Journal of Elementology ISSN 1644-2296

Bermagambetova N.N., Naimanov D.K., Papusza N.W., Miciński J. 2016. *Milk yield and chemical and mineral composition of milk from Kazakh black--variegated cows, offspring of Holstein-Friesian bulls from three lines.* J. Elem., 21(3): 653-667. DOI: 10.5601/jelem.2015.20.3.1005

ORIGINAL PAPERS

MILK YIELD AND CHEMICAL AND MINERAL COMPOSITION OF MILK FROM KAZAKH BLACK-VARIEGATED COWS, OFFSPRING OF HOLSTEIN-FRIESIAN BULLS FROM THREE LINES

Nurgul N. Bermagambetova[1], Doskali K. Naimanov[1], Natalia W. Papusza[1], Jan Miciński[2]

[1]Department of Animal Production Technology National Agricultural University name of Baitursynova in Kostanay, Kazakhstan
[2]Chair of Cattle Breeding and Milk Evaluation University of Warmia and Mazury in Olsztyn, Poland

Abstract

The aim of this study was to determine the effect of 3 sire bulls from different genetic lines on the yield, chemical and mineral composition of milk produced by their daughters that belonged to black and variegated cattle kept in Kazakhstan, in the consecutive lactations and milking seasons. The research included 60 dairy cows, whose average share of HF breed genes did not exceed 50%. The cows were kept on a dairy farm called Wiktorowskoye, located near Tarnov (Kazakhstan). The highest milk yield, fat and protein content were recorded for the offspring of the bull Hamlet (H-239). The lowest body weight was achieved by daughters of Hamlet (H-239) and was significantly different from the other cows at $p \leq 0.01$ and $p \leq 0.05$. The milk yield per body weight (bw) showed that cows in the 3rd lactation produced 911 kg of milk 100 $kg^{-1}_{b.w.}$. Daughters of Hamlet (H-239) distinguished themselves by the best milk yield to body weight conversion rate of 985 kg 100 $kg^{-1}_{b.w.}$. The ratio of protein to fat was satisfying and ranged from 0.82 (1st lactation) to 0.80 (3rd lactation). Cows from the group H-239 produced milk with the highest content of fat. In the 1st lactation, it equalled 3.95%, rising to 4.02% in the 3rd lactation. Depending on the milking season, the highest fat content was in the AU (4.02%) and WI seasons (3.99%) and the lowest one occurred in the SU season (3.87%). The highest protein content was observed in cows of group M-370 and amounted to 3.29% (primiparous cows) and 3.24% (3rd lactation) as well as 3.52% (WI)

prof. dr hab. inż. Jan Miciński, Chair of Cattle Breeding and Milk Evaluation, University of Warmia and Mazury in Olsztyn, Oczapowskiego 5/150, 10-719 Olsztyn, Poland, e-mail: micinsk@uwm.edu.pl

and 3.46 (AU). The highest content of SSC (2.464 thousand cm^{-3}) was found in cows of group B-361 in the WI season, with statistical differences $p \leq 0.01$ and $p \leq 0.05$. The content of FFA was the highest in daughters of the bull M-370 bull, followed by the offspring of the bull H-239.

Keywords: bull sires, milk yield, fat, protein, lactose, calcium, phosphorus.

INTRODUCTION

Breeding programs on dairy cattle have been implemented systematically for over 30 years, and the main goal has been to increase the number of high value breeding cows (Stiepanow 2007). Selection of animals for this purpose has helped to change the genetic make-up of black and white cattle in various countries worldwide (Szarek 1998). An increasingly wider range of modern technologies for milk production, supported by market economy principles, raises the expectations regarding the performance of dairy cattle, including milk yield, the value of breeding animals, their suitability for milking owing to the proper body build (mainly the udder in cows) and longevity (Szarek, Otoliński 2002, Prochorienko 2005).

In many countries, including Poland, cattle breeding programmes crossing black and white cows with Holstein-Friesian (HF) bulls have produced high-performance types of dairy cattle populations (Hibner, Sakowski 1997, Kaczmarek et al. 1997, Litwińczuk et al. 1998, Reklewski et al. 1999, Juszczak et al. 2001, Szarek, Otoliński 2002, Miciński, Klupczyński 2006). Consequently, the milk yield per cow has doubled (Bielak et al. 1996, Szeląg, Skrzypek 2000, Bilik et al. 2001, Strzałkowska et al. 2004). Another objective of these breeding programmes has been to improve the body conformation, i.e. to obtain a stronger body framework, udder and limbs (Pawlina 1991, Walawski, Żelanis 1991, Kamieniecki, Zalewski 1992, Pogorzelska et al. 1998, Oprządek et al. 2003, Ziemiński 2005, Prochorienko 2005).

Juszczak et al. (2001) and Kuczaj (2002) explain that any improvement of functional traits of black-and-white cattle largely depends on reproductive sire bulls. These bulls come mostly from the USA, Canada and the European Union. Sitkowska and Mroczkowski (2004) attributed high genetic progress in milk yield and milk composition to daughters of bulls from Canada and the Netherlands.

A similar attempt has been undertaken in Kazakhstan, where it it hoped to achieve improved breeding and production indicators of Kazakh black-variegated cattle, like cows kept on the farm called Wiktorowskoye, located near Taranov in the region Kostanay. In order to accelerate the improvement of functional traits, a crossbreeding programme was started that involved cows of a local cattle breed and Holstein-Friesian sire bulls from the USA and Canada. The American and Canadian cattle chosen for the breeding programme was characterized by high milk yield as well as a proper structure of the box-shaped udder, with strong vulvo-ventral suspension and evenly developed quarters. Such an udder is well suited for mechanical milking in an industrial technology (PROCHORIENKO 2005).

In order to improve the performance and milk yield of dairy cows, the potential of genetic traits must be enhanced by environmental factors, such as nutrition, housing system, milking season, welfare, etc. Of these, nutrition is most significant. The worst nutritional mistake is failing to ensure the right balance in feeding rations between energy and protein needs (KULETA et al. 1989). In general, there is an insufficient energy supply in feed compared to the standard requirement of dairy cows. For the first 2-3 months of lactation, the concentration of energy taken in the feed does not correspond to the demand. The milk yield starts to increase rapidly just 2 weeks after calving, whereas the energy needs are balanced in the 8^{th} to 12^{th} week (GRAVERT 1991, RAŚ 1999).

Analysis of the chemical composition of milk can facilitate prophylactic evaluation of the health status of cows (REKLEWSKI 2000, KUCZAJ 2002). Milk is a good „mirror" of the metabolic and health status of cows, and changes in the chemical composition of milk can provide a clue for diagnosing early stages of metabolic diseases of cattle. According to HAMMON (2000), in addition to basic milk components such as fat, protein, lactose and urea, the most useful indicator for disease prevention and diagnosis is the milk content of allantoin beta--hydroxybutyric acid, acetone, potassium, sodium, phosphate and citrates.

The aim of this study was to determine the effect of 3 sire bulls from different genetic lines: Barter 361, Hamlet 239 and Marquis 370, on the milk yield as well as the chemical and mineral composition of milk produced by their daughters, which belonged to black-variegated cows, in successive lactations and milking seasons.

MATERIAL AND METHODS

The study was carried out under production conditions and involved a herd of 270 Kazakh black-variegated dairy cows, which were kept on a breeding farm called Wiktorowskoye, near Tarnov, in the region Kostanay, in Kazakhstan. The average share of Holstein-Friesian genes in the genotype of the cows did not exceed 50%. Successive lactations of cows were analyzed. The cows' performance was assessed at the Department of Animal Production Technology, Agricultural University in Kostanay. The physicochemical composition of milk (according to the standard GOST 26809-86 RK – Milk and white milk products, of 1986) was determined in milk samples in the laboratory of the Scientific Innovation Center at the Baitursynova National Agricultural University in Kostanay, in Kazakhstan.

The cows were tethered and a portable milking machine was used for milking. The cows were milked twice daily: the morning milking began at 4.30 a.m. and the evening one started at 5.00 p.m. The cows were fed in the

PMR system (partially mixed ration). Rations for cows designed to sustain production of 15 kg of milk were prepared in a mixer wagon. Concentrated feed was distributed manually to cows with higher milk yield. A monodiet was supplied, composed of the following ingredients: grass silage, hay, straw, concentrated feed, mineral premix.

The composition of rations was programmed for 15 kg of milk yield each, but modifications of the ration composition concerned only the kind of available silage and were introduced twice a year. Silage consisted of green forage grown on meadows and pastures.

Sixty cows were selected from the herd for the study. They were divided into 3 groups, depending on the origin of the Holstein-Friesian (HF) father bull sires. Group I (B-361) consisted of 20 cows from the bull Barter 361 line Siling Trajdżun Rokit 252803, which had 75% genes of the HF breed in his genotype (highest milk yield of his mother was 7,821kg, 4.05% fat). Group II (H-239) was composed of 25 cows from the bull Hamlet 239 line Refliekszin Sowiering 198998, which had 100% gene of the HF breed in his genotype (highest milk yield of his mother was 8,455 kg, 3.96% fat). Group III (M-370) included 15 cows from the bull Marquis 370 line Ujes Ideał 933122, which had 87.5% genes of the HF breed in his genotype (highest milk yield of his mother was 6,596kg, 4.08% fat).

The following were analyzed:

- yield (kg), milk, fat, protein, dry matter, solids non-fat (SNF), for 305 days, 1^{st} (I-L), 2^{nd} (II-L) and 3^{rd} (III-L) lactation;
- content (%) of fat, protein (including casein), lactose, dry matter, solids non-fat (SNF), citric acid and free fatty acid for 305 days 1^{st} (I-L), 2^{nd} (II-L) and 3^{rd} (III-L) lactation;
- content of urea (mg dl^{-1}), pH, density (g cm^{-3}), somatic cell count (SCC) (th cm^{-3}), freezing point (-°C) and conductivity (mS cm^{-3});
- body weight (kg), milk yield converted per 100 kg body weight of cows (milk 100 $kg^{-1}_{b.w.}$), the ratio of protein to fat (RP/F);
- mineral composition of milk cows in 2^{nd} lactation (mg l^{-1}), i.e. calcium (Ca), potassium (K), sodium (Na), magnesium (Mg), zinc (Zn), atomic absorption spectrometer Spectra A280FZ, Varian.

Additionally, results for first-calving cows were divided into three milking seasons. The first was the summer season (SU) with months: June, July, August and September. The second was the autumn season (AU) with months: October, November and December. The third was the winter season (WI) with the months of January, February and March.

The collected data were analyzed statistically. The least square means (LSM) and standard evaluation (Se) were calculated. Analysis of variance in a non-orthogonal system was performed according to the formula:

$$Y_{ij} = \mu + a_i + b_j + (ab)_{ij} + e_{ij},$$

where:

Y_{ij} – the estimated value of trait,

μ – the average population,

a_i – effect of the $i_{\text{-th}}$ group bulls,

b_j – effect of $j_{\text{-th}}$ milkng season,

$(ab)_{ij}$ – interaction,

e_{ij} – random error.

The calculations were made in the program Statistica ver. 10. The significance of differences between means was determined by the Duncan's test.

RESULTS

Milk yield and the basic composition of milk from cows in the 1st, 2nd and 3rd 305-day-long lactation periods are included in Table 1. The milk yield was 3,538 kg in the I-L lactation, increasing to 4,182 kg in III-L. These results are much lower than achieved by HF cows. However, the body weight of the black-variegated cows was just 410 kg in the I-L lactation and 459 kg in

Table 1

Milk yield and basic composition of milk cows in the 1st, 2nd and 3th 305-day lactation

Traits	Statistical measures	Succesive lactations		
		I-L	II-L	III-L
Body weight $_{(b.w.)}$ (kg)	LSM	410^{Aa}	429^{Ab}	459^{B}
	Se	1.22	1.29	1.93
Milk [kg]	LSM	3538^{A}	3879^{B}	4182^{C}
	Se	40.32	61.74	84.75
Milk/100kg $_{b.w.}$ (kg)	LSM	863^{a}	904^{b}	911^{b}
	Se	28.33	29.15	31.97
Fat (kg)	LSM	140^{a}	164^{b}	175^{c}
	Se	1.84	2.73	3.76
Protein (kg)	LSM	115^{a}	132^{b}	153^{c}
	Se	1.36	2.01	2.76
Fat (%)	LSM	3.87^{a}	3.93^{b}	3.95^{b}
	Se	0.01	0.01	0.01
Protein (%)	LSM	3.22	3.54	3.18
	Se	0.004	0.005	0.001
RP/F	LSM	0.82	0.79	0.80
	Se	0.0001	0.0001	0.0001

Significant differences: *A*,*B* – at $p \leq 0.01$; *a*,*b* – at $p \leq 0.05$

III-L. HF breed cows attain a much higher body weight. Therefore, in order to compare the performance of cows, milk yield should be expressed per 100 kg body weight of a cow. Hence, the cows in the III-L lactation produced 911 kg of milk 100 $kg^{-1}_{b.w.}$. For high-performance cows, milk production exceeds 1000 kg 100 $kg^{-1}_{b.w.}$. The milk yield analyzed in our research increased in the three successive lactations, nearing the performance achieved by high yielding cows.

The lowest milk yield as well as the fat and protein content were reported in primiparous cows (Table 1). The average values were: 3,538 kg milk, 140 kg fat and 115 kg protein. Differences relative to the highest average values obtained by cows in the III-L lactation were statistically significant at $p \leq 0.01$ and $p \leq 0.05$. The highest fat content (3.95%) was recorded in the III-L lactation while the highest protein content (3.54%) occurred in the II-L lactation. The differences were statistically significant at $p \leq 0.05$. The protein to fat ratio was satisfying, ranging from 0.82 (I-L) to 0.80 (III-L).

Table 2 compares productivity for a 305-day milking period during the I-L and III-L lactations, depending on the lines of the bull sires. It demonstrates that the lowest body weight was determined in the daughters of the bull Hamlet (H-239), in both the I-L and III-L lactations: 414 kg and 447 kg ($p \leq 0.01$ and $p \leq 0.05$), respectively. However, these cows were distinguished by the highest milk yield, milk fat and milk protein content in I-L and III-L. The differences relative to the average values achieved in the other groups of cows were statistically significantly higher at $p \leq 0.01$ and $p \leq 0.05$. Also, milk yield converted per 100 $kg_{b.w.}$ was the highest among those cows, reaching the peak value of 985 kg 100 $kg^{-1}_{b.w.}$ during III-L.

Analyses of the fat and protein content in milk showed that the highest fat content also occurred in milk from the cows in group H-239 (Table 2). During the I-L lactation, it equalled 3.95% and increased to 4.02% during III-L. However, the content of protein did not follow the same trend, as it was the highest in milk from the M-370 cows, where it reached 3.29% and 3.24% in the same two lactations. Statistically significant differences between these cows and the other groups during I-L and III-L were at the level of $p \leq 0.05$. The highest values of solids non-fat were in milk frrom the B-361 cows: 8.93% in the I-L lactation and 9.94% in III-L. The lowest content of SNF was reported in the daughters of the bull Marquis (M-370): 8.37% and 8.27%, respectively. In both cases, the differences were statistically significant at $p \leq 0.05$.

Table 3 contains data describing the physicochemical and technological parameters of primiparous cows, depending on the lines of the sire bulls and different milking seasons. The highest fat content, irrespective of the milking season, was reported for the daughters of the bull Marquis (M-370) ($p \leq 0.01$): from 3.87% (group SU) to 4.02% (group AU). Our analyses of the fat content in the consecutive milking seasons demonstrated that milk obtained in the summer season was characterized by the lowest fat content, regardless of the cows' origin. This was confirmed by a statistically signifi-

Table 2

Comparison of productivity for a 305-day milking period in I-L and III-L lactations depending on the lines of bull sires

Traits	Lines sires bulls	Selected lactation of cows			
		I-L		III-L	
		LSM	Se	LSM	Se
Body weight – b.w. (kg)	B-361	434^{a}	2.58	$478^{xx\,A}$	2.76
	H-239	414^{b}	1.14	$447^{x\,B}$	2.85
	M-370	430^{a}	2.10	$471^{x\,A}$	4.56
Milk (kg)	B-361	3294^{A}	107.63	$4154^{xx\,a}$	146.81
	H-239	3715^{Ba}	516.38	$4300^{xx\,b}$	144.95
	M-370	3614^{Bb}	122.21	$4123^{xx\,a}$	171.78
Milk/100 kg $_{b.w.}$ (kg)	B-361	759^{a}	11.02	$884^{xx\,a}$	14.12
	H-239	897^{b}	9.55	$985^{xx\,b}$	16.04
	M-370	841^{c}	12.73	$878^{xx\,b}$	14.06
Fat (kg)	B-361	125^{a}	4.02	162^{xx}	6.73
	H-239	148^{b}	4.47	173^{x}	11.91
	M-370	143^{b}	7.49	163^{x}	8.26
Protein (kg)	B-361	103^{a}	3.24	132^{x}	4.47
	H-239	121^{b}	3.46	135^{x}	4.76
	M-370	119^{b}	5.21	132^{x}	5.21
Fat (%)	B-361	3.78^{a}	0.02	$3.88^{x\,a}$	0.05
	H-239	3.95^{b}	0.05	$4.02^{x\,b}$	0.07
	M-370	3.88^{b}	0.06	3.94^{b}	0.06
Protein (%)	B-361	$3,12^{a}$	0.02	3.11^{a}	0.03
	H-239	$3,24^{b}$	0.03	3.12^{b}	0.02
	M-370	$3,29^{b}$	0.03	3.24^{b}	0.05
SNF (%)	B-361	8.93^{a}	0.05	9.94^{a}	0.04
	H-239	8.65^{b}	0.07	8.83^{b}	0.03
	M-370	8.37^{c}	0.05	8.27^{c}	0.04

Significance of differences – between the lines sires bulls: *A*,*B* – at $p \leq 0.01$; *a*,*b* – at $p \leq 0.05$;
– between lactations: *xx* – at $p \leq 0.01$; *x* – at $p \leq 0.05$

cant difference at $p \leq 0.01$ and $p \leq 0.05$. The highest protein content was reported in milk from the daughters of the bull Barter (B-361), in which it varied from 3.34% (group SU) to 3.52% (group WI); $p \leq 0.01$ and $p \leq 0.05$. Analogously to the fat content, the lowest average value of protein in milk occurred in the summer season. The highest content of casein during the summer and autumn was recorded in milk from the daughters of the bulls Hamlet (H-239) and Marquis (M-370). However, in the winter season, most

Table 3

Physicochemical and technological characteristics of milk from first-calving cows in different milking seasons and depending on the lines bull fathers

Traits	Statistic measur.	The lines of bull fathers					
		B-361		H-239		M-370	
		LSM	Se	LSM	Se	LSM	Se
Fat (%)	SU	$^{a}3.73^{Aa}$	0.02	$^{a}3.87^{Ab}$	0.01	$^{a}3.51^{C}$	0.02
	AU	$^{b}3.84^{A}$	0.01	$^{b}4.02^{B}$	0.02	$^{b}3.62^{C}$	0.03
	WI	$^{b}3.83^{a}$	0.03	$^{c}3.99^{b}$	0.02	$^{b}3.86^{c}$	0.01
Protein (%)	SU	$^{a}3.34^{a}$	0.02	$^{a}3.12^{b}$	0.01	3.30^{a}	0.03
	AU	$^{b}3.35^{a}$	0.02	$^{b}3.22^{b}$	0.01	3.46^{c}	0.01
	WI	$^{c}3.40^{A}$	0.01	$^{c}3.34^{B}$	0.02	3.52^{B}	0.01
Casein (%)	SU	$^{a}2.91$	0.03	$^{a}2.98$	0.01	$^{a}2.98$	0.03
	AU	$^{b}2.60^{a}$	0.02	$^{b}2.78^{b}$	0.01	$^{a}2.78^{b}$	0.01
	WI	$^{a}2.80$	0.01	$^{b}2.71$	0.03	$^{a}2.71$	0.01
Lactose (%)	SU	$^{a}4.24^{a}$	0.03	$^{a}4.38^{b}$	0.02	$^{a}4.68^{c}$	0.03
	AU	$^{b}4.23$	0.04	$^{b}4.40$	0.01	$^{b}4.55$	0.02
	WI	$^{b}4.14^{a}$	0.02	$^{c}4.55^{b}$	0.03	$^{a}4.65^{b}$	0.03
Dry matter (%)	SU	$^{a}12.18^{a}$	0.07	$^{a}12.43^{b}$	0.07	$^{a}12.30^{c}$	0.09
	AU	$^{b}11.09^{a}$	0.08	$^{b}11.26^{b}$	0.08	$^{b}11.76^{c}$	0.07
	WI	$^{c}13.06^{A}$	0.06	$^{b}11.81^{B}$	0.07	$^{b}11.95^{B}$	0.08
Solids non-fet SNF (%)	SU	9.12^{a}	0.06	$^{a}9.30^{b}$	0.06	$^{a}9.30^{b}$	0.06
	AU	$^{a}8.57^{Aa}$	0.06	$^{b}8.78^{Ab}$	0.06	$^{b}9.85^{B}$	0.05
	WI	$^{b}9.00^{a}$	0.05	9.13^{b}	0.05	$^{a}9.35^{c}$	0.07
Urea (mg l^{-1})	SU	$^{a}40.34$	2.54	$^{a}35.75$	2.65	$^{a}36.75$	2.12
	AU	$^{b}23.20$	2.33	$^{b}23.58$	2.77	$^{b}24.38$	3.16
	WI	$^{b}27.24$	2.76	$^{b}29.27$	1.98	$^{b}29.27$	3.087
Citric acid (%)	SU	0.11	0.003	0.11	0.004	0.11	0.005
	AU	0.09	0.004	0.09	0.003	0.09	0.004
	WI	0.11	0.003	0.11	0.004	0.11	0.005
pH	SU	6.54	0.06	6.57	0.05	6.57	0.06
	AU	6.61	0.07	6.56	0.07	6.56	0.07
	WI	6.43	0.08	6.54	0.09	6.54	0.05
Density (g cm^{-3})	SU	1.028	0.09	1.029	0.09	1.030	0.08
	AU	1.030	0.06	1.028	0.08	1.030	0.09
	WI	1.029	0.04	1.028	0.07	1.030	0.09
Freezing point (-°C)	SU	0.529	0.003	0.533	0.002	0.535	0.003
	AU	0.514	0.002	0.515	0.001	0.515	0.004
	WI	0.526	0.002	0.533	0.003	0.533	0.002
Somatic cell cound SCC (th cm^{-3})	SU	$^{A}412^{a}$	3.56	$^{A}387^{b}$	3.89	$^{A}386^{b}$	3.78
	AU	$^{B}913^{A}$	4.78	$^{B}717^{Ba}$	5.12	$^{Ba}755^{Bb}$	4.43
	WI	$^{C}2464^{A}$	4.12	$^{C}805^{Ba}$	4.58	$^{Bb}838^{Bb}$	4.48
Free fatty acid FFA (%)	SU	$^{A}10.72^{a}$	1.09	$^{A}10.93^{b}$	1.24	$^{A}10.93^{b}$	2.03
	AU	11.91^{a}	1.12	12.00^{a}	1.67	12.92^{b}	2.24
	WI	$^{B}4.15^{a}$	0.99	$^{B}2.73^{b}$	2.32	$^{B}2.83^{b}$	2.54
Conductivity (mS cm^{-3})	SU	5.09	0.04	5.11	0.05	5.12	0.06
	AU	5.11	0.06	5.10	0.07	5.12	0.05
	WI	5.12	0.03	5.10	0.08	5.11	0.03

Significant differences: *A*,*B* at $p \leq 0.01$; *a*,*b* at $p \leq 0.05$; the left side of the mean – between seasons; the right side of the mean – between lines of bull sires casein was found in milk from the daughters of the bull Barter (B-361). Definitely, the highest content of casein in all the daughters appeared in the summer season. Statistical differences between seasons were at $p \leq 0.05$.

As well as being the main carbohydrate in milk, lactose is the most stable compound among milk sugars. Its content usually ranges from 4.50 to 4.80%. The lactose content was within the expected range only in milk from the daughters of the bull Marquis, in which it varied from 4.55% (group WI) to 4.68% (group SU). The daughters of of the other bull sires produced milk with the lactose content below 4.50%.

No regular patterns were discernible regarding the dry matter content and solids non-fat, as no statistical differences were detected between the individual groups of cows.

The urea content peaked during the summer season, and ranged from 36.75 mg dl^{-1} (M-370) to 40.34 mg dl^{-1} (B-361), which implies that cows in summer can benefit from green fodder with its high protein content. Green fodder was added to rations prepared for cows, which means that the feeds were unbalanced and contained excessive amounts of proteins.

The citric acid concentration was within the accepted limits for raw milk and ranged from 0.09% (group AU) to 0.11% (the other groups). Having analyzed the pH and density of milk, we concluded that the values of these parameters were within accepted limits. The milk pH was similar in all the cow groups: 6.6 on average (from 6.43 to 6.61). The density was from 1.028 g cm^{-3} to 1.030 g cm^{-3}. The freezing point varied from - 0.514°C to - 0.535°C and testified that milk had an appropriate water content. It has been found that the pH, density and freezing point of milk did not depend on the bull sires or the milking season. No statistically significant differences between the groups of cows were determined in this regard.

A statistically significant effect of the bull sires and the milking season was verified with respect to the somatic cell count (SCC) in milk. The highest content of SCC was found in the milk of the daughters of the bull Barter (B-361) in winter season (group WI). Generally, the summer milking season was characterized by the lowest SCC in milk of all the cows (from 386 to 412 thousand cm^{-3}). There were differences statistically significant at $p \leq 0.01$ and at $p \leq 0.05$ between the mean SCC values between the daughters of th different bulls and between the milking seasons. Inferior milk quality implicated by an elevated number of somatic cells was found in winter in the offspring of all the bulls, but the worst udder health was detected in the cows originating from the bull Barter, which may indicate the significant influence of a father on this characteristic. This hypothesis is supported by the highest somatic cell count (SCC) in the milk of cows originating from Barter during each milking season, higher than in cows of the other groups.

Determinations of the content of free fatty acids (FFA) showed that it ranged from 2.83% (group WI and M-370) to 12.92% (group AU and M-370). It was found that the highest values occurred in the autumn milking season, followed by the summer season, and in milk from daughter of bull sires M-370 and H-239. The lowest value was recorded in the winter season, with the highest values of that season scored by daughters of bull B-361. This was confirmed by statistically significant differences at $p \le 0.01$ and at $p \le 0.05$. The conductivity of the milk was correct and ranged from 5.09 to 5.12 mS cm^{-3}. There was no impact of the bull sires or of the season on the average values of this traits. Differences were found in the content of selected macro- and microelements in cows' milk from different milking seasons and lactations. A lower content of Ca was observed in the milk of older cows (Table 4). Simi-

Table 4

The mineral components of milk of cows in 1st and 2nd lactation depending on the milking season (mg l^{-1})

Traits	MS	Selected lactation of cows			
		I-L		III-L	
		LSM	Se	LSM	Se
Ca	SU	^{a}1352*	24.08	1295	21.08
	AU	^{b}1426*	23.79	1277	22.99
	WI	^{c}1233*	25.01	1209	24.32
K	SU	^{a}1797*	35.36	1574	28.67
	AU	^{b}1690*	33.17	1498	29.00
	WI	^{c}1532*	30.08	1200	31.84
Na	SU	^{a}335	9.65	391*	10.64
	AU	^{a}342	10.32	373*	11.56
	WI	^{b}312	8.17	340*	15.13
Mg	SU	^{a}92*	4.17	83	3.99
	AU	^{a}89	5.09	86	6.23
	WI	^{b}80^{a}	6.18	67	5.00
Zn	SU	^{a}4.22*	0.034	3.33	0.067
	AU	^{a}4.13*	0.045	3.40	0.052
	WI	^{b}3.55*	0.028	3.12	0.035

Significant differences – between season: *A*,*B* at $p \le 0.01$, *a*,*b* at $p \le 0.05$,
– between lactation: *xx* – at $p \le 0.01$, * – at $p \le 0.05$

lar results were obtained with respect to the level of K. The Na content was slightly higher in the milk of cows furing the 3rd lactation, exceeding 300 mg l^{-1} in each milking season. The Mg content in milk ranged from 80 to 92 mg l^{-1} in 1st lactation, closer to the lower limit value in milk from older cows during each of the milking seasons. A higher Zn content in milk of primiparous cows than in milk of cows in the third lactation can indicate higher nutritional value of milk of younger cows.

The cows selected for our study were fed in the PMR (Partially Mixed

Ration) system. The rations were designed to sustain milk production of 15 kg, but any change in their composition pertained only to the kind of available silage and occurred twice a year. Silage material consisted of green forage grown on meadows and pastures. That should explain changes in the primary composition and mineral content of milk of the above cows.

DISCUSSION

Kuczaj (2002) conducted research on crossbreeding black and white cattle with the HF breed. He demonstrated some improvement in cows, such as higher daily milk yield and better chemical composition of milk, which depended on reproductive bulls originating from the USA and the European Union but did not depend on the contribution of HF breed's genes in the genotype of cows.

Sitkowska and Mroczkowski (2004) showed strong influence of bull sires from the Netherlands, Canada and Poland on the yield of milk as well as the fat and protein content in milk of their daughters. The superior performance of daughters of bulls from the Netherlands and Canada was statistically significant compared to daughters of bulls from Poland.

Since 1979, Poland has been implementing a program called the 'holsteinization' of Polish dairy cattle. The programme relies on artificial insemination of cows with semen of pure-bred HF bulls (a form of crossbreeding by displacing) originating from the USA, Canada, the Netherlands and Germany. The result was an increase in the body weight of offspring cows (Juszczak et al. 2001), improved build of the udder and limbs (Kamieniecki, Zalewski 1992, Pogorzelska et al. 1998, Oprządek et al. 2003), an increase in the milk yield from 3,111 kg, 114 kg of fat, 3.68% contents of fat in 1970 year (CSAB 1971) to 7,582 kg of milk, 309 kg of fat, 4.08% content of fat and 255 kg of protein yield, 3.36% content of protein in 2014 (PFCBPM 2015).

Tomaszewski (2005) demonstrated the influence of different factors (including Polish bulls) on production traits and on the chemical composition of milk from black and white (BW) cows and hybrid cows with the HF breed (BW*HF). The author showed that a cow's genotype very strongly differentiated milk yields. The lowest yields were obtained from pure-breed BW cows (4,694 kg of milk), the highest one, exceeding 7,000 kg of milk, was produced by cows with a 93.8% share of HF breed genes ($p \leq 0.01$). The fat and protein yields responded similarly to the experimental factors. The sire bulls Jen (no 14697-4-2) and Argon (no 44890-4-6) excelled in respect of the above indicators in their offspring. The performance of these bulls' daughters during a 305-day lactation period was the highest, resulting in 7,105 and 6,835 kg of milk, 273 and 265 kg of fat, 240 and 233 kg of protein, respectively.

Antkowiak and Kliks (1998) and Antkowiak et al. (2009) showed a relationship between the origin of a bull (HF) and milk performance traits of the bull's daughters. Comparative results showed the presence of a strong relationships between the country of origin of bulls and the results their offspring achieved in milk production. The most promising results were obtained when American and French HF bulls were used for reproduction. Daughters of the former were characterized by the highest milk yield, whereas daughters of the latter, apart from a high milk, milk fat and milk protein yields, were also reported to produce milk with a high dry matter content and a favourable protein/fat ratio value.

Short, Lawlor (1992), Pérez-Cabal and Alendy (2002) showed that long-term crossbreeding with medium HF breed bulls resulted in BW cattle being transformed from a dual type (milk and meat) to a dairy type. This process is accompanied by deterioration in the reproductive traits.

Kruszyński (2008) discussed the effect of different HF bulls on the performance life of cows and showed that the performance life in terms of maintaining good milk, fat and protein yield improved with an increasing share of the HF genes. Positive influence of the following bulls has been demonstrated: Supreme (import from Canada), Fox (import from Germany), Joaquin (import from the USA) and Marcel (import from the Netherlands).

CONCLUSIONS

1. Milk yield of cows increased in successive lactations, from 3,538 kg among the primiparous cows to 4,182 kg for cows in the 3rd lactation. The highest milk yield, fat and protein content were obtained by cows daughters of Hamlet sire bull (H-239). Statistical differences were at $p \leq 0.01$ and at $p \leq 0.05$.

2. The body weight of cows was not too high and ranged from 410 kg (primiparous cows) and 459 kg (3rd lactation). The lowest body weight occurred in daughters of Hamlet bull (H-239) and was significantly different from the other cows at $p \leq 0.01$ and $p \leq 0.05$.

3. The milk yield per body weight (bw) showed that cows in the 3rd lactation produced 911 kg of milk 100 $kg^{-1}_{b.w.}$. This result indicates that the performance was comparable to that obtained by HF cows. Daughters of Hamlet bull (H-239) distinguished themselves by the best conversion milk yield to body weight rate of 985 kg 100 $kg^{-1}_{b.w.}$.

4. The lowest fat (140 kg) and protein yield (115 kg) was observed in primiparous cows. Differences versus the highest average values obtained by cows in the 3rd lactation were statistically significant at $p \leq 0.01$ $p \leq 0.05$.

5. The ratio of protein to fat was satisfying and ranged from 0.82 (1st lactation) to 0.80 (3rd lactation).

6. Cows from the group H-239 produced milk with the highest content of

fat. In the 1st lactation it equalled 3.95% and in the 3rd lactation rose to 4.02%. Depending on the milking season, the highest fat content was in the AU (4.02%) and WI seasons (3.99%) and the lowest one was recorded in SU (3.87%).

7. The highest protein content was observed in cows of group M-370: 3.29% (primiparous) and 3.24% (3rd lactation) as well as 3.52% (WI) and 3.46 (AU).

8. There was no influence of the bull father on the level of urea, citric acid content, pH and density or the freezing point of milk.

9. The highest content of SSC (2464 th/cm^3) was found in daughters of group B-361 in the WI season with statistical differences $p \leq 0.01$ and $p \leq 0.05$.

10. The content of FFA was the highest in daughters of the bull M-370, followed by those of the bull H-239.

11. In summary, it can be said that owing to the achieved production results of cows, semen of Hamlet and Marquis bulls may be recommended for use on the Wiktorowskoye farm, located in the region Kostanay in Kazakhstan.

REFERENCES

Antkowiak I., Pytlewski J., Skrzypek R., Jakubowska M. 2009. *The impact of the origin of the bull on milk productivity of daughters*. Rocz. Nauk. PTZ., 5(4): 11-19. (in Polish)

Antkowiak I., Kliks R., 1998. *Use of longevity and life yield of some cow genotypes in Wielkopolska*. Rocz. Akad. Rol. w Poznaniu, 302: 3-7. (in Polish)

Bielak F., Czaja H., Wawrzyńczak S., Trela J., Strządała B., Działowski Z. 1996. *Use of technology for the production of ripening cheeses from milk of cows of different genotypes*. Rocz. Nauk. Zoot., 23(2): 279-290. (in Polish)

Bilik K., Niwińska B., Osięgłowski S. 2001. *Influence of feeding of hybrid breeds of black and white Holstein-Friesian heifers during sexual maturation on their reproductive and milk usefulness*. Rocz. Nauk., Zoot., 28(1): 63-81. (in Polish)

Central Station Animal Breeding (CSAB). 1971. *The results of the performance evaluation of dairy cows in 1970*. Warszawa. (in Polish)

Gravert O. 1991. *Indicators for assessing the energy balance of dairy cows*. Mh.Vet. Med., 46: 536-537. (in German)

Hibner A., Sakowski T. 1997. *The fat and protein content in milk of high yielding cows of the black and white breed*. Prz. Hod., 3: 1-3. (in Polish)

Juszczak J., Hibner A., Tomaszewski A. 2001. *The dynamics of changes in performance indices in a Holstein-Friesian cross-breed cow herd*. Med. Wet., 57(4): 284-287. (in Polish)

Kaczmarek A., Rosochowicz Ł., Kliks R., Antkowiak I. 1997. *Possibilities of improving protein content in dairy cows*. Rocz. Akad. Rol. w Poznaniu, 299: 49-66. (in Polish)

Kamieniecki K., Zalewski W. 1992. *The results of breeding work on creating the type of dairy cattle in agricultural experimental department of the Agricultural University in Lublin*. Pr. i Mat. Zoot., 42: 5-12. (in Polish)

Kruszyński W. 2008. *Analysis of production and functional traits and genetic structure of red-white breed bulls born between 1982-1999*. Zesz. Nauk. UP we Wrocławiu, 561 (Dissertations 250): 1-106. (in Polish)

Kuczaj M. 2002. *Influence of cow breed and successive lactation on the selected milk features*. Med. Wet., 58(8): 628-631. (in Polish)

Kuleta Z., Depta A., Bronicki M. 1989. *A blood test as part of preventive health checks of dairy cows.* Życie Wet., 64: 227-231. (in Polish)

Litwińczuk A., Litwińczuk Z., Barłowska J., Florek M. 1998. *Productivity and chemical composition of milk with particular emphasis on protein and its fractions in black and white, Jersey and hybrid cows with varied HF blood participation*. Zesz. Nauk. AR we Wrocławiu, 17(331): 149-155.

Miciński J., Klupczyński J. 2006. *Correlations between polymorphic variants of milk proteins, and milk yield and chemical composition in Black-and-White and Jersey cows*. Pol. J. Food Nutrit. Sci., 15/56(SI 1): 137-143.

Oprządek A., Oprządek J., Reklewski Z., Dymnicki E. 2003. *Prediction of the future milk usability of dairy heifers based on physiological blood features and zootechnical indicators in the growth period*. Zesz. Nauk. Prz. Hod., 68(1): 217-231. (in Polish)

Pawlina E. 1991. *The effectiveness of crossbreeding between Lowland Red-White and Holstein-Friesian cattle*. Zesz. Nauk. AR Wrocław, 97. (Habilitation Thesis in Polish)

Pérez – Cabal M.A., Alenda R. 2002. *Genetic relationships between lifetime profit and type traits in Spanish Holstein Cows*. J. Dairy Sci., 85: 3480-3491.

Pogorzelska J., Wielgosz-Groth, Kijak Z. 1998. *The impact of Holstein-Friesian bulls on the milk usability of hybrid F1 cows in a highly productive herd*. Zesz. Nauk AR we Wrocławiu, 17(331): 165-173.

Polish Federation of Cattle Breeding and Producer of Milk (PFCBPM). 2015. *The results of the performance indices of dairy cows in 2014*. Warszawa, http://www.pfhb.pl. (in Polish)

Prochorienko P. 2005. *On measures to stabilize the growth of production and sales of milk*. Moloč. Mjasnoe. Život., 2: 7-12. (in Russian)

Raś A. 1999. *A study on the effect of energy disturbances on reproductive processes of dairy cows*. Rozpr. Monogr., 18: 1-69. (in Polish)

Reklewski Z. 2000. *Improving of the health-promoting qualities of milk: The impact of nutrition on quality of fat and cholesterol level*. Zesz. Nauk. Prz. Hod., 51: 27-39. (in Polish)

Reklewski Z., Dymnicki E., Łukaszewicz M. 1999. *Functional features and their role in breeding programs*. Zesz. Nauk. Prz. Hod., 44: 45-61. (in Polish)

Sitkowska B., Mroczkowski S. 2004. *Variability and heritability of selected lactation and usability features of cows from a highly productive herd*. Zesz. Nauk. Prz. Hod., 72(1): 33-39. (in Polish)

Tomaszewski A. 2005. *Patterns of milk cholesterol content in black-and-white breed cows*. Zesz. Nauk. AR we Wrocławiu, 523 (Dissertations 235): 1-75. (in Polish)

Short T.H., Lawlor T.J. 1992. *Genetic parameters of conformation traits, milk yield and herd life in Holstein*. J. Dairy Sci., 75: 1987-1998.

Stiepanow D.W., Sein O.B., Rodina N.D. 2007. *The milk productivity black-variegated cows of different HF genotypes*. Vestnik Orlovskogo Gosudarstvennogo Agrarnogo Universiteta, 1(4): 19-22. (in Russian)

Strzałkowska N., Krzyżewski J., Reklewski Z., Dymnicki E. 2004. *Relationship between the strained length of calving intervals, some reproduction traits and adjusted cow's milk yield*. Med. Wet., 60(12): 1312-1316. (in Polish)

Szarek J. 1998. *Perspective series production in dairy cows*. The Commission Milk Production. Part. I. 49 Congress of the EAAP. Zesz. Nauk. Prz. Hod., 38: 45-55. (in Polish)

Szarek J., Otoliński E. 2002. *Some aspects of the development of cattle breeding in Poland*. Zesz. Nauk. Prz. Hod., 2: 4-7. (in Polish)

Szeląg I., Skrzypek R. 2000. *The growth rate of heifers as a factor in their milk productivity in the I^{st} lactatio*n. Rocz. AR, w Poznaniu, 330: 205-213. (in Polish)

Walawski K., Żelanis B. 1991. *The value in use and indicators of technological suitability of* *milk of cows with different content of HF breed. 1. Milk performance and milk secretion disorders indicators*. Zesz. Nauk. Prz. Hod., 3: 127-131. (in Polish)

ZIEMIŃSKI R. 2005. *The origin, utility types and breeds of cattle. In: Breeding and use of cattle.* Red. Z. LITWIŃCZUK, T. SZULC. PWRiL, Warszawa, pp. 14-51. (in Polish)

HAMMON D.S., WANG S., HOLYOAK G.R. 2000. *Effects of ammonia during different stages of culture on development of in vitro produced bovine embryos*. Anim. Reprod. Sci., 59: 23-30.