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SHAPING OF SELECTED MILK QUALITY PARAMETERS OF OLKUSKA SHEEP AS AFFECTED BY GRAZING IN XEROTHERMIC GRASSLANDS OF *FESTUCO-BROMETEA CLASS*

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Chemical composition of sheep milk depends on various factors, both environmental and physiological ones. The first ones are shaped by nutrition and climatic conditions while physiological factors include, among others, lactation phase. The purpose of the study was to analyse the chemical composition of milk from the Olkuska sheep in the final lactation period that were grazed on xerothermic grasslands of the Festuco-Brometea class (groups II and III). Control group (group I) included ewes of the Olkuska sheep fed on intensively used grasslands. The material for testing was raw milk collected during the morning milking. The collected samples were analysed, inter alia, for chemical composition, fatty acid profile, and the level of retinol and α-tocopherol. The collected data were statistically analysed by using one-way analysis of variance. The significance of the differences between the experimental groups was estimated by using the Duncan test, at the level of P≤0.01 and P≤0.05, which was performed with the use of Statistica 12 statistical software package. Moreover, the botanical composition as well as the chemical properties of green forage from those 3 groups were assessed. The results have shown that selected milk parameters for groups II and III, such as solids content, vitamin A and calcium level, were higher than for the control group (I) that was fed on the green forage of a very good value (Lwu=9.3).

Key words: milk quality, type of forage, Olkuska sheep

The parameters of sheep milk are shaped by various factors, including genetic, physiological and environmental ones. Previous studies on the content of individual milk components have shown that sheep milk is characterised by a higher content of solids in comparison to cow and goat milk. A significant amount of solids determines its suitability for processing, especially in the production of cheese and yoghurts. Furthermore, sheep milk has a high content of micro- and macroelements, vitamins, protein and fat, the latter containing proportionally considerably more free fatty acids than cow milk fat (Konieczny, 2009; Danków and Pikul, 2011; Bielińska-Nowak and Czyżak-Runowska, 2016). Dairy use of

sheep occurs in Polish conditions only in mountainous areas and in the foothills. However, upland areas often characterised by the presence of significant differences in relative heights, in the form of steep hills, not very suitable for agricultural production, are also well-suited for the breeding of these ruminants.

To the north of Krakow, the landscape of the Miechowska Upland is characterised by a fairly large waving of land, with the presence of chalk and limestone slopes, offering excellent conditions for the development of thermophilic grasslands from the *Festuco-Brometea* class (Matuszkiewicz, 2002). They occur by spots, adjacent to numerous arable fields and communities of warm forests and shrubbery. Due to the unique natural values of these plant communities, a dozen or so areas of Natura 2000 special protection habitats have been established in the Miechowska Upland. Their active protection is based on sheep grazing which, as light and agile animals, can use hard-to-reach pastures. At the same time, it ensures the sustainability of such semi-natural ecosystems because grazing animals reduces plant biomass and moves soil, which improves conditions for the development of xerothermic vegetation (Barańska, 2014).

Feeding sheep in the summer season is based on the maximum use of various types of grasslands (Nazaruk et al., 2009). The high quality and the cheapest fodder is mainly provided by permanent grassland, including meadows and pastures which during the vegetation period can be the only source of food for these animals. However, sheep as animals with a relatively broad spectrum of feed intake may also successfully use poorer pastures. As a result, they can be grazed on various types of grasslands, also other than conventional lowland or mountain pastures. Good applications can also be found here for xerothermic grasslands characterised by a different species composition than the rest of the grasslands and showing a large share of rare and residual species of vascular plants (Kostuch and Misztal, 2007). There are, however, relatively few reports about sheep grazing on such thermophilic grasslands. Therefore, it seems justified to include these grasslands as terrains where the grazing should be carried because the requirements of natural environment protection predispose the sheep as a natural participant in the economic processes within these areas.

The domestic breeds of sheep, such as the Olkuska sheep, supplying milk, meat, wool and hides, are considered to be perfectly adapted to local environmental conditions. However, the changing needs and requirements of consumers towards sheep products forced the replacement of local low-productivity sheep breeds with high yielding breeds in the second half of the twentieth century. This led to the gradual disappearance of the Olkuska sheep, which is a domestic variation of the long-wool sheep bred in the inter war period on the territory of the former Olkusz poviat. This breed is characterised by resistance to diseases and difficult environmental conditions as well as good milk yield (Murawski, 2011, Smętek and Korczyński, 2011, Sorkora, et al., 2015).

The purpose of the work was to analyse and compare the parameters of milk from the Olkuska sheep based on the quality composition of collected xerothermic grass and intensive grasslands use.

Materials and methods

The research was carried out in years 2016-2017 on three different farms maintaining sheep of the domestic breed, located in the Miechowski and Olkuski poviats (Tab. 1). The selection of sites for research was intentional, two farms located in the Miechowski poviat, directly adjacent to special areas of habitat protection. These are Natura 2000 areas: Chodów-Falniów (CF) and Cybowa Góra (CG). Within them, the habitats of xerothermic grasslands are protected, where extensive sheep grazing was introduced. The third farm, which is a control group, is located in the Olkuski poviat in Imbramowice (I), where the sheep collected feed coming from intensive grasslands use. Physiographically, the research area is included within two mesoregions, the Miechowski Upland and the Olkuski Upland. The border between them is determined by a line separating the occurrence of resistant Upper Jurassic limestones from less resistant Cretaceous marls, partially masked by the loess cover (Kondracki, 2009).

The total of 60 ewes of the Olkuska breed, kept in the traditional alcove-pasture system, were selected for the experiment. The research was carried out in summer season feeding conditions (June-July) due to the developmental optimum of thermophilic grasslands at that time. Since the turn of April/May animals from all the farms were kept within the pastures. The test material consisted of raw milk of sheep origin collected during milking in the final lactation period (above the 160th day of lactation). In order to carry the analyses, the milk was transported to a laboratory in chilled conditions. The collected samples were analysed for fatty acid profile in milk by gas chromatography with flame ionisation detection (GC-FID) (PN-EN ISO 12966-1: 2015-01, PN-EN ISO 12966-2: 2011 excluding 4.3 and 4.5); the level of retinol and α-tocopherol in milk by high-performance liquid chromatography with fluorescence detection (HPLC-FLD) (PB-40 / HPLC ed. III of 28.02.2009); the content of selenium and calcium in milk by means of microwave mineralisation method (PB-223 / ICP, ed. II of 12.01.2015); chemical composition of milk (% of total protein,% fat,% lactose,% solids and urea content in mg/l) by instrumental, spectrophotometric method using the Milco-scan FT 6000 apparatus (test procedure No. 17, edition 01.01.2012). The collected data were statistically analysed by using one-way analysis of variance. The significance of the differences between the experimental groups was estimated by using the Duncan test, at the level of $P \leq 0.01$ and $P \leq 0.05$, which was done using Statistica 12 statistical package.

Table 1. Description of the studied area and farms

Specification	Place of grazing		
	Imbramowice (I)	Cybowa Góra (CG)	Chodów-Falniów (CF)
	Gr. I – Control group	Gr. II	Gr. III
Location of farms:			
county	olkuski	miechowski	
commune	Trzyciąż	Słaboszów	Charsznica
Physiographic division:			
macroregion	Wyżyna Krakowsko-Częstochowska	Niecka Nidziańska	
mesoregion	Wyżyna Olkuska	Wyżyna Miechowska	
Number of farms	1	1	1
Number of ewes	20	20	20
Type of forage	pasturage	pasturage + meadow hay	
Start of grazing	the turn of April and May		
Type of habitat	intensive grassland	xerothermic grassland	

The botanical composition of xerothermic grasslands and intensive greenery use was estimated using the Klapp method (1962). Botanical inventories were made at the beginning of July in 2016 and 2017, and at the same time when milk samples for the analysis were taken. In each grazing place, 5 such inventories were made, each on the area of 100 m². The Latin and Polish nomenclature was used according to Mirka et al. (2002). The types of plant communities were determined according to Matuszkiewicz (2002), and their use value (Lwu), was given based on the values assigned to particular species and their percentage share in the pasture (Filipek, 1973). Also, the grazing fodder samples were tested from groups I, II and III (tab. 1). The yield of the pasture was assessed by cutting the plants at the area of 1 m² at a height of several cm, in 2 replicates selected at random. The collected representative plant samples were dried to determine the solids content. They were also evaluated for the content of nutrients such as general protein, crude fat, crude ash and crude fibre. The solids were determined by the drying method at 105°C, the basic chemical composition by the AOAC method (2003) and the share of the fibre fraction (ADF, NDF) according to van Soest et al. (1991) using ANCOM 220.

Results

The botanical composition of the pasture and the chemical composition of forage fodder

Group I included pastures of intensive use, which originated from the sowing of a mixture consisting of 14 species of plants (tab. 2). The dominant species included Lolium multiflorum L., representing, on average, 70% of its yield, Onobrychis viciifolia Scop. (15%), *Festuca pratensis* L. (5%) and *Trifolium pratense* L. (5%). They are characterised by a good and very good use value. The

economic value of this community expressed in the Lwu was 9.3, on average, which classifies it as a very good pasture, and the average yield from 1 m² was 1.115 kg. Groups II and III were characterised by the presence of vegetation from the *Festuco-Brometea* BR class. BL. et R.Tx. 1943 and its group *Inuletum ensifoliae* KOZŁ. 1925 (Matuszkiewicz, 2002). This community creates quite low flowery grasslands, composed of extremely limestone and thermophilic plants found on shallow rendzinas. The most important species for this group, such as: *Aster amellus* L., *Cirsium pannonicum* L. and *Linum hirsutum* L. are rare components of Polish flora and are protected species. In the botanical inventories made for the areas of Cybowa Góra and Chodów-Falniów, the average number of species of vascular plants was 35 and 38 species, respectively. The dominant species included *Brachypodium pinnatum L.,* constituting in groups II and III, on average, 30 and 40% of the grassland yield, *Inula ensifolia L.* with the average grassland yield of 10 and 15% and *Cruciata glabra L.,* with the share, respectively, 10 and 5%. Other species, whose share fluctuated from trace amounts (+) up to 5%, and which influenced the improvement of the utility value of the community are primarily leguminous plants, such as: *Anthyllis vulneraria* L., *Lotus corni- culatus* L., *Medicago falcata* L. or *Trifolium repens* L. and grass: *Festuca pratensis* L, *Lolium multiflorum* L., *Avenula pubescens* L. The average economic value of this community expressed in Lwu, was 3.7 and 3.5 for the analysed groups, which classifies it as wasteland. The average yield of sward was for group II 0.550 kg/m², while for group III, 0.985 kg/m², respectively.

During the research period, the content of crude fat in green fodder from the analysed groups was relatively stable in particular years. The values of plant samples from the *Inuletum ensifoliae* community (groups II and III) were higher as compared to the control group (I) (tab. 3). On the other hand, samples from thermophilous grasslands contained significantly less crude ash and general protein than those of intensive green use. For crude ash, these values in the green from group I were 113.6 g/kg of solids on average, while for forage group II, 81.5 g/kg of solids and 97.3 g/kg of solids for forage from group III. The average results for these groups regarding the total protein in green fodder were as follows: group I – 188.5 g/kg of solids, group II – 69.8 g/kg of solids, and group III - 85.4 g/kg of solids. The highest crude fibre content was found in green grass from group II (on average in 2016 and 2017 - 368.3 g/kg of solids). The average share of fibre fraction in particular years in green fodder of group I was in the range of 526.1 - 534.4 (NDF) and 418.7 - 421,7 g/kg of solids (ADF). In green fodder from grasslands of the *Festuco-Brometea* class, the content of the fibre fraction was in the particular years from 624.5-666.0 (NDF) and 435.3- 438.7 g/kg of solids (ADF) for group II and 421.1 - 435.7 (NDF) and 323.5-340.3 g/kg of solids (ADF) for group III.

Table 2. Botanical composition of sward from xerothermic and intensive grasslands (%)

Specification		Place of grazing		
		I (Gr. I)	CG (Gr. II)	CF (Gr. III)
1	2	3	4	5
		No. of relevés		
		5	5	5
		Mean no. of species		
		14	35	38
		Mean yield of the sward (kg/m²)		
		1,115	0,550	0,985
Species	Lwu	**Mean coverage in %**		
1	2	3	4	5
Agrimonia eupatoria L.	2	·	1	+
Anthericum ramosum L.	0	·	1	10
Anthyllis vulneraria L.	5	·	1	+
Asperula cynanchica L.	1	·	1	1
Aster amellus L.	1	·	5	2
Avenula pubescens L.	4	·	1	1
Brachypodium pinnatum L.	3	·	30	40
Briza media L.	5	+	+	+
Campanula glomerata L.	4	·	1	+
Carlina acaulis L.	0	·	5	1
Cirsium arvense L.	0	·	·	·
Cirsium pannonicum L.	0	·	·	+
Convolvulus arvensis L.	4	+	·	·
Coronilla varia L.	-1	·	5	2
Cruciata glabra L.	3	·	10	5
Daucus carota L.	4	1	1	1
Festuca ovina L.	3	·	5	5
Festuca rubra L.	5	2	5	5
Festuca pratensis L.	10	5	+	+
Heracleum sphondylium L.	6	+	·	+
Hypericum perforatum L.	2	·	5	1
Hypochoeris maculata L.	1	·	+	+
Inula ensifolia L.	3	·	10	15
Leucanthemum vulgare LAM.	2	·	+	+
Linum hirsutum L.	0	·	1	+
Lolium multiflorum L.	9	70	+	+
Lotus corniculatus L.	9	+	5	·
Medicago falcata L.	7	·	+	+
Melampyrum arvense L.	-1	·	1	·

Table 2 contd.

1	2	3	4	5
Onobrychis viciifolia Scop.	9	15	·	+
Picris hieracioides L.	3	·	1	1
Pimpinella saxifraga L.	5	1	5	1
Plantago lanceolata L.	7	2	+	+
Plantago media L.	2	·	+	+
Polygala comosa SCHKUHR	1	·	+	+
Potentilla arenaria BORKH.	1	·	1	+
Salvia verticillata L.	3	·	5	1
Sanguisorba minor Scop.	5	·	1	+
Scabiosa ochroleuca L.	3	·	+	+
Taraxacum officinale F.H. Wiggers	6	+	·	·
Trifolium pratense L.	9	5	+	+
Trifolium repens L.	10	+	·	+
Vicia angustifolia L.	6	·	·	+
Mean forage value:		9,3	3,7	3,5

Explanations to the table: **Lwu** – forage value, + - mean coverage less than 1%.

Table 3. Selected components of the green forage (g/kg s.m.)

Specification	Place of grazing					
	I (Gr. I)		CG (Gr. II)		CF (Gr. III)	
	Years					
	2016	2017	2016	2017	2016	2017
Crude fat	10,7	11,5	16,3	15,8	26,0	23,1
Crude ash	115,2	112,0	80,4	82,6	99,4	95,1
Crude protein	189,2	187,7	68,3	71,2	86,3	84,5
Crude fibre	328,6	321,1	370,7	365,8	250,5	268,3
Fibre fractions						
NDF	534,4	526,1	686,0	624,5	421,1	435,7
ADF	421,7	418,7	435,3	438,7	323,5	340,3

Chemical composition of raw milk

In the case of percentage protein content in sheep milk from animals grazed on intensive greenlands (group I) and *Festuco-Brometea* community (groups II and III), its highest share for the last two groups was recorded on average (5.73 and 5.53%, respectively). This value was the lowest for group I (4.97%), with $P \leq 0.05$ (tab. 4). A similar trend was observed in the percentage content of fat. Milk from sheep grazed on phototrophic grasslands contained 6.57 and 6.55% fat, respectively, while on intensive greenlands - 3.97%. The differences between groups I and II and III were statistically highly significant. The highest lactose value occurred in the milk from group II and it was higher by 65.4% as compared

to the milk from group I and by 52.7% to the milk from group III. The differences among these groups were statistically highly significant (P≤0.01). The milk of sheep belonging to group II was characterised by the highest urea level. The value of this parameter was 51.5% (group I) and 43.2% higher (group III), at P≤0,05. A similar dependency occurred in the case of the percentage of solids in sheep milk. The average level of solids in milk from groups II and III and, therefore, in sheep milk grazed on xerothermic grasslands, was, respectively, 17.67% and 15.85%, while for group I this value was 11.70%. The differences between group I and groups II and III were statistically highly significant, at P≤0.01.

Table 4. Chemical composition of the Olkuska sheep's milk

Specification	Place of grazing			SEM
	I (Gr. I)	CG (Gr. II)	CF (Gr. III)	
Protein (%)	4,97 a	5,73 b	5,53	0,001
Fat (%)	3,97 A	6,57 B	6,55 B	0,005
Lactose (%)	1,50 A	4,33 B	2,05 C	0,004
Urea (mg/l)	221,33 a	456,67 b	259,50 a	32,52
Solids (%)	11,70 A	17,67 B	15,85 B	0,01

a, b, c – values in rows with different letters differ significantly (P≤0.05).
A, B, C – values in rows with different letters differ highly significantly (P≤0.01).

Fatty acids profile

Milk from sheep grazing in Imbramowice (group I) was characterised by a statistically significantly higher content of butyric acid (C4: 0) in comparison with milk from other groups (Tab. 5). In the case of lauric acids (C12: 0) and myristic acids (C14: 0), the highest level was found in milk from groups II and III, and the lowest in group I, at P≤0.01. A similar trend was observed with acid C15: 0. The largest fraction of saturated fatty acids in all the analysed groups was palmitic acid (C16: 0), whose average content was 28.5 g/100 g fat. The content of margaric acid (C17: 0) differed depending on the type of pasture. Statistically highly significant differences were found between all the groups. The highest amount of this fatty acid was recorded in group II, and the lowest in group I. The highest share of stearic acid (C18: 0) was found in sheep milk grazed in the Imbramowice area, and the lowest from Chodów-Falniów area, at P≤0.05. Despite the differences in the fraction of individual fatty acids, there were no statistically significant differences in the total of saturated fatty acids (P> 0.05). The share of individual mono-unsaturated fatty acids (MUFA) in sheep milk differed only in the case of acid C14: 1. The highest values were found in group III. The differences between this group and the others were statistically highly significant. Despite the lack of statistical confirmation in the case of the total MUFA fraction, milk from sheep grazed in the Imbramowice area tended to have a higher content of these acids by 4.1% (group II) and 12.6% (group III). Analysing the share of

individual poly-unsaturated fatty acids (PUFA), the differences in the content of linoleic acid were observed. The content of acid C18: 2 was the highest in groups I and II (on average 2.88 g), and the lowest in group III (on average 2.50 g). Statistical differences were highly significant in the case of linolenic acid, where the highest value was recorded in group II as compared to groups I and III. The highest content of PUFAs in sheep milk was observed in group II and was higher by 18.7% (group I) and 40.3% higher (group III), at P≤0,01. Analysing data on the amount of omega-3 acids in sheep milk, the largest share was recorded in the milk of sheep grazed in the Cybowa Góra area. The differences between this group and the others were statistically highly significant. On the other hand, in the case of omega-6 acids, the largest share of this fraction was characteristic for groups I and II in comparison with group III - where the lowest values were recorded, with P≤0.01.

Table 5. Fatty acids profile in the Olkuska sheep's milk (g/100 g fat)

Share of fatty acids (%)	Place of grazing			SEM
	I (Gr. I)	CG (Gr. II)	CF (Gr. III)	
C4:0	4,03 a	3,03	2,50 b	0,28
C6:0	2,20	1,73	1,55	0,16
C8:0	1,17	1,00	1,00	0,05
C10:0	3,53	3,43	3,95	0,18
C12:0	2,10 A	2,30 A	3,30 B	0,21
C14:0	8,43 A	9,13 A	11,80 B	0,58
C15:0	1,30 Aa	2,03 Ba	2,15 Bb	0,13
C16:0	27,87	28,70	29,05	0,57
C17:0	0,80 A	1,37 B	1,15 C	0,08
C18:0	9,43 a	8,97 a	6,95 b	0,47
C20:0	0,30	0,50	0,40	0,03
C22:0	0,13	0,20	0,20	0,02
C24:0	0,1	0,1	0,1	0,00
SFA	62,53	63,50	64,60	0,67
C14:1	0,20 A	0,13 A	0,30 B	0,23
C16:1 suma/total C16:1	1,57	2,06	2,20	0,14
C17:1	0,30	0,53	0,30	0,05
C18:1 suma/total C18:1	27,07	23,90	22,50	0,95
C20:1n9	<0,1	<0,1	<0,1	0,00
MUFA	25,67	24,67	22,80	0,76
C18:2 suma/total C18:2	2,87 a	2,77 a	2,50 b	0,07
total C18:3	1,03 A	1,30 B	0,95 A	0,06
PUFA	3,37 A	4,00 B	2,85 C	0,17
Omega-3	1,30 A	1,70 B	1,10 A	0,10
Omega-6	2,03 A	2,27 A	1,60 B	0,10
Omega-9	21,70	19,97	18,50	0,78

kw.t. – fatty acids
a, b, c – values in rows with different letters differ significantly (P≤0.05).
A, B, C – values in rows with different letters differ highly significantly (P≤0.01).

The average content of vitamins and microelements

Analysing the content of retinol in sheep milk from individual groups, its highest level was found in milk from group III (127.00 µg/100 g). In turn, the lowest value of this vitamin was recorded in the case of sheep milk from group I (66.67 µg/100 g). The differences among these groups were statistically highly significant. The highest content of vitamin E was found in group III, and the lowest in group II, with P≤0.05. Despite the lack of statistical confirmation in the case of selenium, sheep milk grazed in the Chodów-Falniów area (group III) tended to have a higher content of this element. In the milk of sheep from group I, grazed on intensive greenlands, statistically significant differences in the amount of calcium were found in relation to group II (the highest content 145.67 mg/100 g), where the animals were only grazed on xerothermic grass. However, they were no longer found for group III, where animals received additional pasture hay (Tab. 6).

Table 6. Mean content of selected vitamins and microelements in the Olkuska sheep's milk

Specification	Place of grazing			SEM
	I (Gr. I)	CG (Gr. II)	CF (Gr. III)	
Vitamins:				
A (µg/100g)	66,67 Aa	95,00 b	127,00 Ba	7,71
E (mg/100g)	0,37	0,23 a	0,40 b	0,03
Selenium (mg/kg)	0,04	0,03	0,11	0,02
Calcium (mg/100g)	90,63 A	145,67 B	101,90 A	30,46

a, b, c – values in rows with different letters differ significantly (P≤0.05);
A, B, C – values in rows with different letters differ highly significantly (P≤0.01).

Discussion of the results

The communities of xerothermic grasslands from the *Festuco-Brometea* class are perceived by various researchers as floristically very rich (Kostuch and Misztal, 2007, Misztal and Bedla, 2013; Musiał et al., 2017). This was confirmed by the vegetation of groups II and III, where, on average, several dozen species were recorded on the area of 100 m², including rare and protected plants. The application of the assessment of meadow and pasture sward proposed by Filipek (1973), which allows comparing various plant communities with one another, showed the occurrence of species of very good quality in the community of group I. It was the result of sowing specially selected plants for this purpose. In turn, the sward of xerothermic grasslands from groups II and III was assessed as mediocre, however individual plant species showed good and even very good use value. Relatively low nutritional requirements of sheep as well as the possibility of

selective removal of sward components by them, make them easy to adapt to a diverse food base and, therefore, to grazing in various types of grassy vegetation. Therefore, it can be assessed that xerothermic grasslands may be a suitable food base for them. This was reflected in selected parameters of sheep milk from animals grazed on such a plant community. It seems interesting that, for example, the content of vitamin A and calcium in milk from groups II and III was higher than for the control group (I), grazing on sward with very good economic value (average Lwu = 9.3). This shows that the type of grassland, e.g. thermophilic sward, in addition to a beneficial effect on the overall condition and animal well-being, can also positively affect the quality of milk and, as a result, also the products obtained from it, such as cheese. According to Bonczar et al. (1998) and Molik et al. (2007) milk from the fertile Olkuska sheep as the lactation period is prolonged is characterised by an increase in the fat and total protein content, respectively, from 17.8 to 21.6%, from 7.0 to 9.3% and from 5.9 up to 9%. The analysis of sheep milk from the final lactation period, with grazing animals on the *Festuco-Brometea* class grasslands, showed a higher content of solids in milk (17.7%) as compared to conventional feeding (11.7%), which indicates the influence of the type of nutrition on the formation of this milk parameter as well. However, analogous contents for fat did not differ significantly between particular groups (3.9-6.5%) and were lower as compared to what other researchers claim. Similarly, the corresponding values for the general protein were similar.

Milk fat as one of the most complex natural fats contains about 500 fatty acids. They are the most easily digestible fats of animal origin (Jarzynowska and Peter, 2017). The profile of these acids as well as the content of nutrients in milk can be modified by changing the sheep feeding method. According to Bonczar et al. (2009) the average content of selected fatty acids in milk from Polish mountain sheep grazed on mountain pastures, intended for the production of "bundz", is as follows: oleic acid (C18: 1) - 15.50, linoleic acid (C18: 2) - 1, 70, capronic acid (C6: 0) - 3.35, mirynesine acid (C14: 0) - 12.22 and lauric acid (C12: 00) - 5.27. Similarly, the results of the above-mentioned acids in milk from Olkusz sheep grazed on thermophilic grasslands in the upland areas were as follows: C18: 1 - 23.9 and 22.5; C18: 2 - 2.77 and 2.50; C6: 0 - 1.73 and 1.55; C14: 0-9.13 and 11.8 and C12: 00 - 2.30 and 3.30. The carried studies also indicate differences in these acids between the control group (I) and groups II and III. The composition of fat in sheep milk is therefore shaped by the kind of grazing sward and, thus, by feeding the animals.

According to the nutritional norms for sheep (NRC, DLG, 1988) there should be 19-21 g of raw fat per kg of solids in hay. The analysed samples coming from intensive green use contained less of this component (on average 11.1 g/kg of solids) while for samples from group III these values were slightly higher than the norm (24.5 g/kg of solids). These norms also specify optimal values for crude fibre in feed, i.e. 300-356 g/kg of solids. This range includes samples from group I. However, samples from group II contained on average more of this component in both years when the tests were carried out (370.7 and 365.8 g/kg of solids). The content of crude

fat in green fodder from groups II and III was relatively stable, which is associated with the harvest of plants in individual years of the tests in the same developmental phase (Grydzyrzec, 2012). The roughage from grassland should contain 140-60 g proteins per kg of solids (Brzóska, 2008). The highest content of the general protein was found in the samples prepared for group I, i.e. for the area of Imbramowice. On the other hand, in green fodder from the *Inuletum ensifoliae* sward (groups II and III), the average fibre content was 542 g/kg of solids (NDF) and 384.4 g/kg of solids (ADF), which is similar to those shown, for example, for grassland classified as *Alopecuretum pratensis*, of *Molinio-Arrhenatheretea* class (Grygierzec, 2012). This is important because such components of the cell walls are factors that can limit feed intake and digestibility as well as caloric value (Brzóska and Śliwiński, 2011). A similar content of fibre to that of fodder from conventional grassland indicates its good suitability for sheep feeding.

Data on sheep production in 2011 showed that the sheep population in Poland was around 223 thousand. However, sheep milk was obtained in only a small amount. Its production in the given year was estimated at the level of 1000 tons and mainly concerned animals from Podhale and Bieszczady. Domestic breeds, such as Olkuska sheep, show good fertility, which makes them generally characterised by good milk yield (Danków and Pikul, 2011). The ease of adaptation to the diversified environmental conditions of these ruminants makes their non-productive function, which is the protection of nature and landscape, become more and more important. It is implemented through grazing for nurturing purposes in various protected areas (Niżnikowski et al., 2017). Currently, a return to the traditional grazing of sheep can also be an important element in restoring domestic breeds to their traditional regions, such as the Olkuska sheep (Sikora et al. 2015). It was reflected in the research within Natura 2000 areas: Cybowa Góra and Chodów-Falniów, where the protected animal genetic resources find a suitable food base. As a result, extensive sheep grazing may contribute, on the one hand, to lowering sheep production costs, which increases the possibilities of maintaining domestic breeds of these animals and, on the other hand, it has a beneficial effect on the protection of semi-natural ecosystems of xerothermic grasslands.

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Selected milk quality parameters of Olkuska sheep as affected by grazing in xerothermic grasslands of *Festuco-Brometea* class

SUMMARY

Chemical composition of sheep milk depends on various factors, both environmental and physiological. The first is shaped by nutrition and climatic conditions, while physiological factors include lactation phase. The aim of the study was to analyse the content of selected milk parameters from ewes in the final lactation period, that were grazed on xerothermic grasslands of the *Festuco-Brometea* class (groups II and III). Control group (I) were ewes fed on intensive grasslands. The material for testing was raw milk, taken during morning milking. The collected samples of Olkuska sheep's milk were analysed *inter alia* for chemical composition, fatty acid profile, and level of vitamins A and E. Collected data were statistically analysed by using one-way analysis of variance in Statistica 12 program. Moreover there was assessed the botanical composition, as well as the chemical properties of green forage from those 3 groups. The results have shown that selected milk parameters for groups II and III, such as solids content, vitamin A and calcium level, were higher than for the control group (I) that was fed on the green forage of a very good value (Lwu=9.3).

Key words: milk quality, type of forage, Olkuska sheep