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An attempt to develop a method for determining the typical chemical composition of the milk of Polish Holstein-Friesian cows – a proposal

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The aim of this paper is to develop a method for determining the typical chemical composition of the milk of Polish Holstein-Friesian (PHF) cows. The paper uses data collected from 1329 test-day milking records from 20 herds of PHF dairy cattle in Sokołów County, from 2009 to 2015. The effect of the following factors on the chemical composition of milk was determined: lactation stage (15 one-month stages); age of cows (lactations 1, 2, 3–4, and 5–7); genotype (share of PHF breed: less than 50%, 50–75%, 75–82.5% and more than 82.5%); somatic cell count (SCC) in 1 ml of milk (in thousands: 0–200, 200–400, 400–1000 and more than 1000); feeding level (fat to protein (F/P) ratio): ≤ 1.0, 1.0–1.4, 1.4–1.7 and > 1.7); calving season (autumn/winter, spring/summer) and daily milk yield (milk yield in kg: ≤ 15, 15–25, 25–35 and > 35). Nutrition and udder health status were found to be the main factors influencing the chemical composition of milk. For selected cows with optimally balanced feed rations (F/P ratio in milk from 1.1 to 1.4) and a low somatic cell count (SCC ≤ 200,000/ml), daily yield was the main factor affecting the chemical composition of the milk. It was also concluded that government and scientific publications on the PHF breed should take into account the impact of the F/P ratio, SCC and yield of milk on its composition.

KEY WORDS: cows, milk, chemical components

The chemical composition of cow milk is not constant [5, 10, 21]. According to Guliński et al. [11], variation in the content of the main components of milk from cows raised in southern Podlasie, measured by the coefficient of variation, was 19.5% for fat, 13.8% for protein, 5.3% for lactose, and 48.6% for urea. Variation in in milk composition results mainly from the genetic predispositions of animals, i.e. their genotypes, which play a key role in hormonal regulation of the synthesis of milk components, and from the level of nutrients in the feed rations [20, 28, 30]. The chemical composition of cow milk is modified by a number of factors, which consistently affect the level of its components at the production level. These factors are the season, age of the cow, stage of lactation and pregnancy, the body condition of the cow during milk production, diseases (mainly metabolic and udder disorders) and diet [2, 3, 4, 14, 18, 20, 21, 23, 24].

The aim of the research was to propose a method for determining the typical chemical composition of the milk of Polish Holstein-Friesian (PHF) cows. The study examined the impact of several factors on chemical composition. The two main factors were the cow's udder health and diet. The results indicated that milk typical of the PHF breed contains less than 200,000 somatic cells in 1 ml, while a fat-to-protein ratio (F/P ratio) indicative of a proper diet ranges from 1.1 to 1.4. The assumption was that this F/P ratio reflects an optimal proportion of acetic to propionic acid produced in the rumen (3:1). In a selected sample of cows whose milk met both of these criteria, daily yield was assumed to be the main factor having a significantly statistical influence on the chemical composition of the milk of PHF cows. Therefore, the ultimate aim of the research was to predict the proximate chemical composition of PHF milk and to test its dependence on daily yield.

Material and methods

The first stage of research. The study was based on data from 1329 test-day milking records of PHF dairy cows in 20 herds located in Sokołów County from 2009 to 2015. The data were test-day milk yields of PHF cows registered in the Polish national records system (SYMLEK). The effect of several factors on proximate milk composition was determined: month of lactation (15 months after parturition), age of cows (lactations 1, 2, 3 and 4, and 5–7), genotype (less than 50%, 50–75%, 75–82.5 %, and more than 82.5% Polish Holstein-Friesian genes), somatic cell count (SCC) in 1 ml of milk (in thousands: 0–200, 200–400, 400–1000, and > 1000); feeding level (fat to protein (F/P) ratio): ≤ 1.0, 1.0–1.4, 1.4–1.7, and > 1.7); calving season (autumn/winter and spring/summer) and daily milk yield (milk yield in kg: ≤ 15, 15–25, 25–35 and > 35).

A linear model was used for the statistical calculations, including the mixed effects of the month of lactation, cow age, SCC and F/P ratio groups, calving season, and daily milk yield class.

A random additive genetic effect was used for daily milk yield and composition features (fat, protein, lactose, and dry matter). A linear regression model was used as well. The significance of differences between groups was determined by the Duncan test (for number of groups > 2) or a t-test (for number of groups = 2) at P = 0.01. All calculations were performed using SAS software [27].

The second stage of research. The results of the initial tests indicated that the cows' nutrition level and the somatic cell count in the milk, which is associated with udder health, were the two main factors significantly affecting its chemical composition. In the second stage the research was limited to cows with no health issues (milk SCC ≤ 200,000/ml), receiving balanced feed rations (F/P ratio in the milk from 1.1 to 1.4). For this group of cows, a new analysis was conducted of the effect of factors listed in the first part of the Material and methods. A linear regression model was determined in the statistical analysis.

Results and discussion

The importance of udder health status and diet for daily milk yield. The results of the initial tests examining factors differentiating milk chemical composition showed that the health status of the udder determined by the SCC in 1 ml of milk and balanced feed rations defined by the F/P ratio were among the main factors affecting the proximate chemical composition of PHF cow milk. Therefore in the next stage cows in good health were selected, i.e. cows whose milk contained less than 200,000 somatic cells. The second selection criterion was a milk F/P ratio between 1.1 and 1.4, indicating that energy and protein needs were balanced. In this manner, of the 1329 daily observations in 20 herds, 406 observations of cows meeting these two criteria were selected.

The left side of Table 1 presents the daily milk yield of the whole cow sample, before the selection, over the entire lactation period. According to the adopted criterion, the lactation was divided into 15 monthly stages. The average daily yield in the 1329 observations was 22.6 kg. The highest daily yield was in the first month of lactation (30.7 kg). Significantly less milk, by 14.5 kg, was produced in the 12th month of lactation. The results indicate a highly statistically significant effect (P = 0.01) of the month of lactation on daily milk yield.

The right side of Table 1 shows the average daily milk yield of the selected group of cows with good udder health and proper nutrition. The daily milk yield averaged 24.2 kg and was more than 9% higher than for the overall population. The selected sample of healthy and properly fed PHF cows reached its production peak in the third month of lactation, producing on average 32.3 kg of milk. In successive months of lactation the milk yield systematically decreased, reaching its lowest level in the 14th and 15th month, with an average of 17.1 kg per day.

According to Guliński et al. [11], the physiologically normal SCC in milk varies between 150,000 and 200,000 per ml. One ml of milk should contain no more than 400,000 somatic cells. An elevated SCC in milk indicates subclinical mastitis. An increase in the SCC in milk is accompanied by a decrease in milk yield and changes in its chemical composition. Mastitis causes a significant decrease in the percentage of milk fat [12, 17, 26]. The decrease in fat is smaller (about 10 percent) than that observed for lactose (around 15%).

Among all milk components, milk fat is the most susceptible to control through diet. Changes in the content of this component may exceed even 3%, depending on the feeding technology [11]. Malnutrition of cows, excessive use of concentrate feeds, excess protein, and insufficient energy in the feed ration are among the most common reasons for reduced fat in milk [9].

The effect of udder health status and diet on the proximate chemical composition of milk. The data in Table 1 indicate that the average fat, protein, lactose and dry matter content was 4.48%, 3.57%, 4.74% and 13.6%, respectively. The lowest level of protein and dry matter was noted in the 2nd month, i.e. during the peak of lactation, when the milk yield was highest. In the following months there was a systematic increase in the content of these components. The highest content of milk fat and dry matter, 5.03% and 14.41%, respectively, was noted in the 14th month of lactation. The most modifiable milk ingredient is fat [11]. The most effective way to change milk fat content and its composition is through diet, which can lead to changes in fermentation models or in the composition of fat absorbed from the gastrointestinal tract. Diets that increase the proportion of propionic acid in the rumen reduce the percentage of milk fat, with minimal changes in its composition, including a slight increase in the presence of C18 polyunsaturated fatty acids and a slight reduction in the share of C16:0 and C18:0 fatty acids [20, 24, 30].

Because cow milk is the cheapest source of protein among all food raw materials, improving the level of protein in milk has been the focus of attention of dairy farmers around the world for many years. According to Miglior et al. [25], the share of milk protein in the total values of production traits of selection indices used in cattle improvement programmes range from 51% (Switzerland) to 67% (Poland). According to Gaunt [10], selection based on this feature raises milk protein content by 0.075 pp per generation. The author estimates that about 11 generations are needed to obtain similar levels of protein and fat in milk, if protein yield was the only selection criterion. Cattle breeding is currently focused mainly on increasing the concentration of protein and its yield and on improving the F/P ratio towards the most favourable ratio of 1:1

[11, 19]). According to Guliński et al. [11], the average F/P ratio in PHF cow milk in eastern Poland is 1.23.

Due to the close relationship between lactose synthesis and the amount of water needed to produce milk, lactose is the most stable component of cow milk. In successive months of lactation, lactose levels ranged from 4.83% in the 2nd month to 4.62% in the 14th month. As lactose is easily metabolized by microorganisms, cow milk is easily digestible and can be fermented by many species of microorganisms. Hence changes in milk lactose levels are generally assumed to be linked to an increase in SCC, which is a widely accepted indicator of cow udder health.

The lowest levels of fat, protein and dry matter in the milk of the selected cows throughout the lactation period were 3.61%, 3.02% and 12.3%, respectively, in the 2nd month of lactation (Table 1). As the milk yield decreased in successive months of lactation, the concentrations of these components increased, reaching the highest level in the 14th and 15th months of lactation. The highest levels of fat (4.95%), protein (4.06%) and dry matter (14.48%) were noted in the 14th month. The exception was milk obtained in the 8th month of lactation, in which the highest levels of fat, protein and dry matter were probably due to poorly balanced feed rations. The results indicate that proper cow nutrition and hygiene programmes ensuring good udder health are key factors affecting milk production.

The effect of selected factors on the content of basic milk components. An important objective of the research was to assess the impact of a number of environmental factors on the chemical composition of milk. As presented in the *Material and methods* section, the age and genotype of cows, the level of SCC in 1 ml of milk, the F/P ratio, and the calving season were determined to be sources of variation in the chemical composition of the milk of PHF cows. Table 1 presents changes in the level of fat, protein, lactose and dry matter in relation to the factors listed above. For the whole sample of cows before selection, the level of milk fat was the most variable. Fluctuations in its content were as high as 2.3 pp when the level of nutrition, defined by the F/P ratio, was taken into account. It should be noted that the effect of all factors (except for the calving season) on milk fat content was highly statistically significant ($P = 0.01$). Much smaller differences were observed for the variability of protein content. They reached a maximum of 0.7 pp (for extreme F/P ratio levels in milk). The cows' age and genotype and the calving season had a minor effect on milk protein content. However, milk lactose content decreased significantly with age, which was probably linked to the SCC in the milk of older cows. Lactose content was highest in the milk of primiparous cows (4.88%) and decreased with successive calvings (to 4.61%). The data confirm the hypothesis concerning the significance of

SCC for the lactose level in milk. The increase in SCC from 0–200,000 to above 1 million was accompanied by a drop in the lactose percentage from 4.8% to 4.5%. Table 1 presents data on the impact of certain factors on the content of dry matter in milk, which is particularly noteworthy. The level of dry matter was most dependent on nutrition, defined in this paper as the milk F/P ratio. The difference in dry matter concentration between milk with an F/P ratio below 1 and an F/P ratio above 1.7 was 1.33 pp. It was statistically significant and was unquestionably due to the high level of fat, which is a characteristic feature of the milk of cows with clinical ketosis. In the case of lactose content, the statistically confirmed differences between age groups, genotypes and calving seasons should be linked to differences in the health status of the udder (Table 1).

Table 1 presents the results pertaining to one of the main objectives of this study, i.e. analysis of the impact of several genetic and environmental factors on the levels of milk components. Cow age and genotype and the calving season were found to have no statistically significant effect on the percentage content of fat, protein and dry matter in milk. This confirms the hypothesis that these factors do not affect the level of important milk components in properly fed cows with a healthy mammary gland.

Finally, the milk analysis for the whole sample of PHF cows, before selection, revealed significant variation in its chemical composition. The differences in milk chemical composition caused by environmental and genetic factors were significant and were statistically confirmed in most groups of cows. The milk component subject to the most variation was fat, while the lactose level showed the lowest variability.

According to Borkowska and Januś [6], Milogor et al. [25], Summer et al. [29], Varga and Ishler [30], the percentage of fat in cow milk varies considerably depending on the stage of lactation. Its level is usually highest in the colostrum. During the first two months of lactation, fat concentration decreases, and from the third month it slowly increases. Literature reports indicate that the lowest fat content in milk is recorded in the second month of lactation and the highest level in the final lactation period. This trend has been confirmed in research by Henno et al. [13], Brzozowski and Zdziarski [7], and Miciński and Klupczyński [22].

Due to the close link between lactose synthesis and the amount of water taken into milk, lactose content is the least variable component of cow milk [8, 15, 16]. In the milk of cows raised in Podlasie, its level was on average 4.72% [11]. The lactose level decreases as the age of cows increases. A study by Litwińczuk et al. [19] shows the highest lactose content in the milk of cows in their first lactation (4.89%). It systematically decreased with age, reaching 4.69% in the fifth lactation. Similarly, Guliński et al. [11] have shown that the lactose content in the milk of cows in their first lactation was 4.84%, while in lactations 10 and above it decreased by 0.28 pp on average.

The effect of milk yield on its chemical composition. Table 2 provides information on relationship between milk yield and the chemical composition of the milk of PHF cows. The data show that among cows selected according to the F/P ratio and SCC criterion, an increase in milk yield was the main factor affecting the concentration of fat, protein and dry matter. An increase in daily milk yield from ≤ 15 kg to over 35 kg was associated with a decrease in fat, protein and dry matter content by 1.0, 0.8 and 1.6 pp, respectively. As in the present study, Matwiejczuk et al. [21] found that an increasing daily milk yield was accompanied by a decrease in fat, protein and dry matter and an increase in lactose concentration.

Correlation between milk yield and its chemical composition. Table 3 presents the correlations between yield traits and the chemical composition of milk. The main finding of the present study is that for properly fed PHF cows with good udder health, daily yield is the primary factor influencing the chemical composition of milk. High negative correlation coefficients (r) were found between milk yield and the percentage content of fat, protein, dry matter: –0.47, –0.49 and –0.49, respectively. The regression coefficients showed that an increase in daily milk yield by 1 kg was associated with a decrease in the percentage of fat, protein and dry matter by 0.033, 0.027 and 0.052 pp, respectively. Similarly, Alphonsus [1] reports negative correlation coefficients (r) between milk yield and fat and protein content: –0.680 and –0.214, respectively. It should be stressed that for the milk of PHF cows there is a negative correlation between the yield of milk and its chemical composition. To sum up this part of the research, milk yield should be considered the main factor affecting the variability of the chemical composition of the milk of PHF cows in southern Podlasie. This factor plays a key role in the milk composition of dairy herds, where feed rations are rationally balanced and the hygiene programmes ensure that the milk has a low somatic cell count.

Prediction of milk chemical composition based on daily yield of PHF cows. Table 4 presents data on prediction of the chemical composition of the milk of PHF cows based on daily yield. Regression equations were used to calculate the proximate chemical composition of milk with an optimal F/P ratio and SCC in 1 ml.

In conclusion, in PHF cattle the health status of the udder defined as the SCC in 1 ml of milk and balanced feed rations defined by the F/P ratio of milk are among the main factors affecting milk chemical composition. The research indicates that for cows with good udder health receiving a rational diet, the primary factor influencing milk chemi-

Table 1
Effect of selected factors on daily yield ($\bar{x}$) and chemical composition of milk

Factor	All cows						Cows whose milk had a normal F/P ratio (1.1-1.4) and normal SCC (≤200,000/ml)					
	number of observations (n)	daily milk yield (kg)	fat (%)	protein (%)	lactose (%)	dry matter (%)	number of observations (n)	daily milk yield (kg)	fat (%)	protein (%)	lactose (%)	dry matter (%)
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Month of lactation												
1	106	30.7^{A}	4.53^{CD}	3.13^{G}	4.79^{ABC}	13.29^{F}	36	30.2^{AB}	3.94^{GH}	3.16^{IJ}	4.85^{ABC}	12.81^{G}
2	91	29.1^{AB}	4.16^{EF}	2.95^{H}	4.83^{A}	12.78^{G}	25	31.3^{AB}	3.61^{I}	3.02^{J}	4.87^{AB}	12.33^{H}
3	99	29.5^{AB}	4.11^{F}	2.99^{H}	4.81^{AB}	12.79^{G}	37	32.3^{A}	3.7^{HI}	3.03^{J}	4.91^{A}	12.52^{GH}
4	90	26.7^{BC}	4.07^{F}	3.18^{G}	4.83^{A}	12.9^{G}	36	27.5^{ABC}	3.96^{GH}	3.23^{HI}	4.92^{A}	12.91^{FG}
5	90	25.6^{CD}	4.40^{DE}	3.34^{F}	4.79^{ABC}	13.34^{F}	35	27.1^{BC}	4.2^{FG}	3.39^{GH}	4.88^{AB}	13.38^{EF}
6	90	22.6^{E}	4.41^{DE}	3.41^{F}	4.79^{ABC}	13.38^{F}	34	23.6^{CD}	4.27^{EF}	3.42^{FG}	4.82^{ABC}	13.38^{EF}
7	100	22.9^{DE}	3.44^{G}	3.44^{F}	4.75^{BCD}	13.53^{EF}	×	×	×	×	×	×
8	84	21.2^{EF}	4.59^{CD}	4.69^{A}	4.69^{DEF}	13.73^{DE}	27	19.3^{DE}	5.31^{A}	4.68^{A}	4.68^{D}	14.64^{A}
9	102	20.9^{EF}	4.63^{CD}	3.63^{E}	4.72^{CDE}	13.77^{DE}	36	23.7^{CD}	4.3^{EF}	3.59^{EF}	4.77^{BCD}	13.51^{DE}
10	94	18.9^{FG}	4.73^{BC}	3.7^{DE}	4.68^{DEF}	13.88^{DE}	33	20.7^{DE}	4.41^{DEF}	3.67^{DE}	4.78^{BCD}	13.63^{DE}
11	99	18.9^{FG}	4.8^{ABC}	3.77^{D}	4.68^{DEF}	14.05^{BCD}	30	20.2^{DE}	4.67^{BCD}	3.85^{CD}	4.82^{ABC}	14.17^{BC}
12	85	16.2^{G}	4.97^{AB}	3.89^{C}	4.67^{EF}	14.31^{ABC}	19	19.4^{DE}	4.55^{CDE}	3.78^{CD}	4.73^{CD}	13.88^{CD}
13	90	16.3^{G}	4.96^{AB}	3.96^{BC}	4.65^{EF}	14.34^{AB}	26	19.3^{DE}	4.89^{B}	3.89^{BC}	4.80^{ABC}	14.35^{AB}
14	61	16.8^{G}	5.03^{A}	4.04^{B}	4.62^{F}	14.41^{A}	18	16.4^{E}	4.95^{B}	4.06^{B}	4.79^{ABCD}	14.48^{AB}
15	48	17.0^{G}	4.71^{BC}	3.88^{C}	4.65^{EF}	13.99^{CD}	14	17.9^{E}	4.81^{BC}	3.87^{C}	4.81^{ABC}	14.25^{ABC}
Age of cows (lactation)												
1	474	23.8^{A}	4.45^{B}	3.55^{AB}	4.88^{A}	13.7^{A}	180	34.3^{A}	4.29^{A}	3.54^{A}	4.90^{A}	13.48^{A}
2	355	21.6^{B}	4.58^{A}	3.63^{A}	4.69^{B}	13.7^{A}	116	23.8^{A}	4.41^{A}	3.59^{A}	4.78^{B}	13.52^{A}
3-4	317	22.3^{B}	4.52^{AB}	3.56^{AB}	4.65^{C}	13.6^{A}	73	24.8^{A}	4.36^{A}	3.59^{A}	4.72^{B}	13.38^{AB}
5-7	183	21.5^{B}	4.31^{C}	3.52^{B}	4.61^{D}	13.3^{B}	37	24.7^{A}	4.17^{A}	3.43^{A}	4.73^{B}	13.08^{B}

1	2	3	4	5	6	7	8	9	10	11	12	13
Genotype (share of the PHF breed)												
≤50%	191	22.6^{B}	4.37^{C}	3.55^{AB}	4.8^{A}	13.57^{BC}	62	24.9^{AB}	4.34^{A}	3.53^{A}	4.86^{A}	13.5^{A}
50-75%	264	25.8^{A}	4.54^{B}	3.63^{A}	4.76^{B}	13.64^{B}	77	27.0^{A}	4.36^{A}	3.54^{A}	4.84^{AB}	13.5^{A}
75-82.5%	356	19.2^{C}	4.77^{A}	3.56^{AB}	4.72^{C}	13.85^{A}	87	21.7^{C}	4.44^{A}	3.59^{A}	4.83^{AB}	13.5^{A}
>82.5%	518	23.2^{B}	4.31^{C}	3.52^{B}	4.72^{C}	13.43^{C}	180	24.25^{BC}	4.3^{A}	3.55^{A}	4.79^{B}	13.4^{A}
Somatic cell count of milk – SCC (1000/ml)												
0-200	782	24.1^{A}	4.43^{B}	3.52^{C}	4.8^{A}	13.56^{B}	406	24.2	4.33	3.56	4.82	13.44
200-400	276	21.5^{B}	4.49^{B}	3.59^{BC}	4.7^{B}	13.62^{AB}	×	×	×	×	×	×
400-1000	181	19.7^{C}	4.57^{B}	3.65^{B}	4.6^{C}	13.63^{AB}	×	×	×	×	×	×
>1000	90	17.5^{D}	4.78^{A}	3.77^{A}	4.5^{D}	13.86^{A}	×	×	×	×	×	×
Nutrition level (fat/protein ratio – F/P ratio)												
≤1	231	22.5^{A}	3.47^{D}	3.8^{A}	4.72^{A}	13.05^{D}	×	×	×	×	×	×
1,1-1.4	722	22.6^{A}	4.41^{C}	3.6^{B}	4.73^{A}	13.49^{C}	406	24.2	4.33	3.56	4.82	13.44
1,4-1.7	308	22.2^{A}	5.16^{B}	3.4^{C}	4.77^{A}	14.12^{B}	×	×	×	×	×	×
>1.7	68	23.7^{A}	5.76^{A}	3.1^{D}	4.73^{A}	14.38^{A}	×	×	×	×	×	×
Calving season												
autumn/winter	653	22.76^{A}	4.56^{A}	3.56^{A}	4.76^{A}	13.7^{A}	187	25.2^{A}	4.35^{A}	3.50^{A}	4.85^{A}	13.41^{A}
spring/summer	676	22.33^{A}	4.42^{A}	3.58^{A}	4.71^{B}	13.6^{A}	219	23.5^{B}	4.30^{A}	3.59^{A}	4.79^{B}	13.45^{A}
total/average	1329	22.5	4.48	3.57	4.74	13.6	406	24.2	4.33	3.56	4.82	13.44

Means within factors marked with different letters differ significantly at P=0.01
× – none of the data meet the specified criteria

Table 2

Effect of milk yield (kg) on its chemical composition for cows with a normal fat-to-protein ratio (F/P ratio of 1.1-1.4) and low somatic cells counts (SCC ≤200,000/ml)

Daily milk yield (kg)	Number of observations (n)	Daily milk yield (kg)	Percentage content			
			fat ($\bar{x}$)	protein ($\bar{x}$)	lactose ($\bar{x}$)	dry matter ($\bar{x}$)
≤15	63	12.7^{D}	4.81^{A}	3.89^{A}	4.76^{C}	14.2^{A}
15-25	180	19.9^{C}	4.47^{B}	3.71^{B}	4.81^{BC}	13.7^{B}
25-35	105	29.1^{B}	4.06^{C}	3.32^{C}	4.86^{AB}	13.0^{C}
>35	58	42.2^{A}	3.81^{D}	3.14^{D}	4.89^{A}	12.6^{D}
Total/Average	406	24.4	4.33	3.56	4.82	13.43

Means within factors marked with different letters differ significantly at P=0.01

Table 3

Correlation and regression coefficients for milk yield and chemical composition

Correlated traits	Pearson correlation coefficient (r)	Regression equation
Milk yield and percentage of fat	–0.47**	y = 5.13059 – 0.03302 × (x)
Milk yield and percentage of protein	–0.49**	y = 4.20969 – 0.02683 × (x)
Milk yield and percentage of lactose	0.17**	y = 4.73377 + 0.00367 × (x)
Milk yield and percentage of dry matter	–0.49**	y = 14.69258 – 0.05166 × (x)

**Coefficient highly significant at P=0.01

cal composition is daily yield. The study has shown high negative correlations between milk yield and the percentage content of fat, protein and dry matter, with coefficients (r) of –0.47, –0.49 and –0.49, respectively. These results confirm the negative correlation between the milk yield of PHF cows and the content of basic components of the milk. Milk yield can be considered the main factor modifying the chemical composition of milk produced in southern Podlasie. Discussion of the milk chemical composition of

Table 4
Prediction of proximate chemical composition of the milk of Polish Holstein-Friesian cows based on daily yield

Daily milk yield (kg)	Fat (%) 5.14 – 0.03 × (x)	Protein (%) 4.21 – 0.03 × (x)	Lactose (%) 4.73 + 0.004 × (x)	Dry matter (%) 14.69 – 0.05 × (x)
5	4.96	4.07	4.75	14.43
10	4.80	3.94	4.77	14.17
15	4.63	3.80	4.78	13.91
20	4.47	3.67	4.80	13.65
25	4.30	3.53	4.82	13.40
30	4.13	3.40	4.84	13.14
35	3.97	3.27	4.86	12.88
40	3.80	3.13	4.88	12.62
45	3.64	3.00	4.89	12.36
50	3.47	2.86	4.91	12.10
55	3.31	2.73	4.93	11.85
60	3.14	2.59	4.95	11.59
65	2.98	2.46	4.97	11.33
70	2.81	2.33	4.99	11.07

milk typical of the PHF breed, particularly in government and scientific publications on this subject, should take into account the impact of milk yield, SCC and the F/P ratio on its chemical composition.

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