

THE CORRELATIONS BETWEEN MILK YIELD OF GOATS AND SOME MILK NUTRIENT CONTENT DURING A 3- AND 5-MONTH LACTATION AND A FULL LACTATION

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Abstract. A total of 203 White Improved goats from a farm in Rożnów (Kujawsko-Pomorskie province) were investigated in 2007–2009. The study attempted to simplify the current goat milk recording scheme and make it more accurate by shortening of the evaluation time and finding optimum lactation months for recording. In order to reach this aim, coefficients of phenotypic correlation were calculated using the multiple regression method between the yield and basic composition of milk over a 90- and/or 150-day lactation and the same traits for a full lactation taking into account the lactation number. The lactation length in White Improved goats varied according to the lactation from 228 days (1st lactation) to 303 days (3rd lactation), with the daily milk yield from 1.90 kg to 2.60 kg, and the fat content of 3.10–3.30% and protein content of 2.80–2.90%. High and significant coefficients of phenotypic correlation between milk yield and composition over the 90- and 150-day lactation and the same traits over a whole lactation prove that every variant of the shortened recording may serve as a basis for the evaluation of goats before the lactation ends. Slightly higher coefficients of correlation (mostly above 0.900) found for the 5-month compared to the 3-month recording show that the evaluation encompassing four control milkings over a whole lactation is more accurate. However, the 3-month recording during summer months is economically more beneficial. Shortening the frequency of control milkings followed by the reduction of costs will enable a greater number of goat herds to be recorded, which is of considerable importance to the efficiency of the breeding programme.

Keywords: goats, lactation, milk

INTRODUCTION

Successful goat farming is conditional on having reliable information on reproductive and milk performance, and origin (pedegree) of these animals [Bishop et al. 1994, Niżnikowski 1997, Bagnicka et al. 2000]. Milk recording of goats includes measuring amount of milk, milk protein and milk fat in control milkings performed every 30 days in the morning and evening (A_4 standard recording scheme) or every 30 days alternately in the morning or in the evening (A_T simplified recording scheme), in accordance with the Instruction on the evaluation of performance and breeding value and selection of goats.

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The study attempted to simplify the current milk recording scheme of goats and make it more accurate by making the evaluation shorter and finding optimum lactation months for recording. This aim will be achieved by determining the relationship between milk yield and its composition in different lactation periods and a full lactation. Shortening the frequency of control milkings and as result of it the reduction of costs will enable a greater number of goat herds to be recorded, which is of great importance to the efficiency of the breeding programme.

MATERIALS AND METHODS

The research was conducted on 203 White Improved goats from a farm in Rożnowo (Kujawsko-Pomorskie province) used in 2007–2009. The goats were kept indoors and fed in groups in accordance with general standards [Nowicki et al. 1999]. During the winter feeding period the ration contained maize silage, meadow hay, fodder beets and concentrate. In the summer the goats received grass forage, meadow hay or straw and concentrate feed. A mineral-vitamin mixture for goats (Polfamiks), ground limestone and salt licks were used during the whole year.

The milk yield of goats and the chemical composition of milk were determined basing on monthly morning and evening control milkings from both teats – in accordance with the A₄ scheme used in the National Animal Breeding Centre (1985) – during lactation. The milk samples were assessed for percentage of fat, protein, lactose, total solids and solids-not-fat. In addition, lactation length, daily milk yield and lactation milk yield (kg), and yield of fat and protein (kg) in milk for the whole lactation were calculated for each goat. The data were analysed statistically by calculating means and standard error of the means (SEM). Significant differences between the means were analysed by means of Duncan's test using Statistica[®] ver. 5.5 software.

To determine the most beneficial variant of the shortened recording of goats, coefficients of phenotypic correlation were calculated using multiple regression [Żuk 1979] between milk yield and basic milk composition for the 90 and/or 150 days of lactation, and the same traits for the full lactation, taking into account lactation number. The analysis was made on the basis of several examples of a 3- and 4-times daily milking over a whole lactation, taking into account lactation month and the feeding period. The three-times control milkings were performed in the following months of lactation: 3rd (May); 4th (June), 5th (July). The five-times control milkings covered the 1st, 2nd, 3rd, 4th and 5th months of lactation (March, April, May, June and July), i.e. the spring-summer feeding season.

RESULTS

As shown in the table 1, the lactation length in White Improved goats varied according to the lactation from 228 days (1st lactation) to 303 days (3rd lactation), with the daily milk yield of 1.90–2.60 kg, the fat content of 3.10–3.30%, and the protein content of 2.80–2.90%. The milk yield in successive lactations corresponded with lactation length and daily milk yield. The lowest lactation milk yield was found in the first kidders (446.14 kg), which was related to the low daily yield of goats (1.9 kg) from this age group and shorter lactation compared to older goats.

The highest milk yield in the analysed herd was obtained in the 3rd (787.80 kg) and 4th lactations (737.50 kg). The differences in lactation length and milk yield between successive lactations were significant, just as for yield of fat and protein. The milk fat percentage in the goats examined slightly diminished with each successive lactation, milk protein percentage was a subject to very small variation and milk lactose percentage remained similar (Table 1).

Table 1. Milk yield and chemical composition of milk for White Improved goats
Tabela 1. Wydajność mleczna i skład chemiczny mleka kóz rasy białej uszlachetnionej

Traits Cechy	Statistical measures Miary statystyczne	Lactation number Numer laktacji			
		I	II	III	IV
Days of milking Długość laktacji	\bar{x} SEM	228 ^{abc} 2.09	260 ^{ade} 2.56	303 ^{bd} 2.71	295 ^{ce} 4.46
Daily milk yield, kg Dzienna wydajność mleka, kg	\bar{x} SEM	1.90 ^{abc} 0.03	2.40 ^a 0.04	2.60 ^b 0.04	2.50 ^c 0.06
Lactation milk yield, kg Wydajność mleka, kg	\bar{x} SEM	446.10 ^{abc} 9.43	624.00 ^{ade} 11.58	787.80 ^{bd} 12.37	737.50 ^{ce} 18.86
Fat content, % Zawartość tłuszczu, %	\bar{x} SEM	3.30 0.03	3.10 0.03	3.20 0.04	3.10 0.06
Fat efficiency, kg Wydajność tłuszczu, kg	\bar{x} SEM	14.60 ^{abc} 0.31	19.34 ^{ad} 0.38	25.21 ^{bd} 0.40	22.72 ^c 0.66
Protein content, % Zawartość białka, %	\bar{x} SEM	2.84 0.01	2.80 0.02	2.90 0.02	2.80 0.03
Protein efficiency, kg Wydajność białka, kg	\bar{x} SEM	12.63 ^{abc} 0.25	17.47 ^{ad} 0.31	22.85 ^{bd} 0.33	20.72 ^c 0.54
Lactose content, % Zawartość laktozy, %	\bar{x} SEM	4.52 0.01	4.47 0.01	4.48 0.02	4.48 0.02
Dry matter content, % Zawartość suchej masy, %	\bar{x} SEM	11.34 0.04	11.11 0.05	11.12 0.05	11.09 0.09

Means in rows with the same letters differ significantly ($P \leq 0.05$).

Wartości średnich w wierszach oznaczone takimi samymi literami różnią się istotnie statystycznie ($P \leq 0.05$).

The coefficients of phenotypic correlation between the 90- and 150-day milk yield and milk composition and the same traits in the next lactations of White Improved goats are shown in tables 2 and 3.

The correlation coefficients calculated between a 3-month recording in different months and the whole lactation for daily and total milk yield and for fat, protein, lactose and solids content of milk in different lactations were highly significant. For the daily yield, the correlation coefficients ranged from 0.906 to 0.950. For lactation yield, the correlation coefficients ranged from 0.845 to 0.864. The coefficients of phenotypic correlation between fat, protein yield, of milk for 3-month recording and the full lactation ranged from 0.795 to 0.857. For the fat, protein, lactose and dry matter the correlation coefficients ranged from 0.760 to 0.980. Slightly lower values of the correlation coefficients for most traits were found in the first lactation goats compared to older goats (Table 2).

Table 2. Correlations coefficient between a 90-day control of milk yield and chemical composition and full lactation of White Improved breed goats

Tabela 2. Współczynniki korelacji między wydajnością mleka i jego składem dla kóz rasy białej uszlachetnionej za 90 dni laktacji a tymi cechami za pełną laktację

Traits Cechy	Lactation rank (total) Numer laktacji (ogółem)				total
	I	II	III	IV	
Daily milk yield, kg Dzienna wydajność mleka, kg	0.906	0.931	0.925	0.950	0.933
Lactation milk yield, kg Wydajność mleka, kg	0.845	0.846	0.864	0.862	0.864
Fat content, % Zawartość tłuszczu, %	0.864	0.861	0.846	0.760	0.846
Fat efficiency, kg Wydajność tłuszczu, kg	0.865	0.856	0.795	0.857	0.865
Protein content, % Zawartość białka, %	0.940	0.937	0.885	0.790	0.911
Protein efficiency, kg Wydajność białka, kg	0.820	0.847	0.836	0.802	0.843
Lactose content, % Zawartość laktozy, %	0.815	0.926	0.921	0.980	0.884
Dry matter content, % Zawartość suchej masy, %	0.893	0.927	0.874	0.878	0.900

In this study we analysed the dependency between the milk yield of goats and milk composition at 150 days (5 recordings) and full lactation (Table 3). The correlation coefficients calculated between a 5-month recording in different months and the whole lactation for daily and total milk yield and for fat, protein, lactose and dry matter content of milk in different lactations were highly significant. The developed within the limits: for lactation from 0.875 to 0.939 (first lactation) and from 0.897 to 0.986 (older goats); for the chemical composition from 0.848 to 0.957 and from 0.730 to 0.989. The coefficients of phenotypic correlation calculated between milk yield and composition in this recording period and full lactation were high and statistically significant for all the traits, ranging from 0.960 to 0.907 (Table 3).

Table 3. Correlations coefficient between 150-day control of milk yield and chemical composition and full lactation of White Improved breed goats

Tabela 3. Współczynniki korelacji między wydajnością mleka i jego składem dla kóz rasy białej uszlachetnionej za 150 dni laktacji a tymi cechami za pełną laktację

Traits Cechy	Lactation rank (total) Numer laktacji (ogółem)				total
	I	II	III	IV	
Daily milk yield, kg Dzienna wydajność mleka, kg	0.939	0.961	0.960	0.986	0.960
Lactation milk yield, kg Wydajność mleka, kg	0.875	0.913	0.916	0.969	0.907
Fat content, % Zawartość tłuszczu, %	0.912	0.913	0.891	0.830	0.897
Fat efficiency, kg Wydajność tłuszczu, kg	0.891	0.897	0.818	0.915	0.881
Protein content, % Zawartość białka, %	0.957	0.950	0.939	0.910	0.940
Protein efficiency, kg Wydajność białka, kg	0.852	0.914	0.896	0.906	0.892
Lactose content, % Zawartość laktozy, %	0.848	0.948	0.947	0.989	0.910
Dry matter content, % Zawartość suchej masy, %	0.934	0.952	0.931	0.924	0.939

DISCUSSION

The productivity of evaluated White Improved goats in range of production capacity, as well as quality of milk (percentage content of fat, proteins and lactose) was approximate milk to local results for goats of this same breeds [Cultivating sheep and goats in Poland in 2008 and 2009 year]. Similar results regarding the percentage of protein (2.73–3.16%) in the milk of Alpine goats obtained Fekadu et al. [2005]. Different results were obtained by Žan et al. [2006], Kondyli et al. [2007] and Strzałkowska et al. [2009] studies. In Strzałkowska et al. [2009] goat milk White Improved goats was both richer in fat (3.38–3.85%) and protein (2.98–3.66%) compared to milk goats assessed. Žan et al. [2006], assessing the quality of milk goats and Alpine goats and Saanen fed on pasture have found that milk from these animals contained an average of: 3.77% fat (Saanen goats) and 3.36% (Alpine goats) and protein 3.40% and 2.95% respectively.

The lactation number (age of goats) significantly influenced the dairy performance and the basic chemical composition of milk from White Improved goats in the analysed herd. The first-lactation goats were characterized by significantly shorter lactation length compared to older goats by 75 days in relation to the 3rd-lactation goats and by 67 days in relation to the 4th-lactation goats. The highest milk yield in the analysed herd was obtained from the 3rd and 4th lactations with significant differences between the 1st and 2nd, and between 3rd and 4th lactations. This result was influenced by both the high number of milking days and the highest daily milk yield in the 3rd lactation (Table 1).

The lactation number was proved to affect milk yield and milk traits by Browning et al. 1995, Crepaldi et al. [1999], Bagnicka et al. [2000], Bernacka [2000] and Strzałkowska et al. [2002]. These authors demonstrated that the first kidders were characterized by shorter lactation and lower milk yield (both daily and whole lactation) compared to older goats. Similar results were obtained in our study. Lactation number did not significantly affect the percentage of protein, fat and lactose in the milk of the goats tested, which is similar to the study of Kmiec et al. [1997], Niżnikowski [1997] reported that as goats become older, protein milk content increases up to the 4th lactation and fat milk content up to the 5th.

Regular monitoring of milk yield during lactation is essential for the improvement of productive traits in goats. The method involving twice-daily milkings performed once a month (A_4), with determination of fat and protein content, is definitely tried and tested, but also labour-consuming and expensive for the breeders. For this reason, Bagnicka [1995] suggested that milk recording in goats should be modified following the example of other countries, in which control milkings are limited to the first 100 days of lactation or to the period between 3 and 5 months of lactation, which are considered the most representative of the whole lactation.

In Sweden, the milk yield is verified three times a year by farmers, who also determine daily yield and fat content or solids content [Bagnicka 1995]. Similar coefficients of phenotypic correlation between milk yield for the 90-day milking and full lactation of the goats in the analysed herds were obtained by Bishop et al. [1994] and Lipeccka and Szymanowska [2004]. In prior researches related to the evaluation of White and Color Improved goats the calculated correlation coefficients between a 3-month recording in different months and the whole lactation for daily and total milk yield as well as for fat, protein, lactose and solids content of milk was highly significant statistically. Slightly higher correlation coefficients for all traits were found for goats recorded in the 3rd, 5th and 7th month of lactation (summer feeding), compared to the yield from the recording for the first three months of lactation [Bernacka 2008]. Similar results were obtained from the analyzed goat herd (Table 2).

Taking, as an example Bagnicka et al. [2004] results regarding control of functional quality of milk of milking goats in Norway, where control milking is carried by breeders themselves five times a year, including two during the pasture period, in our own study we also carried a control of milk utility 5 times a year, in the first five months of lactation, that is in March, April, May, June and July. The range of correlation coefficients between 150-day control of functional quality of milk and full lactation of white improved breed goats was high and very important statistically (Table 3). They are also similar to those carried earlier, regarding four milking controls over a year encompassing different months of lactation [Bernacka 2008].

As it emerges from the data collected in Tables 2 and 3, both in a 90- and 150-day control the range of correlation coefficients between the results in a given time of control and the successive full lactation, for the most values were the smallest for primiparas.

CONCLUSIONS

High and significant coefficients of phenotypic correlation between milk yield and composition for the 90- and 150-day lactation and the same traits over the whole lactation

are evidence that every variant of shortened recording may serve as a basis for evaluation of goats before lactation ends. However, the 3-month recording during summer months is economically more beneficial. Shortening the frequency of control milkings and the resulting reduction of costs will enable a greater number of goat herds to be recorded, which is of considerable importance to the efficiency of the breeding programme.

REFERENCES

- Bagnicka E., 1995. Stan hodowli kóz na świecie [The condition of cultivating goat in the world]. *Prz. Hod.* 5, 44–45 [in Polish].
- Bagnicka E., Sender G., Krzyżewski J., Strzałkowska N., 2000. Wstępne badania wpływu czynników genetycznych i środowiskowych na cechy produkcyjne kóz mlecznych w Polsce [The preliminary investigations of the impact of genetic and environmental factors on production traits of dairy goats in Poland]. *Zesz. Nauk. AR Wroc.* XXX (399), 67–74 [in Polish].
- Bagnicka E., Słoniewski K., Łukaszewicz M., 2004. Genetyczne doskonalenie kóz mlecznych [The genetic improvement of dairy goats]. *Pr. Mat. Zootech., Monografie i Rozprawy* 10, 1–62 [in Polish].
- Bernacka H., 2000. Wpływ wieku i okresu laktacji na cechy mleczności kóz [Effect of age and lactation period on the characteristics of goat milk]. *Zesz. Nauk. AR Wroc.* XXX (399), 75–82 [in Polish].
- Bernacka H., 2008. Analiza produktywności kóz ras białej i barwnej uszlachetnionej oraz jakości ich mleka [The analysis of the productivity of goat breeds and white and color enhanced and the quality of their milk]. *Rozprawy* 127, UTP Bydgoszcz [in Polish].
- Bishop S., Sullivann B.P., Schaeffer L.R., 1994. Genetic evaluation of Canadian dairy goats using test day data. 29th Session of the International Committee for Animal Recording (ICAR) Otawa, EAAP Publication 75, 299–302.
- Browning R.Jr., Leite-Browning M.L., Sahl T., 1995. Factors affecting standardised milk and fat yields in Alpine goats. *Small Ruminant Res.* 18, 173–178.
- Crepaldi P., Corti M., Cicogna M., 1999. Factors affecting milk production and prolificacy of Alpine goats in Lombardy (Italy). *Small Ruminant Res.* 32, 83–88.
- Fekadu B., Soryal K., Zeng S., Van Hekken D., Bah B., Villaquiran M., 2005. Changes in goat milk composition during lactation and their effect on field and quality of hard and semi-hard cheeses. *Small Ruminant Res.* 59, 55–63.
- Kmieć M., Baranowski P., Szatkowska I., 1997. Charakterystyka stada kóz pod względem wybranych cech użytkowych [The characteristics of goat herds of selected traits]. *Zesz. Nauk. SGGW* 1, 83–88 [in Polish].
- Kondyli E., Katsiari M.C., Voutsinas L.P., 2007. Variations of vitamin and mineral contents in raw goat milk of the indigenous Greek breed during lactation. *Food Chemistry* 100, 226–230.
- Lipecka C., Szymanowska A., 2004. Zależność pomiędzy wydajnością kóz w pierwszych 90 dniach kontroli a pełną laktacją [The relationship between the performance of goats in the first 90 days of inspection and full lactation]. *Zesz. Nauk. Prz. Hod.* 72 (3), 141–147 [in Polish].
- Niżnikowski R., 1997. Wstępna ocena poziomu mleczności kóz utrzymywanych w stadzie RZD Pęczniew [The preliminary assessment of the level of milk goats kept in the herd RZD Pęczniew]. *Zesz. Nauk. SGGW* 1, 89–94 [in Polish].

- Nowicki B., Chrzanowska J., Jamroz D., Pawlina G., 1999. Kozy – chów, hodowla i użytkowanie [Goat-rearing, breeding and use]. PWN, Warszawa [in Polish].
- Strzałkowska N., Jóźwik A., Bagnicka E., Krzyżewski J., Horbańczuk K., Pytel B., Horbańczuk J.O., 2009. Chemical composition, physical traits and fatty acid profile of goat milk as related to the stage of lactation. *Anim. Sci. Rep.* 27 (4), 311–320.
- Žan M., Stibilij V., Rogelj I., 2006. Milk fatty acid composition of goat grazing on alpine pasture. *Small Ruminant Res.* 64, 45–52.
- Žuk B., 1979. Metody genetyki populacji w hodowli zwierząt [The methods of population genetics in animal breeding]. PWRiL, Warszawa [in Polish].

WSPÓLZALEŻNOŚCI MIĘDZY WYDAJNOŚCIĄ MLECZNĄ KÓZ I ZAWARTOŚCIĄ NIEKTÓRYCH SKŁADNIKÓW MLEKA ZA OKRES TRZECH I PIĘCIU MIESIĘCY LAKTACJI A PEŁNĄ LAKTACJĄ

Streszczenie. Badania przeprowadzono na 203 kozach rasy białej uszlachetnionej z gospodarstwa w Rożnowie w woj. kujawsko-pomorskim, użytkowanych w latach 2007–2009. W badaniach podjęto próbę zwiększenia dokładności i uproszczenia dotychczas stosowanej oceny użyteczności mlecznej kóz, przez skrócenie okresu jej trwania i wyszukanie reprezentatywnych miesięcy laktacji do oceny. W tym celu wyliczono metodą regresji wielokrotnej współczynniki korelacji fenotypowej między wydajnością i podstawowym składem mleka za 90 i/lub 150 dni laktacji, a tymi samymi cechami za daną pełną laktacją, uwzględniając kolejne laktacje kóz. Długość laktacji u kóz rasy białej uszlachetnionej wynosiła w zależności od kolejnej laktacji od 228 dni (I laktacja) do 303 dni (III), o dziennej wydajności mlecznej odpowiednio od 1,90 kg do 2,60 kg i zawartości tłuszczu w granicach 3,10–3,30%, białka 2,80–2,90%. Wysokie i istotne statystycznie wartości współczynników korelacji fenotypowej między wydajnością mleka i jego składem za 90 i 150 dni laktacji a tymi cechami za pełną laktacją dowodzą, że każdy wariant skróconej kontroli może być podstawą oceny kóz przed zakończeniem laktacji. Nieco wyższe współczynniki korelacji (w większości powyżej 0,900) stwierdzone dla pięciokrotnej niż trzymiesięcznej kontroli wskazują na większą dokładność oceny obejmującej pięć próbnych udojów w ciągu całej laktacji. Jednak ze względów ekonomicznych korzystniejsza jest kontrola trzymiesięczna obejmująca miesiące żywienia letniego. Skrócenie częstotliwości próbnych udojów i wynikające stąd obniżenie kosztów pozwoli objąć kontrolą większą liczbę stad kóz, co może mieć znaczenie dla efektywności programu hodowlanego.

Słowa kluczowe: kozy, laktacja, mleko

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