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Effect of genotype on yield and chemical composition of sheep milk*

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The study was carried out on three groups of ewes: group 1 – Polish Mountain Sheep (PMS, n=30), group 2 – prolific Olkuska Sheep (OS, n= 30) and group 3 – F_1 PMS × OS crossbreds (n=30). Ewes were aged 4-5 years, weighed 60±5 kg and were milked twice a day from April to the end of August. Individual milk yield was recorded at 10 days intervals and every 30th day bulk milk was sampled to determine its mean chemical composition. During the milking period (*i.e.* from weaning of lambs) the highest milk yield was achieved by prolific OS while the lowest by PMS ewes (47.1 and 27.1 litres, respectively). Crossbreds yielded on average 31.2 litres of milk, *i.e.* by 4.1 litres more than PMS ewes. In the milk from first sampling the highest protein content was found in PMS, followed by OS and F_1 crossbred ewes.

KEY WORDS: chemical composition / ewes / milk yield /native breed / sheep

The use of sheep to produce milk has a long tradition throughout the world. Sheep milk accounts for only 2% of the global volume of milk obtained, but in some countries (Yemen, Mediterranean countries) this proportion reaches as much as 50 or 90%. In order to increase the efficiency of sheep production in the Polish mountains,

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it is necessary to improve the native population of Polish Mountain Sheep – PMS [Ciuryk *et al* 1999a, Drożdż 1986]. Many attempts have been made at improving the prolificacy of mountain sheep, since sheep breeding in the Tatra Mountain and sub-mountain Podhale regions is characterized by production of light (milk) lambs and traditional milking of ewes [Ciuruś 1985]. Owing to its rich chemical composition, sheep milk is an excellent raw material for processing into fermented drinks and cheeses. In many countries, including highly developed ones, sheep milk is highly appreciated and processed into products characterized by unique taste and nutritive value [Molik *et al*. 2004, Caballero *et al*. 2007]. Compared to cow milk, sheep milk contains more dry matter, fat, protein, unsaturated fatty acids, calcium, phosphorus, iron, magnesium and vitamins [Kisza *et al*. 1994, Borys and Pisulewski 2001]. A change in the production type of sheep and the increased interested in sheep's milk products offers a chance to make this branch of animal production more profitable [Molik and Murawski 2007].

Therefore, the authors of the present report aimed at recognizing the possibility of improving the prolificacy and milk yield of PMS using the native breed of prolific Olkuska Sheep (OS) for crossbreeding. The use of a native breed to improve the productivity of mountain sheep gives a hope that the offspring obtained will show better prolificacy and greater adaptability to hash highland conditions.

Material and methods

The study was carried out at the Experimental Station of the Department of Sheep and Goat Breeding of the Agricultural University of Cracow on ewes aged 4-5 years, weighing 60±5 kg, and belonging to three genetic (breed) groups: group 1 – Polish Mountain Sheep (PMS, n=30), group 2 – local highly prolific Olkuska Sheep (OS, n=30) and group 3 – F_1 PMS × OS crossbreds (n=30). All the ewes were in their III-IV lactation and had similar body weight in individual groups. Ewes of all groups were mated from 15 to 30 September and lambed in the second half of February. Lambs were kept with their dams to day 56 of age and then weaned. After weaning lambs, the ewes were milked. During the rearing period, milk production of ewes was estimated based on the weight gain of lambs from 2 to 28 days of age, using a conversion factor of 4.5 litre milk consumed per kg weight gain achieved. Ewes were milked twice a day from 26 April to the end of August using the ALFA LAVAL AGRI milking machine, with individual milk yield being recorded every 10 days. To determine the chemical composition of milk, bulk milk samples were collected every 30th day from May to August from ewes belonging to individual groups. The chemical composition of milk was determined at the Department of Animal Products Processing of the Agricultural University of Cracow, following the methods presented by Budsławski [1973]. Throughout the period of collecting milk samples (a total of 13 samplings), ewes were fed according to Feeding Standards of the National Research Institute of Animal Production, Cracow [1993] based on the pasture and hay supplement for standardization. All animals had free access to water and mineral licks.

The results were statistically evaluated with the SAS package using one-way analysis of variance and the Scheffe's test (SAS 9.1).

Results and discussion

Milk yields of ewes are presented in Table 1. In the first 28 days of lactation, the highest milk yield was reached by prolific OS while the lowest by PMS ewes (52.07 and 34.2 litres, respectively, P≤0.01). High milk yield during the period of lambs rearing was also obtained by F_1 crossbreds, which produced 52.01 litres of milk from day 2 to 28. These figures are comparable to the milk yield of OS and significantly higher compared to the milk yield of PMS (P≤0.01). The use of OS rams to improve the productive parametres of PMS resulted in increasing the prolificacy (210% – details not tabulated) and milk yield in F_1 crossbreds during the rearing of lambs, which makes it possible to obtain twins and rear them well. Further analysis showed the intergroup differences to occur neither in lactation length nor in days of milking. In PMS the lactation lasted 196 days and it was comparable with that of the other groups, but the milk yield counted for the first 28 days and for the further whole milking period were the lowest. The results obtained for the milk yield level of PMS and OS ewes during the rearing of lambs occurred similar to those reported by Ciuryk *et al*. [1999b], Drożdż [2000], Murawski *et al*. [2004, 2006]. OS ewes produced significantly more (P≤0.01) milk (47.0 litres) during milking period compared to F_1 crossbreds (31.2 litres). By far, least milk (P≤0.01) was produced by PMS ewes (27.1 litres). According to Ciuryk *et al*. [1999ab] the mean milk yield in OS ewes for the milking period was 44.2 litres, with mean daily yield of 0.37 litres.

Table 1. Means and their standard deviations (SD) for milk production traits in ewes of three genotypes

Genotype	Milk yield day 2 to 28 (litres)		Days of milking		Whole lactation (days)		Milk yielded during the period of milking (litres)	
	mean	SD	mean	SD	mean	SD	mean	SD
Polish Mountain Sheep (PMS)	34.2^{AB}	8.9	133	4.0	196	11.9	27.1^{AB}	15.9
Olkuska Sheep (OS)	52.07^{A}	14.1	135	1.2	194	5.9	47.0^{AC}	31.7
F_1(PMS × OS)	52.01^{B}	17.1	134	2.3	199	6.8	31.2^{BC}	19.8

^{ABC}Within columns means bearing the same superscripts differ significantly at P≤0.01.

The analysis conducted for the course of lactation, based on 13 consecutive control milkings showed that the highest daily yield during the first control milking was reached by OS ewes (0.84 litres), followed by crossbreds (0.57 litres) – Figure1. The lowest daily milk yield was found in PMS ewes (0.38 litres, P≤0.01). During the

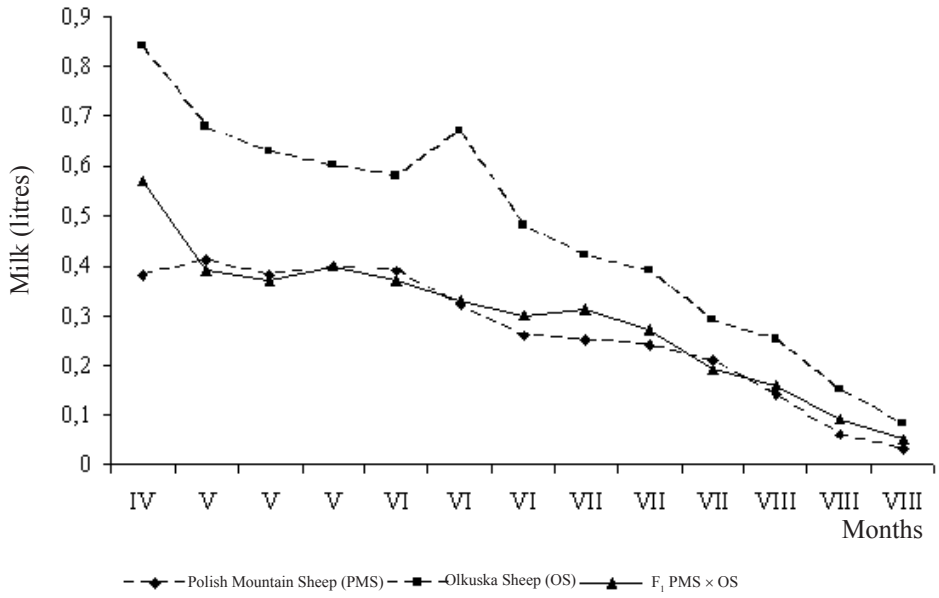

Fig. 1. Daily milk yield in ewes of three genotypes during milking (post-weaning) period.

next three control milkings, the highest yield was reached by OS, significantly lower by crossbreds, and the lowest by PMS ewes. At the sixth control milking, OS ewes still had the highest daily milk yield (0.67 litres), followed by a lower (P≤0.01) yield in the crossbreds (0.33 litres) and the lowest (P≤0.01) in PMS (0.32 litres). In July, as lactation proceeded, the daily milk yield in genetic groups decreased to 0.21, 0.29 and 0.19 litres in PMS, OS and F_1 ewes, respectively. All three groups completed their lactations in August, but during the final control milking the OS group was characterized by the highest daily milk yield (0.08 litres).

Analysis of the changes in the chemical composition of milk showed that within the first sampling (May) the highest density characterized the milk of PMS ewes (1038.0 g/cm^3), whereas the densities of milk from OS and F_1 ewes were both slightly lower (1035.3 g/cm^3) differing, however, from PMS at P≤0.01 – Table 2. During the third sampling (July), the highest milk density was found in crossbreds (1032.6 g/cm^3), followed by 1031.0 g/cm^3 in OS and 1030.0 g/cm^3 in PMS ewes, with significant differences in relation to F_1 group (P≤0.01). At the fourth sampling no significant differences were identified in the milk density between three ewe groups considered.

During the first sampling the highest dry matter content was found in the milk of OS and F_1 ewes (17.1% and 17.2%, respectively), followed by PMS (16.9%), with intergroup differences significant at P≤0.01. No significant intergroup differences in the dry matter content within the second sampling were found, but significant differences occurred within the third and fourth samplings.

Table 2. Means and their standard deviations (SD) for milk components in ewes of three genotypes

Trait	Polish Mountain Sheep (PMS)		Olkuska Sheep (OS)		F_1(PMS × OS)	
	mean	SD	mean	SD	mean	SD
Sampling 1 – May						
density (g/cm^3)	1.038^{AB}	0.05	1.036^{A}	0.04	1.036^{B}	0.03
dry matter (%)	16.9^{AB}	0.03	17.1^{A}	0.03	17.2^{B}	0.4
protein (%)	5.8^{AB}	0.04	5.6^{A}	0.03	5.6^{B}	0.03
fat (%)	5.2^{AB}	0.02	5.8^{A}	0.1	5.9^{B}	0.04
lactose (%)	4.5^{AB}	0.07	4.4^{A}	0.03	4.3^{B}	0.04
Sampling 2 – June						
density (g/cm^3)	1.035	0.64	1.034	0.54	1.034	0.54
dry matter (%)	18.2	0.06	18.4	0.11	17.9	0.35
protein (%)	5.8^{AB}	0.01	5.6^{AC}	0.01	5.4^{BC}	0.07
fat (%)	6.9	0.1	7.3	0.1	7.03	0.3
lactose (%)	4.4	0.02	4.3	0.01	4.5	0.02
Sampling 3 – July						
density (g/cm^3)	1.030^{AB}	0.05	1.031^{A}	0.05	1.033^{B}	0.05
dry matter (%)	18.9^{AB}	0.02	17.8^{AC}	0.01	18.3^{BC}	0.02
protein (%)	5.4^{AB}	0.05	5.3^{AC}	0.05	5.1^{BC}	0.01
fat (%)	8.0^{AB}	0.03	7.0^{AC}	0.01	7.6^{BC}	0.02
lactose (%)	4.4^{AB}	0.01	4.4^{A}	0.01	4.6^{B}	0.05
Sampling 4 – August						
density (g/cm^3)	1.031	0.9	1.033	0.57	1.032	0.62
dry matter (%)	21.6^{AB}	0.3	19.6^{A}	0.7	19.5^{B}	0.05
protein (%)	6.6^{AB}	0.05	6.1^{A}	0.05	6.0^{B}	0.04
fat (%)	9.9^{AB}	0.2	8.3^{A}	0.2	8.2^{B}	0.8
lactose (%)	4.0	0.1	4.0	0.1	4.1	0.08

^{ABC}Within lines means bearing the same superscripts differ significantly at P≤0.01.

The highest protein content within the first sampling was found in the milk of PMS (5.8%), whereas the milk of OS and F_1 ewes showed a slightly lower level of that compound (5.6% and 5.6%, respectively, P≤0.01 in both cases). At the second sampling in June, the milk of PMS still had the highest protein content (5.8%) compared to the milk of OS and F_1 ewes (5.4% and 5.6%, respectively, P≤0.01 in both cases).

During the first month of milking (*i.e.* of post-rearing period), the milk of F_1 crossbreds had the highest fat content (5.9%) and that of PMS ewes the lowest (5.2%), with significant intergroup differences at P≤0.01 – Table 2. As lactation proceeded, both the protein and fat content of milk increased in all groups. In August, the highest protein content was found in PMS (6.6%), followed by OS (6.1%) and F_1 (6.0%) ewes. Similar tendencies were found in fat content.

Within the first milking the highest lactose content occurred in the milk of PMS (4.5%), followed by OS and F_1 ewes (4.3% and 4.4%, respectively) – Table 2. Differences were identified significant in relation to PMS, at P≤0.01. No significant intergroup differences in lactose content were found in the later samplings. The results

presented here confirmed that genetic factors determine not only milk yield but also its chemical composition [Bonczar 1989, Casoli i wsp. 1989, Gut *et al*. 1997]. According to Drożdż [1986, 2000] and Ciuryk *et al*. [2004], sheep milk contains on the average 18.2% solids, 4.3% protein and 6.0-8.4% fat, which is similar to the results reached in this study. In Poland, tradition of the use of sheep for milk production is tightly related to Podgórze, a sub-mountain region where the PMS is kept. That breed is characterized by a low fecundity and low milk yield, and it is necessary to improve its productive parametres. Studies on genetic profile of OS have been carried out for a long time and Murawski *et al*. [2004] reported the significant influence of OS genes on increasing fecundity in PMS. The study presented here shows that the milk yield by PMS was the lowest among genetic groups considered. Introduction of a native OS genotype, aiming at improving the utility of PMS, led to a significantly increased milk production in crossbreds, which yielded by about 0.4 litres milk per milking period more than did PMS ewes. Moreover, F_1 ewes were characterized by a high lactation persistency.

Facing the above it has to be emphasized that the use of a native Polish breed – Olkuska Sheep – creates a real chance to improve production parametres of Polish Mountain Sheep and gives possibility of effective use of crossbreds in sub-mountain Pogorze region.

Taking into consideration the increasing interest in sheep milk products and their high prohealthy properties, the chemical composition of milk is now an important factor which provides information of the quality of milk for cheese making.

The use of OS genotype to improve the milk production traits in PMS resulted in improving the milk yield in F_1 crossbreds without a negative effect on chemical parametres of milk. The value of milk as a raw material for cheese making was not found reduced.

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Wpływ genotypu maciorek na wydajność i skład chemiczny mleka owczego

S t r e s z c z e n i e

Badania przeprowadzono na maciorkach trzech grup: polska owca górska (PMS, n=30), plenna owca olkuska (OS, n=30) i mieszańce F_1 (PMS×OS, n=30). Owce dojono od kwietnia do końca sierpnia. Dla oznaczenia składu chemicznego mleka pobierano co 30 dni próbki zbiorcze, od każdej grupy maciorek.

Najwyższą mlecznością w okresie dojenia (tj. po odsadzeniu jagniąt) charakteryzowały się maciorki olkuskie, podczas gdy najmniej mleka w takim samym okresie wyprodukowały maciorki polskiej owcy górskiej. Maciorki F_1 wyprodukowały w okresie dojenia średnio po 31,2 litry mleka, czyli o 4,01 litra mleka więcej niż maciorki polskiej owcy górskiej. Wykazano istotne różnice w składzie chemicznym mleka między maciorkami badanych trzech genotypów.