:1 mixture of mare's milk with sheep milk were prepared. Such a proposed share in the mixture of each of the milks resulted from the previously conducted studies of the authors (Cais-Sokolińska et al., 2016).

Production of kefir samples

Pasteurised (90 ºC for 2 min.) mare's milk and its mixtures were acidified using lactic acid-alcoholic fermentation with a share of mesophilic strains of lactic acid bacteria (LAB): *Lactococcus lactis* subsp. *lactis*, *Lactococcus lactis* subsp. *cremoris*, *Lactococcus* *lactis* subsp. *lactis* biovar diacetylactis, *Leuconostoc mesenterroides* subsp. *cremoris*, *Lactobacillus plantarum*, *Lactobacillus casei* as well as yeast *Kluyveromyces fragilis* (*Kluyveromyces marxianus* subsp. *marxianus*). The starter cultures were a commercial product, introduced in a lyophilized form at 30 u.a. to 100 L of milk and incubation was carried out at 22 °C. The dose of the introduced cultures was selected so that the end point of the fermentation would provide a product with pH 4.5-4.4. The products were poured into PS (polystyrene) containers with a capacity for 150 g of the product, and were then cooled to 5±1 °C. The products were tested 48 h after the end of the fermentation process (0 weeks) and after 3-week storage at 5±1 °C.

The process was run on a pilot plant scale with 9 samples for each type of product.

Physicochemical analysis

The basic chemical composition and pH were determined using standard methods (AOAC 1995; Cais-Sokolińska et al., 2015a). Total nitrogen content by Kjeldahl method was determined with the assistance of the Kjetec System 1026 apparatus of the Distilling Unit (Tecator Company, Őrebro, Sweden). Nitrogen-casein was expressed as % of total nitrogen (N x 6.38). Casein concentration was calculated from the difference between the level of total protein (TP) and non-casein nitrogen (NCN). The level of whey proteins was determined from the difference between NCN and non-protein nitrogen (NPN) (AOAC, 2000; Amatayakul et al., 2006; Chever et al., 2014). The total number of bacteria (TBC) and somatic cell counts (SCC) were detected by the flow cytometric method on Bactocount IBC-m (Bentley Instruments, MN, USA), according to the ISO 21187 (2004) standard. A Bactocount apparatus was calibrated on the basis of the numbers of colonies, which were determined by reference method (counting the colonies of bacteria at 30 °C), according to the ISO 4833 (2003) standard (Bentley Polska Sp. o. o.).

Rheological and profile texture analyses

Values of dynamic viscosity of unfermented milk were determined applying a method described by Anema et al. (2004). Absolute values of dynamic viscosity of samples before fermentation were recorded using a Hőppler KF10 viscosimeter by RheoTec Messtechnik GmbH (Ottendorf, Germany). The time (s) was measured (t) for a ball to fall over a distance of 100 mm at an inclination angle of 70° within a volume v=40 cm^3. The angle constant for the measurement was F_H=0.952(-). Balls used in the tests were made from an Fe-Ni alloy with diameters $Ø_{k3}$=15.552 mm and $Ø_{k4}$=15.199 mm and mass m_{k3}=16.0627 g and m_{k4}=14.1797 g, density d_{k3}=8.156 $g{\cdot}cm^{-3}$ and d_{k4}=7.713 $g{\cdot}cm^{-3}$ at the apparatus constants ascribed based on the certificate K_3=0.13543 $mPa{\cdot}cm^3{\cdot}g^{-1}$ and K_4=1.2268 $mPa{\cdot}cm^3{\cdot}g^{-1}$. On the basis of sample density (d_p), established using an areometer by Areometr (Warszawa, Poland) at a fiducial temperature (T=20°C) within the range from 1015 to 1045 $g{\cdot}cm^{-3}$ dynamic viscosity was calculated as $\eta=t(d_k-d_p)\cdot K\cdot F$ (mPa·s).

Firmness, consistency, cohesiveness and the viscosity index of fermented samples were determined using reverse extrusion in a TA-XT plus texture meter by Stable Micro Systems (Surrey, UK) (Pereira et al., 2003; Vargas et al., 2008). The A/BE attachment with a compression disc (Ø=35 mm) was used. A sample was placed inside a cylinder with an internal diameter Ø=50 mm (75 % filling). Measurement conditions were: a distance of 30 mm, pre-test 1.0 $mm{\cdot}s^{-1}$ and post-test 10.0 $mm{\cdot}s^{-1}$. Samples for analyses were prepared according to Marshall and Rawson (1999) and Brennan and Tudorica (2008). Sample behaviour during compression and return movement of the disc was analysed (sample firmness - maximum positive force F^+, consistency - space under the curve of force F^+ in time t_1:t_2, cohesiveness - maximum negative force F^-, viscosity index - space under the curve of force F^- in time t_2:t_3). Results were recorded in the Texture Exponent E32 version 4.0.9.0 software.

Sensory analysis of the texture profile

Sensory evaluation was conducted using the profiling method. Mouthfeel attributes reflecting the texture profile of tested samples were determined. Descriptors of the analyses together with their descriptions were as follows - *Prickling* - a tingling feeling on the tongue similar to a carbonated mineral water; *Density* - the thickness of samples in the mouth after the panelists have taken a bite; *Creamy* - velvet/soft feeling in the mouth (not fatty/oily); *smoothness* - the extent, to which samples ave an even consistency (absence of any granules); *Mouth-coating* - sensation of a thin film coating the oral cavity; *Fatty sensation* - fatty feeling on oral tissues perceived after swallowing (Wróblewska et al., 2009). The evaluation panel comprised 8 individuals (3 males, 5 females, aged 23-51 years), adequately trained and prepared for examinations. They evaluated the intensity of each descriptor in a scale of 1 to 10 points, where 1 denotes "imperceptible" and 10 - "highly perceptible". Analyses were conducted in a sensory examination laboratory under controlled temperature and lighting conditions (ISO 8589, 1998). Sample volume was 40 mL and temperature 7-8 ºC (Gomes et al., 2013).

Statistical analysis

A critical level of significance at p=0.05 was used throughout this study. Two-way ANOVA, Bonferroni test and Tukey's test were used to test the significance of differences. Statistical calculations were carried out using the STATISTICA, version 10 data analysis software (StatSoft, Inc. 2011).

Results and discussion

Chemical properties and composition of unfermented mare's milk and its mixtures

The mixture of sheep and goat milk used in the production process was of good hygienic quality. In both milk types TBC was max. $200 \times 10^3 \cdot mL^{-1}$. Also SCC values were high, in sheep milk amounting to 283.6×10^3 cells mL^{-1} and in goat milk to 462.5×10^3 cells mL^{-1}. Mare's milk had 18.2×10^3 TBC mL^{-1} and 23.4×10^3 SCC mL^{-1}, thus confirming its high quality expressed in terms of its microbiological and cytological parameters. Results of hygienic quality evaluation for all the three milk types indicate appropriate milking and milk handling after milking, in this way confirming results recorded by other authors for high quality processed milk (Danków et al., 2003; Skrzypek et al., 2003; Cieślak et al., 2015).

Mare's milk and its mixtures used as the experimental material varied in terms of their rheological properties. Among unfermented samples the lowest viscosity (3.09 mPa·s) was recorded for mare's milk. Statistically significant greater viscosity was found for a mixture of mare's milk with goat milk (4.36 mPa·s) and a mixture with sheep milk (4.45 mPa·s), which was probably connected with the content of proteins, mainly casein (Table 1). Jandal (1996) in goat and sheep milk reported the share of whey proteins in the total protein content at 15 % and 13 %, respectively.

However, this value to a considerable degree is dependent on the animal breed, resulting in discrepancies between literature data. For example, Bornaz et al. (2010) reported the ratio of casein proteins to whey proteins in goat milk of 3.6, at the share of whey proteins amounting to almost 21 %. Ceballos et al. (2009) when determining the protein profile showed that in the total amount of protein in goat milk whey proteins account for 17.3 %, while casein proteins account for 82.7 % (including α_{S1}-casein at 18.92 %, α_{S2}-casein at 8.52 % and β+κ-casein at 55.26 %). The ratio of casein proteins to whey proteins in milk tested by those authors

Table 1. Basic chemical composition of unfermented mare's milk and its mixtures (mean±SD)

Component ($g \cdot kg^{-1}$)	Mare's milk and its mixtures (1:1)		
	mare	mare+goat	mare+sheep
Protein (N×6.38):	23.9±0.2[a]	26.1±0.1[b]	29.5±0.2[c]
casein	14.9±0.3[a]	18.8±0.3[a]	20.6±0.2[c]
whey protein	9.0±0.5[b]	7.3±0.1[a]	8.9±0.5[b]
C:W*	1.7	2.6	2.3
SNF**	84.0±0.3[b]	80.7±0.6[a]	87.9±0.7[c]

*C:WP - ratio of casein to whey protein
SNF - solids-not-fat
a-c different small letters with mean values in rows indicate statistically significant differences at p<0.05

was 4.8. In turn, mare's milk is rich in whey proteins, accounting for 39 % total protein content (Bornaz et al., 2010). Markiewicz-Kęszycka et al. (2013) studied the composition of milk from Polish Cold-blooded mares and found that β-lactoglobulin (29.2 %) and α-lactoalbumin (25.4 %) had the greatest share in whey proteins.

Casein proteins are present in milk as micelles forming a colloid solution. Micelles are composed of monomers of individual casein fractions bound with bridges formed by calcium, phosphate and citrate ions. On average 1 cm^3 milk contains approx. $7\cdot10^{13}$ micelles and their diameter has a significant effect on the measure of internal friction, such as viscosity (Park, 2007). A study by Bornaz et al. (2010) showed that over 20 % casein proteins in goat milk are from 125 to 150 nm in diameter. In turn, Park (2007) stated that casein proteins in goat milk have a diameter Ø=260 nm and this value is much greater than in sheep milk (Ø=193 nm). Malacarne et al. (2002) reported that the diameter of casein protein micelles in mare's milk is Ø=255 nm. However, it needs to be stressed that the total amount of casein proteins in mare's milk is the smallest among the analysed milk types (Pegliarini et al., 1993).

Table 2. Parameters of texture of kefir from mare's milk and its mixtures during cold storage (mean±SD)

Storage time (weeks)	Kefir from milk		
	mare	mare+goat	mare+sheep
	Firmness (g)		
0	20 ± 2^{aB}	174 ± 15^{cA}	50 ± 14^{bA}
1	20 ± 1^{aB}	168 ± 12^{cA}	50 ± 8^{bA}
2	19 ± 5^{aB}	168 ± 7^{cA}	53 ± 5^{bA}
3	10 ± 3^{aA}	162 ± 21^{cA}	58 ± 13^{bA}
	Cohesiveness (g)		
0	-306 ± 25^{aA}	-280 ± 3^{bA}	-270 ± 8^{bA}
1	-264 ± 27^{aB}	-278 ± 8^{bA}	-241 ± 7^{bB}
2	-265 ± 14^{aB}	-141 ± 11^{cB}	-243 ± 12^{bB}
3	-127 ± 13^{bC}	-130 ± 19^{bB}	-201 ± 15^{aC}

a-c; A-C different small letters with mean values in rows and capital letters with mean values in columns separately for firmness and cohesiveness indicate statistically significant differences at p<0.05

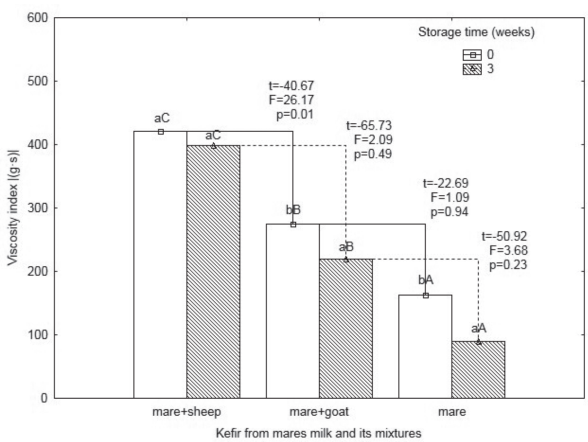
Texture profile

Values of firmness, cohesiveness and consistency were calculated based on the curves plotted for measurement results recorded in tests for mechanical properties of mare's milk and its mixtures subjected to fermentation and further storage. Analysis of texture attributes of the samples showed that firmness of kefirs produced using mixtures of mare's milk was significantly greater than that of kefir from mare's milk alone (Table 2). At the same time, kefir from a mixture of mare's milk with goat milk was 3.5-fold firmer than that from the mixture with sheep milk (P<0.05).

Directly after production kefir from mare's milk was more cohesive (306 g) than kefirs made with an addition of goat milk (280 g) or sheep milk (270 g) (Table 2). However, after 3-week storage cohesiveness of kefir from mare's milk was identical as that of kefir produced from the mixture with goat milk and it was 2.5-fold lower than after production. Cohesiveness of kefir containing sheep milk storage decreased by one quarter after 3 weeks of storage.

Viscosity indexes were to a considerable degree dependent on the type of used milk (Fig. 1). Among analyzed samples of kefir from mare's milk and its mixtures statistically significant differences were observed for viscosity indexes ranging from 81 to 438 g·s. Irrespective of testing time of the analyzed samples, the greatest value of the

Figure 1. The effect of type of kefir from mare's milk and its mixtures on the significance of differences in viscosity index (|g·s|)



t -value of the Bonferroni test, F - variance quotient, p - value of test probability
a-b; A-C different small letters for storage and capital letters for sample indicate statistically significant differences at p<0.05

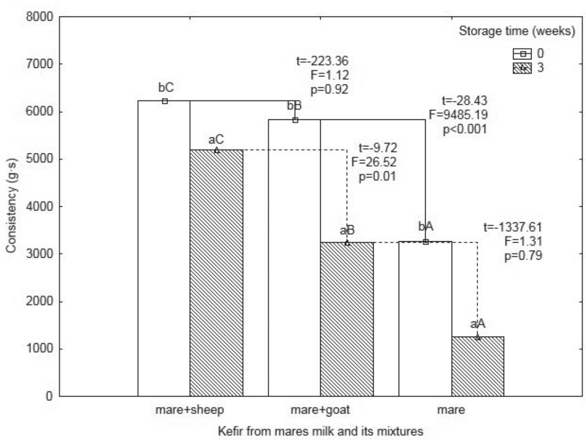
viscosity index was recorded for kefir produced from a mixture of mare's milk with sheep milk (409 g·s), while kefir made from mare's milk alone showed the lowest value (126 g·s). The observed difference in viscosity index for kefirs directly after production and after 3-week storage was not statistically significant, except for samples with different share of sheep milk in the mixture (P>0.05). Considering other tested samples, viscosity indexes in were significantly greater after a 3-week storage than directly after their production, by 20 % in kefir made with the addition of goat milk and by as much as 45 % in kefir from mare's milk alone.

Such low viscosity of fermented beverages based on mare's milk in comparison to samples with a share of goat or sheep milk seems to originate from b lower contents of casein proteins in mare's milk and thus a lower ratio of casein proteins to whey proteins, as well as from a different proportion of the casein fraction and the size of casein micelles. Mare's milk is composed of identical amounts of β-casein and α_{s1}-casein, which is the dominant fraction of cow milk (Ochirkhuyag et al., 2000; Malacarne et al., 2002). The content of κ-casein in mare's milk is also lower than in cow milk (Egito et al., 2002). Casein micelles in mare's milk are larger and less porous than in cow milk (Buchheim et al., 1989). These differences significantly determine rheological properties of fermented milk.

Upon the completion of the fermentation process the lowest value of the parameter describing consistency was recorded in kefir from mare's milk (3258 g·s), while it was highest in the product with the addition of sheep milk (6223 g·s.) (Fig 2). As a result of storage the value of consistency in each sample decreased significantly. Differences in consistency of the produced samples increased after 3 weeks. Consistency of kefir made from a mixture of mare's milk with sheep milk was 1.6-fold greater than that of kefir produced from a mixture of mare's milk with goat milk and as much as 4.1-fold greater that the consistency of kefir from pure mare's milk.

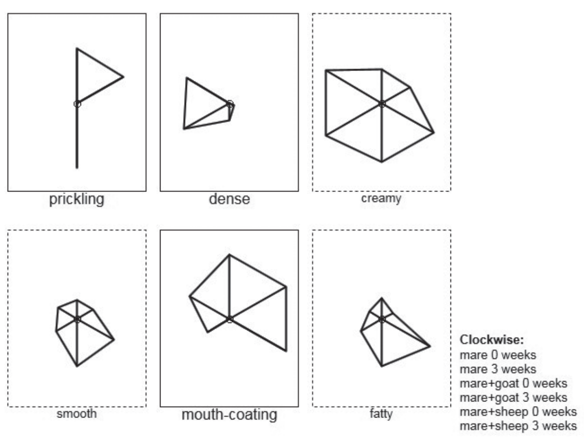
The low value of consistency in kefir from mare's milk and its mixture with goat milk in comparison to sheep milk could have resulted from the low contents of casein proteins, particularly the α_{s1}-casein fraction. In goat milk α_{s1}-casein accounts only 18.9 % of the total casein proteins. In mare's milk the share of this fraction is greater, amounting to 46.7 %, but total casein protein content is slightly over 10 g·kg^{-1}. Consequently, curd of goat milk is frequently described in literature as soft, delicate and fine-grained. For comparison, in cow milk the share of the α_{s1}-casein fraction is 48.5 % total amount of casein proteins, being much greater than in other milk types and amounting to 25 g·kg^{-1} (Ceballos et al., 2009).

Figure 2. The effect of type of kefir from mare's milk and its mixtures on the significance of differences in consistency (g·s)



t -value of the Bonferroni test, F - variance quotient,
p - value of test probability
a-b; A-C different small letters for storage and capital letters for sample indicate statistically significant differences at p<0.05

Figure 3. The importance of descriptors in sensory examination of texture in kefirs from mare's milk and its mixtures



--- weak effect, — strong effect

Texture in sensory examination - mouthfeel attributes

The evaluated descriptors were selected based on the exploration technique consisting in the presentation of recorded values in the form of multidimensional graphic objects (Fig. 3). This technique facilitated identification of interactive dependencies between samples depending on their type and storage time. No statistically significant difference ($P>0.05$) were found between kefirs when evaluating creamy, smooth and fatty perception. It was shown that the descriptions of prickling, dense and mouth-coating perception were those which differentiated the samples to the greatest extent. These dependencies were observed both after production and after 3-week storage. The prickling sensation, connected mainly with the presence of carbon dioxide, was most detectable in kefir from pure mare's milk (Table 3). The addition of goat milk and particularly sheep milk significantly decreased the prickling sensation ($P<0.05$). In kefirs produced from mixtures of mare's milk, the prickling perception decreased significantly with time, which was not observed in kefir from mare's milk alone. The dense sensation was did not change during sample storage and intensified with the use of milk from ruminants. The dense perception of kefir produced from the mixture of mare's milk with sheep milk ($x_{\Delta\tau}=5.0$ points) was almost 2-fold greater than that of kefir from the mixture of mare's milk with goat milk ($x_{\Delta\tau}=2.4$ points). Assessing the mouth-coating of kefirs, sensory panel gave the highest scores to samples from pure mare's milk (irrespective of the sensory examination time $x_{\Delta\tau}=4.6$ score) and to samples with an addition of sheep milk, but only after storage (4.6 points).

Table 3. Sensory descriptors of kefir from mare's milk and its mixtures during cold storage (mean±SD)

Storage time (weeks)	Kefir from milk		
	mare	mare+goat	mare+sheep
	prickling (scale 1-10)		
0	4.0 ± 0.2^{cA}	2.1 ± 0.3^{bA}	1.3 ± 0.3^{aA}
3	4.1 ± 0.2^{cA}	3.4 ± 0.4^{bB}	2.1 ± 0.2^{aB}
	dense (scale 1-10)		
0	1.4 ± 0.5^{aA}	2.2 ± 0.2^{bA}	5.2 ± 0.4^{cA}
3	1.5 ± 0.3^{aA}	2.6 ± 0.2^{bA}	4.8 ± 0.1^{cA}
	mouth-coating (scale 1-10)		
0	4.5 ± 0.4^{bA}	3.5 ± 0.3^{aB}	3.2 ± 0.3^{aA}
3	4.7 ± 0.3^{bA}	2.3 ± 0.3^{aA}	4.6 ± 0.2^{bB}

a-c; A-B different small letters with mean values in rows and capital letters with mean values in columns separately for firmness and cohesiveness indicate statistically significant differences at $p<0.05$

Mouth-coating of kefirs with addition of sheep milk was by 30 % less intensive immediately after production than after 3-week storage ($P<0.05$). Thus it may be stated that the use of milk from ruminants to produce kefir is the primary cause for changes in prickling, dense and mouth-coating sensations during storage. Primary differences were associated with the protein system and structure, as well as dispersion and size of fat globulins being different than those in mare's milk. In turn, secondary differences were connected with the dynamic of the fermentation process, and thus in the range of proteolysis and lipolysis as well as produced metabolites, e.g. exopolysaccharides. Differences between tested kefirs resulting from different chemical composition and physical properties of milk produced by different mammalian species were reflected in sensory evaluation. The three selected mouthfeel attributes may also be identifiers of produced kefirs in the course of further studies. Wróblewska et al. (2009) investigated certain attributes of kefir with pH 4.60 produced from cow milk with 2 % fat content, and described values of prickling, dense and mouth-coating perception. Those authors did not report any prickling sensation in the examined control samples. The dense sensation was 2.6 in a 0-10 scale, while the mouth-coating sensation was assessed at 5.7 points. Storage time (2 weeks) had no significant effect on the detectability of prickling, dense and mouth-coating sensations in kefirs.

Conclusions

Viscosity of unfermented mare's milk may be significantly increased by its partial supplementation with goat or sheep milk. By applying identical conditions of lactic acid-alcoholic fermentation with mesophilic LAB as those for mare's milk kefirs based on mixtures of mare's milk with goat or sheep milk may be produced. Kefir produced from a mixture of mare's milk with goat or sheep milk has a different texture profile than that produced from pure mare's milk. The share of goat and sheep milk in kefirs caused their greater firmness, consistency and higher viscosity index values. Only cohesiveness of kefirs from mare's milk was greater than that of its mixtures. Storage of kefirs causes significant changes in cohesiveness and consistency describing their mechanical properties. An exception is found for firmness of kefirs from both mixtures and the viscosity index of kefir with sheep milk, which remained stable for 3 weeks. The descriptors: prickling, dense and mouth-coating perception, evaluated in sensory examination of kefirs produced from mare's milk and its mixtures to a considerable extent reflect their different texture profiles. No significant difference were found between kefirs from mare's milk and its mixture with goat and sheep milk when evaluating creamy, smooth and fatty perception.

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Reološka, teksturalna i senzorska svojstva kefira proizvedenog od kobiljeg mlijeka i njegovih mješavina s kozjim i ovčjim mlijekom

Sažetak

Cilj ovog istraživanja bio je provesti mliječno kiselu i alkoholnu fermentaciju kobiljeg mlijeka i mješavine kobiljeg mlijeka s kozjim kao i ovčjim mlijekom pomoću mezofilnih bakterija mliječne kiseline te odrediti reološka (indeks viskoznosti i konzistenciju), teksturalna (čvrstoća i kohezivnost) i senzorska (osjet peckanja, zbijenosti i premaza u ustima) svojstva proizvedenih kefira. Rezultati analiza pokazali su kako kefir proizveden od mješavine kobiljeg mlijeka s kozjim kao i ovčjim mlijekom ima bolju čvrstoću, konzistenciju i veći indeks viskoznosti u odnosu na kefir proizveden isključivo od kobiljeg mlijeka. Pohrana kefira u trajanju od 3 tjedna na temperaturi od 5±1 °C utjecala je na promjenu svih određivanih svojstava proizvoda. Izuzetak je svojstvo čvrstoće kefira proizvedenog od obje mješavine mlijeka te indeks viskoznosti kefira proizvedenog od mješavine kobiljeg i ovčjeg mlijeka, koji su ostali stabilni tijekom pohrane.

Ključne riječi: kobilje mlijeko, kozje mlijeko, ovčje mlijeko, kefir, tekstura

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