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The viability of probiotic monoculture and quality of goat's and cow's bioyogurt

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Bio-yogurts are obtained from milk of various ruminant species (most often cow and goat) and are a rich source of a variety of valuable nutritional compounds and probiotic microorganisms. The objective of the study was to assess the quality of fermented goat's and cow's milk containing probiotic monocultures during refrigerated storage (5±1°C). Bio-yogurts were produced from raw material obtained from Saanen goats and Holstein Friesian Black and White cows, both kept on the organics farms. Four experimental products were produced: two from goat's milk: KBJ-L811 (with the YE-L811 yogurt starter culture and probiotics: *L. acidophilus* LA-5 and *B. animalis* subsp. *lactis* BB-12) and KBJ-X16 (the YC-X16 yogurt culture, LA-5 and BB-12) and two analogical cow's milk variants: BJ-L811 and BJ-X16. The products underwent microbiological, physicochemical, textural and sensory evaluation. The study confirmed that the activity of yogurt and probiotic cultures in

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goat's and cow's products was similar. In the case of yogurt cultures, their viability was min. 8 log (cfu/g). The count of probiotic bacteria was 7.7-8.4 log (cfu/g) for *Bifidobacterium* sp. and 5.9-7.4 log (cfu/g) for *L. acidophilus*. Although the yogurt cultures did not differ in their composition of bacteria species, the resulting products showed varied quality properties.

KEYWORDS: bio-yogurts / cow's milk / fermented milk / goat's milk / monocultures / texture

The basic raw material for the dairy industry is primarily cow's milk. In developed countries in Europe and North America more than 95% dairy products are made from cow's milk. The situation is slightly different in the Mediterranean region, as well as Asia and North Africa, where rearing of small ruminants (sheep and goats) as well as processing of milk of these species is closely related to the tradition and culture of local communities [Thanh and Suksombat 2015, Miller and Lu 2019, FAO 2020]. Milk and dairy products are staple foods in the diet of modern consumers, which contributes to the dynamic development of the dairy market in the world [Strzałkowska *et al*. 209abc, Jóźwik ***et al***. 2010ab, Miller and Lu 2019, FAO 2019, Willer and Lernoud 2019, Bórawski *et al.* 2020]. In recent years, there has been a growing interest in certified organic food, including dairy products, which is reflected in the increasing number of farms operating in this sector [Willer and Lernoud 2019]. The most common reason for buying organic products is that customers are convinced of their health benefits, i.e. lack of preservatives and artificial dyes, and they opt for healthy diet [Miller and Lu 2019].

Consumers are more and more willing to choose fermented milk beverages produced from milk obtained from certified organic farms. Bio-yoghurts that are part of the functional food trend deserve special attention. Apart from typical yogurt microflora (*Lactobacillus delbrueckii* ssp. *Bulgaricus*, *Streptococcus thermophilus*), bio-yogurts contain probiotic strains of bacteria from genera *Lactobacillus* or *Bifidobacterium*, which exhibit a beneficial effect on the body functions [Brodziak *et al.* 2018].

Bio-yoghurts are mainly made with cow's milk, although more and more often they are also produced from goat's milk, being a good source of many valuable nutrients, which helps to preserve and even increase its nutritional and dietary value [Hadadji and Bensoltane 2006, Costa, *et al.* 2016, Mituniewicz-Małek *et al.* 2017]. Numerous studies show that goat's milk, compared to cow's milk, contains significant amounts of taurine and is also characterized by a higher content of whey proteins and sulfur amino acids. Importantly, goat milk protein and fat are digested faster and easier, and its amino acids are better absorbed. The greater digestibility of fat, among other things, results from the higher content of low-molecular-weight fatty acids than in cow's milk. The advantage of goat's milk is also a slightly higher ash content, which makes it richer in terms of the amount of minerals and vitamins [Prosser *et al.* 2021]. This is due to the fact that the diet of goats contains a more numerous group of plants than is the case with diet of cows [Miller and Lu 2019, Dopieralska *et al.* 2020]. The most decisive factor determining this is the production system [Król *et al.* 2020].

Therefore, the aim of the studies was to assess the survival of yoghurt and probiotic microflora in bio-yoghurts produced from raw material obtained from Black and White Holstein-Friesian cows and Saanian goats kept on certified organic farms and to assess their quality characteristics during the cold storage period.

Material and methods

Materials and bacterial cultures

The experimental bio-yogurts were manufactured under laboratory conditions in a thermostat-equipped system. The raw material was cow's and goat's milk collected in organic farms in north-western Poland. In the production two traditional yogurt starter cultures (YC-X16 and YE-L811) and two probiotic monocultures of *L. acidophilus* LA-5 and *B. animalis* subsp. *lactis* BB-12 were used. All cultures were purchased from Chr. Hansen, Poland. Two variants of cow's and goat's milk bio-yogurts were prepared. The differentiating factor in these products was the type of yogurt culture, which according to the producer had the same qualitative composition (*Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*); however, it differed in metabolic characteristics.

Preparation of fermented milk samples and the experimental design

Both types of raw milk were separately pasteurized by the tank method (85°C/30 min), cooled down to 42°C and inoculated with one of the previously activated yogurt started culture (YC-X16 or YE-L811, Chr. Hansen, Poland) and probiotic monocultures: *L. acidophilus* LA-5 and *B. animalis* subsp. *lactis* BB-12. The yogurt culture, the LA-5 culture and the BB-12 culture were mixed at a 1:1:1 ratio. Starter cultures for bio-yogurt production were activated by dissolving (at 0.6 g/1000 cm^3) and pre-heating in sterile skimmed milk at 40°C for 4÷5 h (yogurt starter cultures) or 37°C for 7÷8 h (probiotic starter cultures). The following four types of bio-yogurts were prepared:

– KBJ-X16 – bio-yogurt from goat's milk with YC-X16, *L. acidophilus* LA-5 and *B. animalis* subsp. *lactis* BB-12;
– KBJ-L811 – bio-yogurt from goat's milk with YE-L811, *L. acidophilus* A-5 and *B. animalis* subsp. *lactis* BB-12;
– BJ-X16 – bio-yogurt from cow's milk with YC-X16, *L. acidophilus* LA-5 and *B. animalis* subsp. *lactis* BB-12;
– BJ-L811 – bio-yogurt from cow's milk with YE-L811, *L. acidophilus* LA-5 and *B. animalis* subsp. *lactis* BB-12.

The incubation process was conducted at 42°C until firm curd was received. Consequently, products were cooled down to 5±°C and stored at this temperature for a period of 10 days. The total number of experimental products was 80 samples. For the analysis 10 samples of each bio-yogurt were randomly collected after 1 and 10 days of refrigerated storage.

Analysis of raw material

The analysis of milk included assessment of total protein and fat contents according to ISO 1871:2009 [ISO 1871:2009], as well as density, titratable acidity and active acidity according to ISO 2446:2008 [ISO 2446:2008]. In addition, the content of the other organochlorine compounds (α-HCH, β-HCH, γ-HCH, pp′-DDE, pp′-DDD, pp′-DDT) was determined using the GC-MS method [Witczak *et al*. 2013].

Microbiological, physicochemical, textural and sensory analysis of bio-yoghurts

The experimental bio-yogurts were subjected to microbial, physicochemical, textural and sensory analyses. Microbial analysis included enumeration of yogurt bacteria by the pour plate method. The preparation of samples for microbial analysis and their decimal dilutions were made according to the recommendation of the PN-EN ISO 6887-5:2020-10 standard. The evaluation of *L. delbrueckii* subsp. *bulgaricus* and *S. thermophilus* was conducted in accordance with the ISO 7889:2003 standard. The enumeration of viable cells of probiotic bacteria *L. acidophilus* and *Bifidobacterium* sp. was performed according to the method of Süle *et al*. [2014]. Using the above-mentioned methods, bacterial cultures were run at 1. and 10. storage days, which made it possible to estimate survivability of probiotic bacteria over time. Evaluated physicochemical characteristics included titratable acidity in °SH [Affane *et al.* 2011], active acidity with the use of a pH-meter (CP-411 model) and acetaldehyde content [Lees and Jago 1969]. Texture profile analysis (TPA) was performed with the use of a computer-assisted TA.XT plus Texture Analyzer (Stable Micro Systems, England). The samples were penetrated with an aluminium cylindrical probe with a diameter of 20 mm to the depth of 25 mm. The test speed was 5 $mm \cdot s^{-1}$ and trigger force was 1 N [Miocinovic *et al*. 2016]. TPA analyzes such textural characteristics of products as hardness, adhesiveness, cohesiveness and gumminess. However, the study was limited to the analysis of the hardness, which according to the literature [Salvador and Fiszman 2004] is the crucial textural parameter of quality in fermented milk beverages. Sensory evaluation of the products was performed by the group of 6 trained panellists in a laboratory free of foreign odours and included the assessment of appearance, taste, smell and consistency using a 5-point scoring method according to ISO 6658:2017. The panelists were asked to indicate how much they liked or disliked each sensory discriminant of the bio-yoghurt on a 5-point hedonic scale (5 = like extremely; 1 = dislike extremely). The samples used for the analyses were selected randomly. Each time the sensory analysis was performed by the same group of panelists. The results for each descriptor were added together and were expressed as an arithmetic mean.

Statistical analysis

Obtained results of microbial, physicochemical and rheological measurements underwent statistical evaluation. Using Shapiro-Wilk's test, it was stated that all variables had a normal distribution. The analysis of variance was performed to examine if two quality factors – bio-yogurt type and storage time, influenced the analyzsed quality properties. To check if bio-yogurt samples differed from another, mean values were compared by Student's t-test with the Cochran-Cox adjustment. The significance level of all statistical analyses was P<0.05 [Szkolnicka *et al.* 2020].

Results and discussion

Raw material characterization

The composition and physicochemical characteristics of cow's and goat's milk used for bio-yogurts production (Tab. 1) were in compliance with findings presented by other authors [Costa *et al*. 2016, Vargas *et al.* 2008, Eissa *et al.* 2011, Gomes *et al.* 2013].

Table 1. Physicochemical characteristics (averages and standard deviations – in parenthesis) of milk for yogurt production

Characteristics	Total protein content (%)	Fat (%)	Titratable acidity °(SH)	Active acidity (pH)	Density ($g \cdot cm^{-3}$)
Goat's milk	2.69 (0.1)	3.38 (0.03)	6.07 (0.30)	6.89 (0.09)	1.026 (0.0)
Cow's milk	3.26 (0.1)	4.60 (0.06)	6.90 (0.08)	6.73 (0.11)	1.031 (0.0)

Survivability of probiotics and LAB

The count of *S. thermophilus* in all analyzed samples exceeded 8 log (cfu/g) during a 10-day storage period (Tab. 2). Statistical analysis revealed that survivability of these species was not influenced by either the type of milk, or the type of starter culture. However, after refrigerated storage a slight, but statistically significant decrease of viable cell counts was noted. Analogically, in the case of *Lactobacillus* it was found that the count of these yogurt bacteria depended only on the storage period.

Table 2. Number of live cells of starter culture bacteria [log cfu/g] (mean values and standard deviation, n = 4)

Samples	Storage time (days)	*S. thermophilus*	*Lactobacillus* sp.	*L. acidophilus*	*Bifidobacterium* sp.
KBJ-AX16	1	8.4^a (0.3)	8.0^a (0.5)	6.3^a (0.4)	8.1^a (0.3)
	10	8.1^b (0.3)	7.6^b (0.1)	5.9^b (0.3)	7.7^b (0.5)
BJ-AX16	1	8.8^a (0.2)	8.3^a (0.5)	7.0^a (0.2)	8.4^a (0.4)
	10	8.3^b (0.4)	7.8^b (0.2)	6.1^b (0.2)	8.2^a (0.4)
KBJ-BL811	1	8.7^a (0.3)	8.2^a (0.4)	7.0^a (0.1)	8.1^a (0.1)
	10	8.5^b (0.2)	7.7^b (0.3)	6.6^b (0.3)	7.7^b (0.5)
BJ-BL811	1	8.9^a (0.2)	8.1^a (0.4)	7.4^a (0.5)	8.1^a (0.5)
	10	8.7^b (0.2)	7.6^b (0.2)	6.7^b (0.1)	7.9^a (0.4)
p-values:					
sample		0.8039	0.0640	0.9420	0.0393
storage time		0.0300	0.0000	0.0024	0.5647
interactions		0.9955	0.6387	0.8340	0.0565

[ab]The same letters within one column means there are no statistically significant differences between the compared numerical values (p<0.05).

From the initial level of 8.2 log cfu/g, after 10 days of storage at 5±1°C it decreased to 7.6-7.8 log cfu/g, regardless of the type of milk and starter culture. The viability of potentially probiotic strains *L. acidophilus* LA-5 and *B. animalis* subsp. *lactis* BB-12 in experimental goat's and cow's milk bio-yogurts ranged at similar levels. The count of *L. acidophilus* in products from both types of milk was significantly lower than in the case of typical yogurt bacteria species and directly after production ranged from 6.3 to 7.4 log cfu/g. The count of viable cells of this species was significantly lower in bio-yogurt KBJ-AX16 than in the other samples. Furthermore, also in the case of that species, refrigerated storage contributed to the reduction of bacteria viability. The initial count of bifidobacteria amounted on average to 8.1 log cfu/g and did not depend on the type of milk and yogurt starter culture. After 10 days of storage a significant reduction of bifidobacteria survivability was observed only in products from goat's milk.

Physicochemical characteristics

Titratable acidity of experimental bio-yogurts made from goat's milk ranged from 25.60±0.40 to 33.73±0.46 °SH, while in the case of products from cow's milk it fell within the range of 28.27±0.32 - 36.53±0.23 °SH. During a 10-day storage period, in all the analyzed variants of the product an increase of titratable acidity value was observed (Fig. 1). Statistical analysis revealed that this parameter was significantly ($P<0.05$) influenced by the type of used milk and starter culture. Beverages prepared from cow's milk were characterized by a higher titratable acidity. However, on the first day of the storage period bio-yogurt KBJ-L811 made from goat's milk with the use of the YE-L811 yogurt starter culture had higher value of titratable acidity than the analogical product made from cow's milk (BJ-L811).

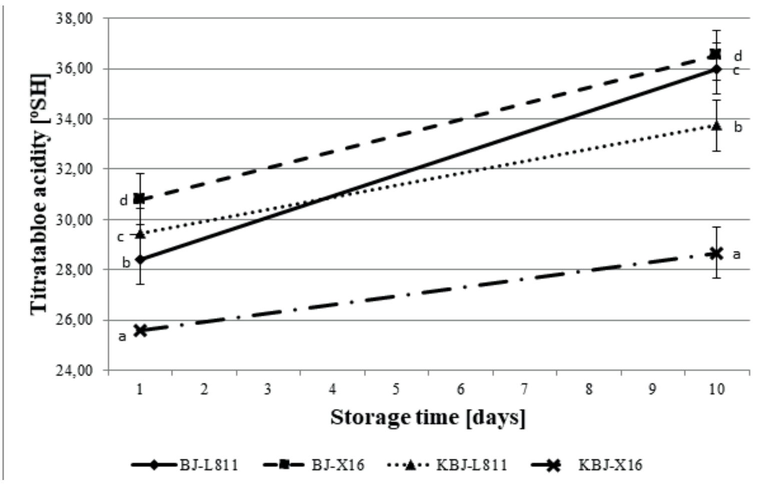

Fig. 1.Titratable acidity of bio-yoghurts from cow's (BJ-L811, BJ-X16) and goat's (KBJ-L811, KBJ-X16) milk during cooling storage. a,b,c,d – different letters indicate statistically significant differences ($p<0.05$) between products at one storage day.

Experimental bio-yogurts demonstrated a gradual reduction of pH value (Fig. 2). Furthermore, it was found that goat's milk products had a lower value of this parameter in comparison with cow's milk products. The pH of goat's and cow's milk bio-yogurts varied respectively in the range from 4.19±0.01 to 4.56±0.06 and in the range from 4.50±0.03 to 4.99±0.06.

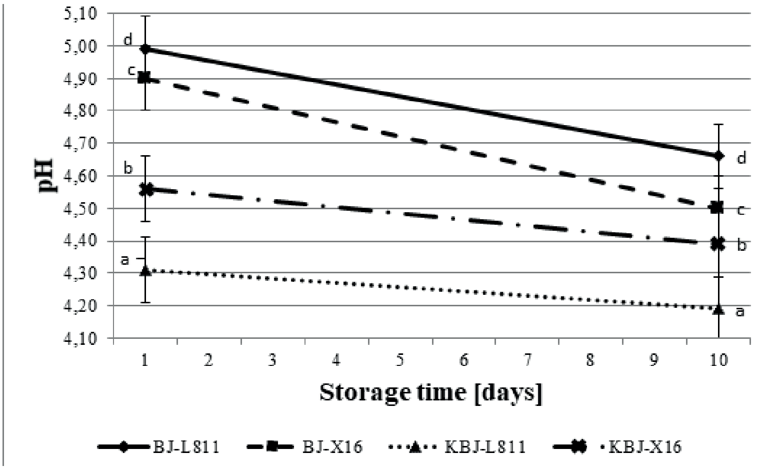

Fig.2. pH of bio-yoghurts from cow's (BJ-L811, BJ-X16) and goat's (KBJ-L811, KBJ-X16) milk during cooling storage. a,b,c,d – different letters indicate statistically significant differences ($p<0.05$) between products at one storage day.

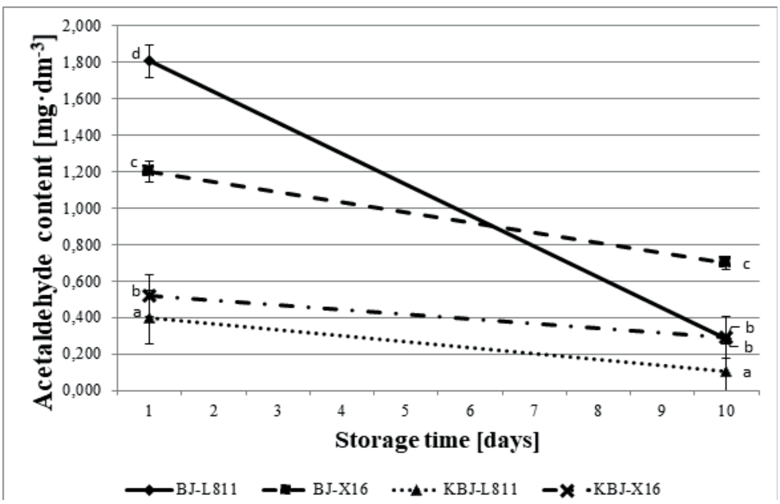

Fig. 3. Acetaldehyde content in bio-yoghurts from cow's (BJ-L811, BJ-X16) and goat's (KBJ-L811, KBJ-X16) milk during cooling storage. a,b,c,d – different letters indicate statistically significant differences ($p<0.05$) between products at one storage day.

One of the most important aroma compounds responsible for typical sensory properties of yogurt is acetaldehyde concentration [Xu *et al.* 2015]. The content of this compound in experimental bio-yogurts was found to be low and fell within the range of 0.104÷1.806 mg·dm^{-3} (Fig. 3). The beverages made from cow's milk showed significantly higher acetaldehyde contents than goat's milk products. After 1 day of storage the highest level of this aroma compound was quantified in the BJ-L811 sample made from cow's milk and containing the YE-L811 starter culture. At the end of the storage period, the sample with the highest acetaldehyde content was BJ-X16, also made from cow's milk, but containing a different starter culture, i.e. YC-X16. Analysis of the results regarding goat's milk bio-yogurts showed that product KBJ-X16 had a higher acetaldehyde content than product KBJ- L811 during the whole storage period. Performed statistical evaluation confirmed that the type of yogurt starter culture was the factor which determined ($P<0.05$) the level of acetaldehyde in both cow's and goat's milk bio-yogurts.

Texture analysis

In the texture profile analysis the following parameters were evaluated: hardness, adhesiveness, cohesiveness and gumminess. Nevertheless, only the hardness values were thoroughly analyzed in the study, which was due to the fact that this parameter influences other textural properties [Dmytrów 2012]. The hardness values of experimental beverages are presented in Figure 4. This study showed that bio-yogurts made from cow's milk were characterised with significantly higher ($P<0.05$) hardness compared with bio-yogurts from goat's milk.

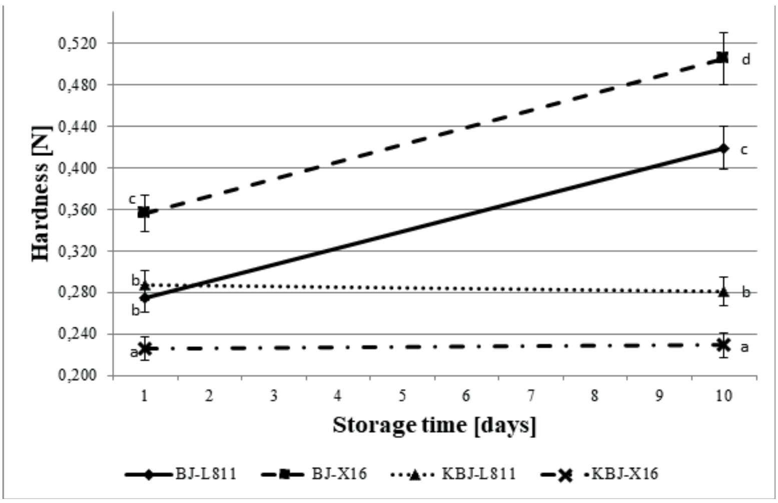

Fig. 4. Hardness of bio-yoghurts from cow's (BJ-L811, BJ-X16) and goat's (KBJ-L811, KBJ-X16) milk during cooling storage. a,b,c,d – different letters indicate statistically significant differences ($p<0.05$) between products at one storage day.

Taking into account the type of starter culture, in the case of cow's milk bio-yogurts products with the YC-X16 culture exhibited greater hardness (BJ-X16). In contrast, in the case of goat's bio-yogurts the YE-L811 (KBJ-L811) culture resulted in greater hardness. Performed analyses allowed to state that another factor which determined the changes in beverages' hardness was the time of refrigerated storage, which was also confirmed in other studies [Mituniewicz-Małek *et al.* 2013, Cheng *et al.* 2017].

Sensory evaluation

The results indicated that experimental bio-yogurts obtained from both goat's and cow's milk had desirable sensory characteristics throughout the 10-day refrigerated storage (Tab. 3). Taking into account products from cow's milk, the highest notes (3.83÷5.0 points) were given to bio-yogurt BJ-X16 made from cow's milk with the use of the YC-X16 yogurt starter culture as well as the LA-5 and BB-12 probiotic monocultures. This product was characterised by very good appearance without whey separation, a delicate, aromatic smell typical for fermented beverages and a mild taste. The consistency of this product was described as sticky and lumpy; however, after blending it was perceived positively. In the case of goat's milk beverages, better sensory attributes were reported for KBJ-X16 (3.67÷4.83 points), which production also involved the use of YC-X16, LA-5 and BB-12 starter cultures. This product was described as aromatic, with a slightly salty taste characteristic for goat's milk, which became more distinct after 10 days of storage and its flavour was typical for fermented milk. The consistency was dense, plain and free of liquid separation; however, after blending the curd was evaluated as too loose, but creamy. Negligibly lower notes of sensory analysis (3.5÷4.67 points) of the other bio-yogurts made from both cow's and goat's milk containing the YE-L811 starter culture and the LA-5 and BB-12 probiotic monocultures (variants BJ-L811 and KBJ-L811) were connected with their more sour taste and respectively too dense and too loose consistency, although the syneresis also did not appear.

Table 3. Results of sensory evaluation (5-point scoring method) of bio-yogurts from cow's and goat's milk

Product	Characteristics							
	appearance		taste		smell		consistency	
	time of storage (days)							
	1	10	1	10	1	10	1	10
BJ-L811	4.67 (0.58)	4.67 (0.58)	3.67 (0.29)	3.67 (0.29)	3.83 (0.76)	4 (0)	4.33 (0.29)	4.5 (0.50)
BJ-X16	5 (0)	5 (0)	3.83 (0.58)	3.83 (0.58)	4.5 (0.50)	4 (0)	4.83 (0.29)	4.67 (0.58)
KBJ-L811	4.5 (0.5)	4.5 (0.5)	3.83 (0.58)	3.83 (0.58)	4.67 (0.29)	4 (0)	4.33 (0.29)	3.83 (0.29)
KBJ-X16	4.83 (0.29)	4.83 (0.29)	3.67 (0.29)	3.67 (0.29)	4.67 (0.29)	4.17 (0.76)	4.67 (0.29)	3.67 (0.29)

BJ-X16 – bio-yogurt from cow's milk with yogurt culture YC-X16 and probiotic cultures LA-5 and BB-12; BJ-L811 – bio-yogurt from cow's milk with yogurt culture YE-L811 and probiotic cultures LA-5 and BB-12; KBJ-X16 – bio-yogurt from goat's milk with yogurt culture YC-X16 and probiotic cultures LA-5 and BB-12; KBJ-L811 – bio-yogurt from goat's milk with yogurt culture YE-L811 and probiotic cultures LA-5 and BB-12.

The high probiotic bacteria survivability exceeding 10^6 cfu/g is considered as an important requirement, which should be met in order to achieve declared health benefits. This number of bacteria should be maintained from the production through delivery system to the end of the shelf life of the product according to Codex Stan 243-2003. Other authors reported variable viability of lactic acid bacteria and probiotic strains of *L. acidophilus* and bifidobacteria in fermented goat's and cow's milk. This changeability is most likely connected with fluctuations in milk's composition and properties. The factors which especially affect bacteria viability include mineral compound contents, volatile fatty acid contents as well as protein composition [Shah *et al.* 1995, Gueimonde *et al.* 2004, Ziarno *et al.* 2011, Gomes *et al.* 2013, Mituniewicz-Małek *et al.* 2013, Mituniewicz-Małek *et al.* 2014, Mituniewicz-Małek *et al.* 2017]. Moreover, the divergences which can be observed among the results obtained in different studies may be explained by the features of used bacteria species and/or strains and their sensitivity to the parameters applied in the production process such as temperature and time of fermentation, oxygenation and availability of nutrients [Kailasapathy *et al.* 2008, Ziarno *et al.* 2011]. Mituniewicz-Małek *et al.* [2014] proved that goat's milk presents a good growth medium for probiotics *L. acidophilus* LA-5 and *B. animalis* subsp. *lactis* BB-12. The authors reported the viability of the above-mentioned bacteria strains at the level of 6 log cfu/g after 8 weeks of refrigerated storage at 5°C. Very good survival ability of *B. animalis* and *L. acidophilus* in fermented products made from goat's milk during their refrigerated storage (5-7°C for 10 days) was also stated by Kongo *et al*. [2006]. In the case of the changes in the count of bifidobacteria, the results obtained in this study are consistent with those found in works of other authors [Hadadji and Bensoltane 2006, da Silva *et al.* 2013]. Furthermore, the results related to *L. acidophilus* LA-5 find confirmation in another study on commercially produced or obtained in laboratory conditions yogurts [Li *et al.* 2006].

Among several physicochemical characteristics under study, the increase of titratable acidity during storage of goat's and cow's milk bio-yogurts was observed also in researches of other authors [Mituniewicz-Małek *et al.* 2013, Terpou *et al.* 2017, Turgut and Cakmakci 2017]. The literature suggests that post-acidification of fermented milk during refrigerated storage is caused by the metabolic activity of LAB, which despite being inhibited by low temperature, continues to occur [Baba *et al.* 2014]. Moreover, the decrease in pH value during storage of cow's and goat's milk bio-yogurts was confirmed in a number of studies [Guler-Akin and Akin 2007, SenakaRanadheera *et al.* 2012, Hrnjez *et al.* 2014, Turgut and Cakmakci 2017]. According to Kailasapathy *et al.* [2008], this phenomenon is due to the post-acidification process conducted by starter cultures of LAB and, as it is claimed by Hrnjez *et al.* [2014], may be connected with the increase of titratable acidity in fermented beverages. The pH of bio-yogurts was significantly ($P<0.05$) affected by the type of both milk and yogurt starter culture. Also the effect of storage period on the pH decrease in samples made from both types of milk was statistically significant ($P<0.05$). Current literature [Mituniewicz-Małek *et al.* 2015, Xu *et al.* 2015] also indicates statistically significant differences in the content of acetaldehyde in yogurts from cow's and goat's milk made with the use of different starter cultures.

The textural properties are some of the most significant quality characteristics of fermented dairy beverages and they extensively determine consumer's acceptability of the product [Cheng *et al.* 2017]. In regard to the hardness value of bio-yogurts, Miocinovic *et al.* [2016] in the study on goat's and cow's milk yogurts also noted a lower hardness value of the former goat's yogurt. Herrero and Requena [2005] stated that differences in the hardness of cow's and goat's yogurts may result from different chemical composition of both raw materials. Goat's milk is less abundant in casein than cow's milk and contains very small amounts of α_{s1} casein or is even characterized by its lack. Furthermore, casein micelles of goat's milk have a higher degree of dispersion. Apart from the type of milk, hardness of bio-yogurts was significantly affected by the type of yogurt starter culture used for their production, which finds confirmation in a study conducted by Zhang *et al.* [2016].

The higher sensory quality of fermented beverages from cow's than goat's milk reported in this manuscript is consistent with the results presented by Martín-Diana *et al.* [2003]. Moreover, at the end of storage period the sensory properties of analyzed bio-yogurts deteriorated. Numerous studies [Stratford 2006, Świątecka and Podsiadło 2007, Kowal 2014] confirm that with a prolonged refrigerated storage period, food quality deteriorates gradually and this trend also applies to fermented milk. Gradual deterioration of sensory properties in fermented goat's milk was stated also elsewhere [Mituniewicz-Małek *et al.* 2013, 2014, 2015, 2017] and it is due to the fact that during storage the goat's aftertaste becomes more intensive, consistency is becoming looser and the curd is more susceptible for liquid phase separation. The study performed by Salih *et al.* [2017], which concerned refrigerated storage of cow's milk yogurt, also indicated deterioration of sensory characteristics over the storage time connected with poorer consistency.

Conclusion

Goat's and cow's milk bio-yogurts investigated in the study demonstrated desirable sensory properties during the analyzed storage period. The results showed that the survivability of yogurt and probiotic microflora was similar in products from both types of milk. In the case of *Lactobacillus* sp. and *S. thermophilus*, their count in all analyzed products exceeded 8 log (cfu/g) during 10-day refrigeration. Whereas the count of probiotic bacteria in bio-yogurts from both types of milk directly after production amounted to 6.1 log (cfu/g) for *L. acidophilus* and 8.1 log (cfu/g) for *Bifidobacterium* sp., after 10-day storage the count of probiotic bacteria declined to 5.9 log (cfu/g) and 7.9 log (cfu/g), respectively. The study allows to conclude that physicochemical and rheological properties of cow's and goat's milk fermented beverages are significantly affected by the type of yogurt starter culture as well as the refrigerated storage time. However, the research should be regarded as preliminary.

REFERENCES

1. AFFANE A.L.N., FOX G.P., SIGGE G.O., MANLEY M., BRITZ T.J., 2011 – Simultaneous prediction of acidity parameters pH and titratable acidity in kefir using near infrared reflectance spectroscopy. ***International Dairy Journal*** 21, 11, 896-900.
2. BABA A.S., NAJARIAN A., SHORI A.B., LIT K.W., KENG G.A., 2014 – Viability of lactic acid bacteria, antioxidant activity and in vitro inhibition of angiotensin-I-converting enzyme of lyciumbarbarum yogurt. ***AJSE*** 39, 5355-5362.
3. BÓRAWSKI P., PAWLEWICZ A., PARZONKO A., HARPER J.K., HOLDEN L., 2020 – Factors shaping cow's milk production in the EU. ***Sustainability*** 12, 420, 2-15.
4. BRODZIAK A., KRÓL J., WOLANCIUK A., BARŁOWSKA J., KĘDZIERSKA-MATYSEK M., 2018 – Quality assessment of fermented milk beverages produced with milk of Simmental cows kept on organic farms. 13th International Scientific Conference Food of the 21st century 'Food and bioactive compounds' (Konferencja Naukowa z cyklu Żywność XXI Wieku „Żywność a składniki bioaktywne''), Cracow, Poland, 44-51. In Polish.
5. CHENG J., XIE S., YIN Y., FENG X, WANG S., GUO M., NI C., 2017 – Physiochemical, texture properties, and the microstructure of set yogurt using whey protein – sodium tripolyphosphate aggregates as thickening agents. ***Journal of the Science of Food and Agriculture*** 97, 2819-2825.
6. Codex Standard For Fermented Milks, 2010 – Codex Stan 243-2003. Adopted in 2003. Revision 2008, 2010. Accessed July 01, 2017. http://www.codexalimentarius.net/download/standards/400/CXS_243e.pdf.
7. COSTA R.G., BELTRÃO FILHO E.M,SOUSA S., CRUZ G.R.B., QUEIROGA R.C.R.E., CRUZ E.N., 2016 – Physicochemical and sensory characteristics of yoghurts made from goat and cow milk. ***Animal Science Journal*** 87, 703-709.
8. DA SILVA D.C.G., BRUGNERA D.F., DE ABREU L.R., 2013 – Quantification of lactic acid bacteria and bifidobacteria in goat milk based yoghurts with added water-soluble soy extract. ***African Journal of Food Science*** 7, 10, 392–398.
9. DMYTRÓW I., 2012 – Selected technological factors as determinants of sensory quality and storage stability of acid curd cheeses. West Pomeranian University of Technology Publishing House, ISBN 978-83-7663-131-8. Szczecin, Poland. In Polish.
10. DOPIERALSKA P., BARŁOWSKA J, TETER A., KRÓL J., BRODZIAK A., DOMARADZKI P., 2020 – Changes in fatty acid and volatile compound profiles during storage of Smoked Cheese Made from the Milk of Native Polish Cow Breeds Raised in the Low Beskids. ***Animals*** 10, 3-15.
11. EISSA E.A., BABIKER E.E., YAGOUB A.E.A., 2011 – Physicochemical, microbiological and sensory properties of Sudanese yoghurt (zabadi) made from goat's milk. ***Animal Production Science*** 51, 53-59.
12. FAO, 2019 – Food and Agriculture Organization of the United Nations bhttp://www.fao.org/home/search/en/?q=%2027%2F5000%20sheep%20and%20goat%20milk%20production, availability: 28.01.2021.
13. FAO, 2020 – Food and Agriculture Organization of the United Nations http://www.fao.org/dairy-production-products/production/dairy-animals/en/, availability: 28.01.2021.
14. GOMES J.J.L., DUARTE A.M., BATISTA A.S.M., DE FIGUEIREDO R.M.F., DE SOUSA E.P., DE SOUZA E.L., QUEIROGA R.C.R.E., 2013 – Physicochemical and sensory properties of fermented dairy beverages made with goat's milk, cow's milk and a mixture of the two milks. ***LWT – Food Science and Technology*** 54, 18-24.
15. GUEIMONDE M., DELGADO S., MAYO B., RUAS-MADIEDO P., MARGOLLES A., DE LOS REYES-GAVILN C.G., 2004 – Viability and diversity of probiotic Lactobacillus and Bifidobacterium population included in commercial fermented milks. ***Food Research International*** 37, 9, 839-850.

16. GULER-AKIN M.B., AKIN M.S., 2007 – Effects of cysteine and different incubation temperatures on the microflora, chemical composition and sensory characteristics of bio-yogurt made from goat's milk. ***Food Chemistry*** 100, 2, 788-793.
17. HADADJI M., BENSOLTANE A., 2006 – Growth and lactic acid production by Bifidobacterium longum and Lactobacillus acidophilus in goat's milk. ***African Journal of Biotechnology*** 5, 6, 505-509.
18. HERRERO A.M., REQUENA T., 2006 – The effect of supplementing goats milk with whey protein concentrate on textural properties of set-type yoghurt. ***International Journal of Food Science and Technology*** 41, 87-92.
19. HRNJEZ D., VAŠTAG Ž., MILANOVIC S., VUKIC V., ILICIC M., POPOVIC L., KANURI K., 2014 – The biological activity of fermented dairy products obtained by kombucha and conventional starter cultures during storage. ***Journal of Functional Food*** 10, 336-345.
20. ISO 1871:2009, 2009 – Food and feed products - General guidelines for the determination of nitrogen by the Kjeldahl method. Geneva, Switzerland: International Organization of Standardization (ISO).
21. ISO 2446:2008, 2008 – Milk – Determination of fat content. Geneva, Switzerland: International Organization of Standardization (ISO).
22. ISO 6658:2017, 2017 – Sensory analysis - Methodology - General guidance. Geneva, Switzerland: International Organization of Standardization (ISO).
23. ISO 7889:2003, 2003 – Yogurt – Enumeration of characteristic microorganisms – Colony-count technique at 37 degrees C. General guidance. Geneva, Switzerland: International Organization of Standardization (ISO).
24. JÓŹWIK A., STRZAŁKOWSKA N., BAGNICKA E., ŁAGODZIŃSKI Z., PYZEL B., CHYLIŃSKI W., CZAJKOWSKA A., GRZYBEK W., SŁONIEWSKA D., KRZYŻEWSKI J., HORBAŃCZUK J.O., 2010a – The effect of feeding linseed cake on milk yield and milk fatty acid profile in goats. ***Animal Science Papers and Reports*** 28 (3), 245-251.
25. JÓŹWIK A., BAGNICKA E., KRZYŻEWSKI J., HORBAŃCZUK K., PYZEL B., SŁONIEWSKA D., HORBAŃCZUK J.O., 2010b – The concentration of free fatty acids in goat milk as related to the stage of lactation, age and somatic cell count. ***Animal Science Papers and Reports*** 28 (4), 389-396.
26. KAILASAPATHY K., HARMSTORF I., PHILLIPS M., 2008 – Survival of Lactobacillus acidophilus and Bifidobacterium animalis ssp. lactis in stirred fruit yogurts. ***LWT-Food Science and Technology*** 41, 1317-1322.
27. KONGO J.M., GOMES A.M., MALCATA F.X., 2006 – Manufacturing of fermented goat milk with a mixed starter culture of Bifidobacterium animalis and Lactobacillus acidophilus in a controlled bioreactor. ***Letters in Applied Microbiology*** 42, 6, 595-599.
28. KOWAL K., 2014 – Food Spoilage by Yeasts. ***Przemysł Spożywczy*** 68, 11, 30-32. In Polish.
29. KRÓL J., WAWRYNIUK A., BRODZIAK A., BARŁOWSKA J., KUCZYŃSKA B., 2020 – The effect of selected factors on the content of fat-soluble vitamins and macro-elements in raw milk from Holstein-Friesian and Simmental cows and acid curd cheese (Tvarog). ***Animals*** 10, 1800.
30. LEES G.J., JAGO G.R., 1969 – Methods for the estimation of acetaldehyde in cultured dairy products. ***Australian Journal of Dairy Technology*** 24, 181-185.
31. LI S., GOKAVI S., GUO M.R., 2006 – Selective enumeration of different strains of Lactobacillus acidophilus in goats' milk yogurt beverage. ***Journal of Dairy Science*** 89 (Suppl.1.), 182.
32. MARTÍN-DIANA A.B., JANER C., PELÁEZ C., REQUENA T., 2003 – Development of a fermented goat's milk containing probiotic bacteria. ***International Dairy Journal*** 13, 827-833.
33. MILLER B.A., LU CH.D., 2019 – Current status of global dairy goat production: an overview. ***Asian-Australasian Journal of Animal Science*** 8, 32, 1219-1232.
34. MIOCINOVIC J., MILORADOVIC Z., JOSIPOVIC M., NEDELJKOVIC A., RADOVANOVIC M., PUDJA P., 2016 – Rheological and textural properties of goat and cow milk set type yoghurts. ***International Dairy Journal*** 58, 43-45.

35. MITUNIEWICZ-MAŁEK A., DMYTRÓW I., BALEJKO J., ZIARNO M., 2013 – Commercial probiotic Lactobacillus sp. cultures (*Lb. paracasei, Lb. casei* and *Lb. acidophilus*) in fermented drinks made from goat's milk***. Żywność. Nauka. Technologia. Jakość.*** 3, 88, 99-110. In Polish, with English summary.
36. MITUNIEWICZ-MAŁEK A., ZIARNO M., DMYTRÓW I., 2015 – Application of frozen goat's milk to production of potentially probiotic fermented drink. ***Żywność. Nauka. Technologia. Jakość.*** 6, 103, 140-149 In Polish, with English summary.
37. MITUNIEWICZ-MAŁEK A., ZIARNO M., DMYTRÓW I., 2014 – Incorporation of inulin and transglutaminase in fermented goat milk containing probiotic bacteria. ***Journal of Dairy Science*** 97, 6, 3332–3338.
38. MITUNIEWICZ-MAŁEK A., ZIARNO M., DMYTRÓW I., BALEJKO J., 2017 – Effect of the addition of Bifidobacterium monocultures on the physical, chemical, and sensory characteristics of fermented goat milk***. Journal of Dairy Science*** 100, 9, 6972-6979.
39. PN-EN ISO 6887-5:2020-10, 2020 – Microbiology of food and animal feeding stuffs – Preparation of test samples, initial suspension and decimal dilutions for microbiological examination. Part 5: Specific rules for the preparation of milk and milk products. Geneva, Switzerland: International Organization of Standardization (ISO).
40. PROSSER C. G., 2021 – Compositional and functional characteristics of goat milk and relevance as a base for infant formula. ***Journal of Food Science*** 2, 86, 257-265.
41. SALIH M.A.M., ABDALLA M.O.M., 2017 – Physicochemical and sensory characteristics of stirred yoghurt flavoured with mango (*Mangifera indica* L.) During Storage Period. ***Pakistan Journal of Nutrition*** 16, 5, 378-383.
42. SALVADOR A., FISZMAN S.M., 2004 – Textural and sensory characteristics of whole and skimmed flavoured set-type yoghurt during long storage. ***Journal of Dairy Science*** 87, 12, 4033-4041.
43. SENAKA RANADHEERA C., EVANS C.A., ADAMS M.C., BAINES S.K., 2012 – Probiotic viability and physico-chemical and sensory properties of plain and stirred fruit yogurts made from goat's milk. ***Food Chemistry*** 135, 1411-1418.
44. SHAH N.P., LANKAPUTHRA W.E.V., BRITZ M.L., KYLE W.S.A., 1995 – Survival of Lactobacillus acidophilus and Bifidobacterium bifidum in commercial yoghurt during refrigerated storage. ***International Dairy Journal*** 5, 5, 515-521.
45. STRATFORD M., 2006 – Food and beverage spoilage yeasts. In: Yeasts in food and beverages. Fleet G.H., Querol A., (eds.). Berlin, Heidelberg, Germany: Springer Verlag 335-380.
46. STRZAŁKOWSKA N., JOŹWIK A., BAGNICKA E., KRZYŻEWSKI J., HORBAŃCZUK J.O., 2009a – Studies upon genetic and environmental factors affecting the cholesterol content ion cow milk. I: Relationship between the polimorfic form of beta-lactoglobulin, somatic cell count, cow age and stage of lactation and cholesterol content of milk. ***Animal Science Papers and Reports*** 27 (2), 95-105.
47. STRZAŁKOWSKA N., JÓŹWIK A., BAGNICKA E., KRZYŻEWSKI J., HORBAŃCZUK J.O., 2009b – Studies upon genetic and environmental factors affecting the cholesterol content ion cow milk. II. The effect of silage type offered. ***Animal Science Papers and Reports*** 27 (3), 199-206.
48. STRZAŁKOWSKA N., JÓŹWIK A., BAGNICKA E., KRZYŻEWSKI J., HORBAŃCZUK K., PYZEL B., HORBAŃCZUK J.O., 2009c – Chemical composition, physical traits and fatty acid profile of goat milk as related to the stage of lactation. ***Animal Science Papers and Reports*** 27 (4), 263-272.
49. SÜLE J., KÕRÖSI T., HUCKER A., VARGA L., 2014 – Evaluation of culture media for selective enumeration of bifidobacteria and lactic acid bacteria. ***Brazilian Journal of Microbiology*** 45, 3, 1023-1030.

50. ŚWIĄTECKA D., PODSIADŁO H., 2007 – Demands on food packaging and methods of its testing. ***Opakowanie*** 9, 50-55. In Polish, with English summary.
51. SZKOLNICKA K., DMYTRÓW I., MITUNIEWICZ-MAŁEK A., 2020 – Buttermilk ice cream - New method for buttermilk utilization. ***Food Science and Nutrition*** 8, 3, 1461-1470.
52. TERPOU A., BEKATOROU A., KANELLAKI M., KOUTINAS A.A., NIGAM P., 2017 – Enhanced probiotic viability and aromatic profile of yogurts produced using wheat bran (Triticum aestivum) as cell immobilization carrier. ***Process Biochemistry*** 55,1-10.
53. THANH L.P., SUKSOMBAT W., 2015 – Milk yield, composition, and fatty acid profile in dairy cows fed a high-concentrate diet blended with oil mixtures rich in polyunsaturated fatty acids, ***Asian-Australasian Journal of Animal Science*** 28, 796-806.
54. TURGUT T., CAKMAKCI S., 2017 – Probiotic strawberry yogurts: microbiological, chemical and sensory properties. ***Probiotics and Antimicrobial Proteins*** 10, 1, 64-70.
55. VARGAS M., CHÁFER M., ALBORS A., CHIRALT A., GONZÁLEZ-MARTÍNEZ C., 2008 – Physicochemical and sensory characteristics of yoghurt produced from mixtures of cows' and goats' milk. ***International Dairy Journal*** 18, 1146-1152.
56. WILLER H., LERNOUD J., 2019 – The world of organic agriculture. Statistics and emerging trends. FiBL & IFOAM, Frick and Bonn.
57. WITCZAK A., MITUNIEWICZ-MAŁEK A., DMYTRÓW I., 2013 – Assessment of daily intake of organochlorine pesticides from milk in different regions of Poland. ***Journal of Environmental Science and Health*** 48, 83-91.
58. XU Z, LI S., GONG G., LIU Z., WU Z., MA C., 2015 – Influence of different acidifying strains of lactobacillus delbrueckii subsp. bulgaricus on the Quality of Yoghurt. ***Food Science and Technology Research*** 21, 2, 263-269.
59. ZHANG L., FOLKENBERG D.M., AMIGO J.M., IPSEN R., 2016 – Effect of exopolysaccharide-producing starter cultures and post-fermentation mechanical treatment on textural properties and microstructure of low fat yoghurt. ***International Dairy Journal*** 53, 10-19.
60. ZIARNO M., ZARĘBA D., ŚCIBISZ I., 2011 – Viability of probiotic lactic acid bacteria in model fruit yoghurts. ***Bromatologia i Chemia Toksykologiczna*** 44, 3, 645-649. In Polish.