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THE INFLUENCE OF SELECTED FACTORS ON THE YIELD AND QUALITY OF COLOSTRUM PRODUCED BY POLISH HOLSTEIN-FRIESIAN COWS

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ABSTRACT

The aim of the study was to analyse the concentration of immunoglobulins in colostrum produced by Polish Holstein-Friesian (PHF) cows in relation to selected factors. An important element of the study is the analysis of colostrum yield and density. The research was conducted between April 2017 through April 2018. The yield and selected traits of colostrum obtained from the first 9 milkings from 20 PHF cows calving during this period were analysed. A total of 180 measurements were made. The average immunoglobulin content in the 180 observations was 37.7 g · L^{-1}, ranging between 7 and 140 g · L^{-1}. The study showed a significant effect of time after calving on the content of immunoglobulins. The highest content of the antibodies was found in colostrum obtained immediately after calving. Its average level at that time was 90.2 g · L^{-1} and in 20 assessed cows it ranged within the wide limits of 32–140 g · L^{-1}. The quality of colostrum radically deteriorated soon after calvong. The lowest level of immunoglobulins was found in the 96th hour after parturition and it was on average 10 g · L^{-1}. The average yield of colostrum was 10.3 kg. The yield of colostrum increased with time elapsing after calving. The lowest colostrum yield was observed within 2 hours, the highest within 96 hours after calving, respectively, 6.9 and 12.4 kg. The average specific density of colostrum was 1.041 g · cm^{-3}. The study showed that the highest density was characterized by colostrum obtained in the first milking post-partum. Its specific weight was 1.059 g · cm^{-3}. In subsequent milkings, the calcareous density of colostrum systematically decreased to 1.030 g · cm^{-3} in the 90th hour after calving.

Key words: cows, colostrum, performance, density, immunoglobulins, Polish Holstein-Friesian

INTRODUCTION

Due to the structure of the bovine placenta, which prevents the passage of antibodies from the dam to the fetus, newborn calves are very sensitive to pathogens present in the environment. The only protection is the passive immunity which calves acquire by assimilating antibodies taken with colostrum. Colostrum is the secretion produced by the mammary gland immediately after parturition. The quality of colostrum is influenced by both environmental factors, such as cow's age, yield of colostrum, cow's health status history in previous lactations, season of the year, past diseases, and genetic factors of the animals, i.e. breed, type and individual characteristics. The length of the dry period, the feeding of pregnant cows, the length of the calving period, the length and methods of drying, and the time elapsed from parturition are also important in terms of the quality of colostrum [Szulc and Zachwieja 1998, Gapper et al. 2007, Robinson et al. 2009, Wojtas and Zachwieja 2016].

Colostrum compared to normal milk contains less lactose and more fat, protein, peptides, non-protein nitrogen, ash, vitamins and minerals, hormones, growth factors, cytokines and nucleotides. With the exception of lactose, the levels of these compounds drop sharply over the first 3–7 days of lactation. A particular feature of bovine colostrum is the very high concentration of immunoglobulin G (IgG), which is particularly important for a newborn calf, whose gut, directly after giving birth, allows the passage of large molecules of immunoglobulins of this class, thus making them passively immune in the first stages of their postnatal life [Quigley

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et al. 1994, Smolenski et al. 2007, Strekozov et al. 2008, McGrath et al. 2016].

In order to obtain high-quality colostrum, the breeder must have sufficient knowledge, make conscious decisions and retain discipline. Any negligence, poor hygiene or late delivery of the first milk to the calf may have a negative effect on the life of the new organism.

The main aim of the study was to analyze the concentration of immunoglobulins in the colostrum produced by Polish Holstein-Friesian (PHF) cows in relation to selected factors. An important element of the analysis involved assessment of yield and density of colostrum. The research was carried out on 20 PHF cows within 2, 12, 24, 36, 48, 60, 72, 84, and 96 hours following parturition. The working hypothesis assumed an effect of time elapsed post-partum and cow age on colostrum yield and density, and the concentration of immune proteins.

MATERIAL AND METHODS

The research was carried out in a herd of cows located in the gmina of Korytnica, in Węgrów County, Masovian Voivodeship, Poland. During the research, the herd consisted of 77 PHF Black-and-White cows. The average annual milk yield per cow was 7340 kg. The average milk fat and protein levels were 4.14% and 3.58%, respectively. The analysis involved 20 cows, kept in calving pens on deep litter, placed in a separate building 4 weeks before expected parturition. During the lactation, rearing (in the case of heifers), and drying, the cows were fed TMR (Total Mixed Ration), which consisted of grass silage, maize silage and feed additives. The animals also received concentrate and vitamins.

The research was conducted between April 2017 and April 2018. We analyzed the yield and selected characteristics of colostrum obtained from the first 9 milkings from 20 cows calving during this period. A total of 180 measurements were carried out. Four elements and 5, 4, 4, 2 and 1 cow were randomly selected for the study, which started at lactation 2, 3, 4, 5 and 6, respectively.

Measuring immunoglobulins content in bovine colostrum

The colostrum was measured using a commercially available hydrometer (Kruuse colostrometer). The testing was performed following the manufacturer's guidelines, and the same colostrometer was used throughout the measurements. During the test, milk was poured into a special cylinder containing exactly 250 ml liquid. Temperature was measured with a digital thermometer. Colostrum was cooled to 20°C. The densimeter was floated and the density of colostrum was read off the scale. The obtained result was checked in the table, the content of immunoglobulins was noted. The first milking was carried out up to two hours after calving, other ones every 12 hours. For the purpose of the study, we did not use the colostrum from cows suffering from mastitis. All samples were cream-colored and did not contain any lumps of blood or discoloration.

The working hypothesis assumed three sources of variability. The age of cows was determined on the basis of the subsequent lactation. Taking into account this factor, individual cows were classified into 6 age groups, which marked the beginning of lactation: 1, 2, 3, 4, 5 and 6. In relation to time elapsed from calving, 9 groups of cows were distinguished. Based on this criterion, cows were classified into the following groups for which the length of the post-calving period was: 2, 12, 24, 36, 48, 60, 72, 84 and 90 hours. For the yield of colostrum, the following 3 groups of animals were grouped, from which the colostrum yield was: ≤9 kg, >9 to ≤12 kg, >12 kg.

Statistical analysis included one-way ANOVA performed with the least squares method. The following numerical model has been used for this purpose:

$$y_{ij} = \mu + a_i + e_{ij}$$

where:

y_{ij} – trait level,
μ – population mean,
a_i – effect of time after calving (i = 1, 2, 3, 4, 5, 6, 7, 8, 9) or age of cows (i = 1, 2, 3, 4),
e_{ij} – error.

Significance of differences between means were estimated using the Duncan test at the significance level $P \leq 0.01$. The GLM procedure of the SAS statistical package (SAS Institute 2003) was used in the calculations.

RESULTS AND DISCUSSION

Colostrum yield

Table 1 presents data on the colostrum yield in the analyzed cows. The average yield for 180 observations was 10.3 kg, increasing with time post-partum. The lowest yield, 6.9 kg, was noted within 2 hours, whereas the highest yield, 12.4 kg, within 96 hours after calving. Analysis of the dams' age against the yield of colostrum, significant differences in the pattern of this feature were found in the analyzed population. The highest yield of colostrum was found in those beginning the third lactation (11.5 kg), the lowest beginning the sixth lactation (8.2 kg). This difference was statistically significant at $P \leq 0.01$. Robinson et al. [2009] showed that the average yield of colostrum in the first milking after calving in the Holstein breed in the United States was 10.6 kg, for primiparous cows, and 13.6 kg, for multiparous cows. In turn, Gavin et al. [2018] , who studied Jersey cows in the US in 2016, noted the average colostrum yield ranging between 6.6 kg per cow (in June) and 2.5 kg per cow (in December). According to the authors, extremely low performance of colostrum occurred in several lines of sires and therefore they linked the yield level of colostrum to genetic factors. In the report by Duplessis et al. [2015], who studied 84 Holstein cows in the US, the average colostrum yield in the first milking after calving was 6.8 kg. Quigley et al. (2012) reported that the average colostrum yield in the first milking after parturition in 99 Holstein cows was 9.5 kg. The authors estimated the average first milking time as 6.1 hours after calving.

Colostrum density

Table 2 provides information on the density of colostrum. The average was 1.041 g · cm^{-3} with individual results ranging between 1.029 g · cm^{-3} to 1.073 g · cm^{-3}. The study shows that the highest colostrum density was the case in the first milking post-partum. Its specific weight was 1.059 g · cm^{-3}. In the subsequent milkings, the density of colostrum systematically decreased to 1.030 g · cm^{-3} in the 90th hour after calving. The results obtained in our study correspond with the results of Jankowska and Baliński [2009]. The authors report the highest colostrum density in the first milking [1.052 g · cm^{-3}] and note a gradual decrease in subsequent milkings after parturition. Madsen et al. [2004] reported that the density of colostrum dropped from 1.048 to 1.034 g · cm^{-3} within the first 2 days after calving, with its lowest level on day 6 post-partum (1.030 g · cm^{-3}). Strekozov et al. [2008] observed changes in the density of colostrum depending on the age of cows and the time of calving. The average density of colostrum obtained from the first milking was 1.059 g · cm^{-3}, compared to 1.068 g · cm^{-3} obtained for cows starting the third and fourth lactation. Comparing the importance of the calving season for the density of colostrum, these authors found the highest density of colostrum for cows calving in winter and the lowest for those calving in spring. The results reported by Robinson et al. [2009] and Guliński and Giersz [2006] also indicate the similar effect of cow's age on the density of colostrum.

According to Jenness and Patton [1959], the specific gravity of whole milk at 15.5°C is close to 1.030–1.035 g · cm^{-3}. Quigley et al. [1994] reported that the specific gravity of colostrum was in the range 1.028 to 1.074 g · cm^{-3}, with an average 1.052 g · cm^{-3}. The same authors described a positive correlation between the specific weight and the total nitrogen and protein content in the colostrum. Jeong et al. [2009], observed a decreasing trend in the specific weight of colostrum between the first and fourth milkings, from 1.055 g · cm^{-3} to 1.034 g · cm^{-3}. Likewise, Kertz [2008] confirmed that colostrum specific gravity in Holstein cattle in the US decreased from 1.056 g · cm^{-3} to 1.033 g · cm^{-3} over the first five milkings after parturition.

Immunoglobulins content in colostrum

Table 3 presents the results on the main goal of this study, i.e. colostrum immunoglobulins content in subsequent hours after calving. The average for 180 observations was 37.7 g · L^{-1} and ranged from 7 to 140 g · L^{-1}. The study showed a significant influence of the age of cows and time post-partum in relation to colostrum immunoglobulins content. Their highest content was found in the colostrum obtained immediately after calving, with its average level 90.2 g · L^{-1}. Colostrum immunoglobulins content in 20 subsequent milkings ranged from 32 to 140 g · L^{-1}.

Generally, the quality of colostrum in the studied herd should be rated as very good, except for one cow, whose level of immunoglobulins in the first milking after calving was very low, 32 g · L^{-1}. Later, colostrum IgG concentration was lower. The lowest level of immunoglobulins was found in 96 hours post-partum, on average 10 g · L^{-1}. It should be noted that at the 48th hour after calving, the level of immunoglobulins in most of the produced colostrum was below 30 g · L^{-1}. This fact means that in the population of Polish HF cows maintained in the conditions of eastern Poland, the production period of colostrum with normal properties is up to 2 days after parturition, from the third day the cows produce a secretion with approximate composition to the so-called transitional milk. In the subject literature, there is no unambiguous opinion regarding the length of the period in which cows produce colostrum. Opinions of various authors vary, from 2 days [Playford 2001], to 3–4 days [Zhang et al. 2011], to 5–7 days post-partum [Abd El-Fattah et al. 2012].

Farreli et al. [2004] claim that the three major classes of milk immunoglobulins, i.e. IgG, IgM and IgA, constitute about 1% of total milk protein or about 6% of the total whey protein. Colostrum contains higher levels of IgG, IgA and IgM [Smolenski et al. 2007], and immunoglobulins account for 70–80% of the total protein in colostrum [Larsen et al. 1992], which is of particular importance for the newborn calves, as the passive transmission of immunity occurs through colostrum, and not via the placenta [Zhang et al. 2011].

The data on colostrum concentration of immunoglobulins in the milk of the first milking after calving reported by various authors vary greatly, from 30 to 200 g · L^{-1} [Larsen et al. 1992, Korohnen et al. 1995, Gapper et al. 2007]. Morrill et al. [2012] noted concentration of IgG in first milking ranging from <1 to 200 g · L^{-1}, with an average 68.8 g · L^{-1}. These authors point out that almost 30% of colostrum contained less than 50 g of IgG · L^{-1}.

In conclusion, the authors emphasized that current industry recommendations include colostrum rejection with less than 50 g IgG · L^{-1}. In their study, 29.4% colostrum had IgG concentrations lower than the recom-

Table 1. Yield of bovine colostrum in relation to time after parturition and subsequent lactation

Tabela 1. Wydajność siary krów z uwzględnieniem czasu od wycielenia i laktacji

Factors Czynniki	Number of observations, n Liczba obserwacji, n	Colostrum yield, kg – Wydajność siary, kg			
		x̄	sd	min	max
Time elapsed from parturition, hours Czas po wycieleniu, godziny					
2	20	6.9^{E}	2.8	4.0	14.3
12	20	8.5^{D}	3.1	5.8	16.5
24	20	9.0^{DC}	2.8	4.0	14.5
36	20	10.1^{BCD}	2.3	7.0	14.5
48	20	10.8^{ABC}	2.5	7.1	16.0
60	20	11.2^{AB}	2.4	7.5	15.8
72	20	11.8^{AB}	2.5	7.5	16.0
84	20	11.9^{AB}	2.5	7.8	16.5
96	20	12.4^{A}	2.4	8.0	16.0
Lactation – Laktacja					
1	36	9.6^{BC}	2.6	4.0	13.4
2	45	10.2^{AB}	2.9	5.3	16.5
3	36	11.5^{A}	3.8	4.4	16.0
4	36	10.5^{AB}	3.2	4.5	16.5
5	18	10.0^{AB}	2.0	7.1	12.9
6	9	8.2^{C}	2.6	4.0	10.6
Total / average Razem / średnio	180	10.3	3.1	4.0	16.5

A, B – the means marked with different letters within factors differ significantly P ≤ 0.01.
A, B – średnie oznaczone różnymi literami w obrębie czynników różnią się istotnie przy P ≤ 0,01.

Table 2. Density of bovine colostrum ($g \cdot cm^{-3}$) in relation to time after parturition and subsequent lactation

Tabela 2. Gęstość siary ($g \cdot cm^{-3}$) krów z uwzględnieniem czasu od wycielenia i laktacji

Factor Czynnik	Number of observations, n Liczba obserwacji, n	Colostrum density, $g \cdot cm^{-3}$ – Gęstość siary, $g \cdot cm^{-3}$			
		x̄	sd	min	max
Time elapsed from parturition, hours Czas po wycieleniu, godziny					
2	20	1.059^{A}	0.011	1.038	1.078
12	20	1.052^{B}	0.010	1.029	1.071
24	20	1.045^{C}	0.007	1.030	1.055
36	20	1.039^{D}	0.005	1.032	1.049
48	20	1.037^{DE}	0.004	1.030	1.045
60	20	1.034^{EF}	0.004	1.029	1.043
72	20	1.033^{FG}	0.003	1.029	1.040
84	20	1.032^{FG}	0.003	1.029	1.040
96	20	1.030^{G}	0.001	1.029	1.034
Lactation – Laktacja					
1	36	1.036^{B}	0.006	1.029	1.053
2	45	1.041^{A}	0.012	1.029	1.073
3	36	1.041^{A}	0.014	1.029	1.078
4	36	1.041^{A}	0.012	1.029	1.068
5	18	1.039^{AB}	0.010	1.029	1.067
6	9	1.041^{A}	0.009	1.031	1.056
Total /average Razem / średnio	180	1.041	0.010	1.029	1.073

A, B – the means marked with different letters within factors differ significantly P ≤ 0.01.
A, B – średnie oznaczone różnymi literami w obrębie czynników różnią się istotnie przy P ≤ 0,01.

Table 3. Bovine colostrum immunoglobulins content ($g \cdot L^{-1}$) in relation to time after calving and subsequent lactation

Tabela 3. Zawartość immunoglobulin ($g \cdot l^{-1}$)w siarze krów z uwzględnieniem czasu od wycielenia i laktacji

Factor Czynnik	Number of observations, n Liczba obserwacji, n	Immunoglobulin content, $g \cdot L^{-1}$ – Zawartość immunoglobulin, $g \cdot l^{-1}$			
		$\bar{x}$	sd	min	max
Time elapsed from parturition, hours Czas po wycieleniu, godziny					
2	20	90.2^{A}	30.1	32	140
12	20	70.1^{B}	28.1	15	121
24	20	50.2^{C}	20.4	10	78
36	20	37.1^{D}	15.1	10	62
48	20	28.4^{DE}	12.3	10	51
60	20	22.0^{EF}	11.7	7	45
72	20	17.3^{FG}	10.1	7	37
84	20	14.1^{FG}	8.9	7	37
96	20	10.3^{G}	3.6	7	21
Lactation – Laktacja					
1	36	28.1^{B}	17.8	7	72
2	45	40.9^{A}	32.9	7	126
3	36	40.7^{A}	38.3	7	140
4	36	40.7^{A}	33.8	7	113
5	18	35.5^{AB}	28.6	7	110
6	9	42.4^{A}	27.1	13	81
Total / Average Razem / Średnio	180	37.7	31.2	7	140

A, B – the means marked with different letters within factors differ significantly $P \leq 0.01$.
A, B – średnie oznaczone różnymi literami w obrębie czynników różnią się istotnie przy $P \leq 0,01$.

mended IgG level, putting nearly 30% of calves in the US at the risk of passive immunity transfer failure.

In the final part of our study, an attempt was made to assess the effect of colostrum on the level of immunoglobulins contained in it. The data presented in Table 4 indicate a strong relationship between colostrum yields and the level of immunoglobulins it contains. The study showed that an increase in the yield of colostrum was accompanied by a decrease in the concentration of the proteins. In cows with a colostrum yield of $\leq$9 kg, >9 – $\leq$12 kg and >12 kg, the level of immunoglobulins was on average 60.4, 24.4 and 18.8 $g \cdot L^{-1}$. The differences were found to be statistically significant at $P \leq 0.01$.

SUMMARY

The average immunoglobulin content in 180 observations was 37.7 g/L and was between 7 and 140 $g \cdot L^{-1}$. The study showed a significant effect of time after calving on the content of immunoglobulins. The content of immunoglobulins in 2, 12, 24, 36, 48, 60, 72, 84 and 90 hours after calving were respectively: 90.2, 70.1, 50.2, 37.1, 28.4, 22,0, 17.3, 14.1, 10.3 $g \cdot l^{-1}$. Statistical analysis confirms the significance of these differences at $P \leq 0.01$. The highest content of immune bodies was found in colostrum collected immediately after calving. Its average level in 20 cows at that time was 90.2 $g \cdot L^{-1}$, ranging widely between 32 and 140 $g \cdot L^{-1}$. As time elapsed postpartum, the quality of colostrum deteriorated radically. The lowest level of immunoglobulins was found 90 hours after parturition, 10 $g \cdot L^{-1}$ on average. It should be noted that 48 hours after calving, the level of immunoglobulins in most of the sampled colostrum was below 30 $g \cdot L^{-1}$.

If we look at the yield of colostrum, the average for 180 observations was 10.3 kg. Colostrum yield increased over time. The lowest yield, 6.9 kg, was noted within 2 hours, whereas the highest, 12.4 kg, 96 hours postpartum. In terms of the effect of age on the yield of colostrum, significant differences in the pattern of this characteristic were found in the analyzed cow population. The highest yield of colostrum was found in the cows beginning the third lactation (11.5 kg), whereas the lowest beginning the sixth lactation (8.2 kg).

The average specific gravity of colostrum was 1.041 $g \cdot cm^{-3}$. Individual results ranged from 1.029 $g \cdot cm^{-3}$ to 1.073 $g \cdot cm^{-3}$. The highest density was characteristic for the colostrum collected in the first milking post-partum, 1.059 $g \cdot cm^{-3}$. In subsequent milkings, the density of colostrum systematically decreased to 1.030 $g \cdot cm^{-3}$ in the 90th hour post-partum.

Our study indicates a strong association between the colostrum yield and colostrum immunoglobulins content. An increase in colostrum yield was accompanied by a decrease in the concentration of immunoglobulins. In cows

Table 4. Influence of colostrum performance in cows on immunoglobulin content ($g \cdot L^{-1}$) in the following hours after calving

Tabela 4. Wpływ wydajności siary krów na zawartość immunoglobulin ($g \cdot l^{-1}$) w kolejnych okresach po wycieleniu

Time after parturition, hours Czas po wycielenu, godziny	Colostrum yield level, kg – Przedział wydajności siary, kg							
	≤ 9		> 9 to ≤ 12		> 12		Total / Average Razem / średnio	
	n	x̄	n	x̄	n	x̄	n	x̄
2	17	95.3^{1}	1	32.0^{3}	2	75.5^{2}	20	90.2^{A}
12	15	77.1^{1}	2	70.0^{2}	3	39.0^{3}	20	70.1^{B}
24	13	55.7^{1}	3	42.3^{2}	4	38.0^{3}	20	50.2^{C}
36	10	43.4^{1}	5	33.6^{2}	5	27.8^{3}	20	37.1^{D}
48	7	35.4^{1}	7	26.5^{2}	6	22.2^{3}	20	28.4^{DE}
60	4	35.8^{1}	8	23.0^{2}	8	14.3^{3}	20	22.0^{EF}
72	3	29.0^{1}	8	19.7^{2}	9	11.2^{3}	20	17.3^{FG}
84	3	24.7^{1}	1	15.4^{2}	10	9.9^{3}	20	14.1^{FG}
96	3	15.3^{1}	4	10.0^{2}	13	9.2^{2}	20	10.3^{G}
Total / Average Razem / Średnio	75	60.4^{1}	45	25.4^{2}	60	18.8^{3}	180	37.7

A, B – the mean values marked with different letters in the column differ significantly $P \leq 0.01$.
1, 2 – the means marked with different numbers in the lines differ significantly $P \leq 0.01$.
A, B – średnie oznaczone różnymi literami w kolumnach różnią się istotnie przy $P \leq 0,01$.
1, 2 – średnie oznaczone różnymi cyframi w wierszach różnią się istotnie przy $P \leq 0,01$.

with colostrum yields ≤9 kg, >9 – ≤12 kg and >12 kg, the levels of immunoglobulins were respectively: 60.4, 24.4 and 18.8 $g \cdot l^{-1}$.

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WPŁYW WYBRANYCH CZYNNIKÓW NA WYDAJNOŚĆ I JAKOŚĆ SIARY PRODUKOWANEJ PRZEZ KROWY RASY POLSKIEJ HOLSZTYŃSKO-FRYZYJSKIEJ

STRESZCZENIE

Celem pracy była analiza poziomu immunoglobulin w siarze produkowanej przez krowy rasy polskiej holsztyńsko-fryzyjskiej (phf) w zależności od wybranych czynników. Ważnym elementem była również analiza wydajności siary i jej gęstości. Badania przeprowadzono od kwietnia 2017 r. do kwietnia 2018 r. Analizie poddano wydajność i wybrane cechy siary uzyskane z pierwszych 9 udojów od 20 krów cielących się w tym okresie. Wykonano łącznie 180 pomiarów. Stwierdzono, że średnia zawartość immunoglobulin w 180 obserwacjach wynosiła 37,7 g $\cdot$ l^{-1}, a jej poziom zamykał się w granicach od 7 do 140 g $\cdot$ l^{-1}. Badania wykazały istotny wpływ czasu po wycieleniu na zawartość immunoglobulin. Najwyższą zawartość ciał odpornościowych charakteryzowała się siara uzyskana bezpośrednio po ocieleniu. Ich średni poziom w tym czasie wynosił 90,2 g $\cdot$ l^{-1} i zamykał się u 20 ocenianych krów w szerokich granicach 32-140 g $\cdot$ l^{-1}. Z upływem czasu po wycieleniu jakość siary uległa radykalnemu osłabieniu. Najniższy poziom immunoglobulin stwierdzono w 90. godzinie po porodzie. W tym czasie wynosił on średnio 10 g $\cdot$ l^{-1}. Średnia wydajność siary wynosiła 10,3 kg. Wydajność siary rosła wraz z upływem czasu po wycieleniu krów. Najniższą wydajnością odznaczała się siara uzyskana w 2. godzinie, najwyższą w 96. godzinie po ocieleniu. Wydajność siary wynosiła odpowiednio: 6,9 i 12,4 kg. Średnia gęstość właściwa siary ukształtowała się na poziomie 1,041 g $\cdot$ cm^{-3}. W pracy wykazano, że najwyższą gęstością charakteryzowała siara uzyskana w pierwszym doju po porodzie. Jej ciężar właściwy wynosił w tym okresie 1,059 g $\cdot$ cm^{-3}. W kolejnych dojach gęstość siary systematycznie malała, przyjmując w 90. godzinie po ocieleniu wartość 1,030 g $\cdot$ cm^{-3}.

Słowa kluczowe: krowy, siara, wydajność, gęstość, immunoglobuliny