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THE COMPOSITION AND PHYSICOCHEMICAL PROPERTIES OF COLOSTRUM IN BLACK-AND-WHITE POLISH HOLSTEIN-FRIESIAN COWS, MONTBÉLIARDE COWS AND THEIR CROSSBREEDS

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Abstract. The study involved 32 cows, including 13 Black-and-White Polish Holstein-Friesian cows, 6 Montbéliarde cows and 13 crossbred cows. Material for the study included samples of colostrum, which were analysed for basic components, somatic cell count, total bacteria count, immunoglobulin G1 concentration and physicochemical properties. In contrast to Polish Holstein-Friesian and Montbéliarde breeds, the colostrum of crossbred cows contained higher levels of dry matter, protein and fat, as well as lower lactose levels both in the first and the third milkings. Additionally, in the colostrum of these cows the level of titratable acidity, total bacteria count, somatic cell count, density, resistance and coagulation were higher, while active acidity and thermostability were lower. The immunoglobulin G1 concentration in the colostrum of crossbred cows showed greater stability on the first day when compared to Polish Holstein-Friesian and Montbéliarde breeds.

Key words: cows, genotype, colostrum, basic components, physicochemical properties

INTRODUCTION

Colostrum is a form of milk produced by the mammary glands of cows in late pregnancy and a few days after calving [Sawa et al. 2006, Heinrichs and Elizondo-

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-Salazar 2008]. Compared to milk, it contains more biologically active, bactericidal and bacteriostatic nutrients, which are necessary for maintaining the vital functions of newborns [Pecka et al. 2012]. Additionally, it contains whey proteins, which include immunoglobulins influencing the transfer of passive immunity to sucklings. Many authors claim that the basic components and physicochemical properties of colostrum change under the influence of genetic and non-genetic factors, such as nutrition, fitness, metabolic disorders, the length of the dry period, the age of cows, the length of the period after calving, obstructed labour and the maintenance system [Zachwieja et al. 2002b, Reinicke 2006, Csapó et al. 2011, Inamdar 2012, Sobczuk-Szul et al. 2013].

Genetic variation is an important criterion affecting the quality of colostrum [Guliński et al. 2006, Cziszter et al. 2008, Ježek et al. 2012]. Dual-purpose (milk and meat) cows, as well as beef cows produce colostrum with a higher immunoglobulin concentration [Lipp 2005, Mendonsa 2011]. A differentiating factor is the level of milk yield, which correlates negatively with immunoglobulins. Many authors have shown that the long-term selection of Polish Holstein-Friesian cows with respect to their production characteristics has contributed to an increase in the incidence of diseases that can impair the quality of colostrum, and thus limit the transfer of passive immunity to calves [Zachwieja et al. 2002a, Kuczaj et al. 2010, Zachwieja 2011].

In order to improve functional properties, the majority of farmers decide to use Montbéliarde cows [Gołębiewski et al. 2012]. Good results are also produced by crossbreeding Polish Holstein-Friesian cows with bulls of the French breed [Trela 2003]. The resulting crossbreeds are characterized by a higher health status, which may indicate the production of colostrum with a higher concentration of antibodies.

The aim of this study was to compare the components and the physicochemical properties of colostrum in Black-and-White Polish Holstein-Friesian and Montbéliarde cows, and their crossbreeds, all under the same environmental conditions.

MATERIAL AND METHODS

The study was conducted in a farm located in the south-eastern part of the Wielkopolska region of Poland. The analysis involved 32 cows from the first to fourth lactation, including 13 Black-and-White Polish Holstein-Friesian cows, 6 Montbéliarde cows and 13 crossbreeds (Polish Holstein-Friesian × Montbéliarde). The selection of animals to experience was a random within the breeds. The animals were kept in free stalls and fed the same total mixed rations (TMR). During the dry period, they were fed grass silage (70%) and corn silage (30%). In the

late (transition) dry period, they were given a mixture designed for cows in early lactation, which consisted of: corn silage (56.2%), grass silage (31%), brewers' spent grain (7.75%) and concentrates (5.05%). The average milk production in the herd within 305 days of lactation was 8022 kg. The milk contained 3.9% of fat and 3.19% of proteins.

Colostrum, in the amount of 100 ml, was collected from each cow in two milkings: two hours (first milking) and 24 hours (third milking) after calving. Each sample was immediately frozen at –20°C. A total of 64 colostrum samples were obtained, including 26 samples from the Polish Holstein-Friesian breed, 12 samples from the Montbéliarde cows and 26 samples from the crossbreeds. Once thawed, the levels of dry matter, protein, fat and lactose (Infrared Analyser 150 Bentley), as well as somatic cell count (Somacount Analyser 150 Bentley), total bacteria count (Bactocount Analyser 70 Bentley), immunoglobulin G1 concentration (polyacrylamide gel electrophoresis), active acidity (pehametr Level 2), titratable acidity (method of Soxhlet-Henkel), density (DMA 35N Portable Density Meter), electrical resistivity (Draminski mastitis detector), thermostability (attempt to alcohol PN-A-86003/A1: 1998) and coagulation time (method of rennet Scherna), were determined in the colostrum samples. Statistical analysis was performed using Statistica 10.0 by means of one-way analysis of variance.

RESULTS

Basic components, immunoglobulin G1 concentration, somatic cell count and total bacteria count determined in the colostrum of Polish Holstein-Friesian cows, Montbéliarde breeds and crossbreeds are presented in Table 1. There were no significant differences in the total protein contents of individual genotypes in the analysed samples of colostrum obtained in the first milking after calving, but the highest total protein content was obtained in the colostrum of crossbreeds in the first and third milkings: 15.34% and 11.86%, respectively.

Twenty-four hours after calving, the largest increase in the proportion of fat (around 2.35%) was observed in the colostrum of crossbreeds, when compared to the colostrum of the Polish Holstein-Friesian cows (1.89%) and the Montbéliarde breed (2.01%).

The lactose content was the lowest in the colostrum of crossbreeds collected two hours and 24 hours after calving, which amounted to 2.43% and 2.86%, respectively. In turn, the lactose level dropped with an increase in density and an extended clotting time in the colostrum of the Polish Holstein-Friesian cows and the Montbéliarde breed. These relationships correlated with an increased number of somatic cells.

Table 1. The immunoglobulin G1 concentrations, total bacteria count, somatic cell count and basic composition of colostrum of Black-and-White Polish Holstein-Friesian cows, Montbéliarde cows and their crossbreeds

Tabela 1. Koncentracja immunoglobulin klasy G1, ogólna liczba drobnoustrojów, liczba komórek somatycznych i skład podstawowy siary krów rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej, krów montbeliarde oraz mieszańców tych ras

Breed Rasa	M	S	Dry matter, % Sucha masa, %	Protein, % Białko, %	Fat, % Tłuszcz, %	Lactose, % Latoza, %	TBC jtk · ml^{-1}	SCC tys. · ml^{-1}	IgG1 g · l^{-1}
PHF HO	1	x	23.32	15.32	3.40	2.49	7703.77	2293.85	23.07
		SD	6.26	3.96	2.97	0.63	11811.05	1829.83	4.10
	3	x	20.10	10.45	5.29	3.40	8115.54	1309.85	17.87
		SD	3.30	2.42	1.85	0.52	7088.51	1977.82	6.68
PHF HO × MO	1	x	23.58	15.34	3.70	2.43	15315.00	5067.46	20.49
		SD	4.58	3.73	1.88	0.94	16136.73	4285.02	5.60
	3	x	21.81	11.86	6.05	2.86	22013.85	3110.77	18.58
		SD	4.44	3.43	3.25	0.82	25162.06	3044.30	6.17
MO	1	x	21.98	14.24	3.22	2.48	6275.00	2585.50	19.55
		SD	2.25	3.32	2.05	0.47	8705.52	2816.10	2.81
	3	x	18.77	9.43	5.23	3.22	15477.00	1009.33	15.23
		SD	4.08	0.90	4.41	0.30	14991.87	829.89	2.54

S – symbol, M – milking, TBC – total bacteria count, SCC – somatic cell count.
S – symbol, M – dój, TBC – ogólna liczba drobnoustrojów, SCC – liczba komórek somatycznych.

The dry matter content was highest in the colostrum of crossbreeds acquired two hours and 24 hours after calving: 23.58% and 21.81%, respectively. The highest total bacteria count and somatic cell count were observed in the colostrum of crossbreeds in the first and third milkings after calving. There was a smaller increase in the total bacteria count (by 411.77 U · ml^{-1}) and a smaller decrease in the number of somatic cells (by 984 thousand · ml^{-1}) in the colostrum of the Polish Holstein-Friesian Black-and-Whites in the period between the second and twenty-fourth hour after calving.

The immunoglobulin concentrations in all the examined samples were relatively low, and ranged from 11.86 to 32.35 g · l^{-1}. The highest average concentration of IgG1 in the first colostrum was obtained in the Polish Holstein-Friesian cows (23.07 g · l^{-1}), and the lowest in the Montbéliarde cattle (19.55 g · l^{-1}). In the third milking, the smallest decline in the concentration of antibodies was observed in the colostrum of crossbreeds, because the immunoglobulin concentration decreased by only 9.32% (Fig. 1). The decline in the concentration of antibodies was substantial in the colostrum of the Polish Holstein-Friesian and Montbéliarde breeds, and amounted to 22.54% and 22.10%, respectively.

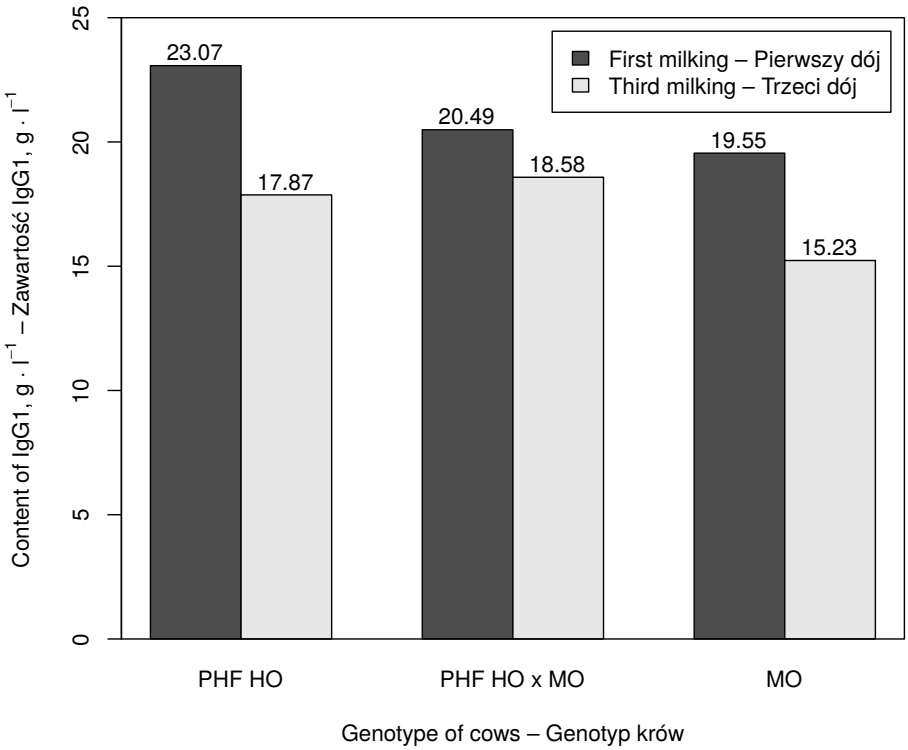

Fig. 1. Changes in the level of immunoglobulin class G1 in colostrum of Black-and-White Polish Holstein-Friesian cows, Montbéliarde cows and their crossbreeds in the first day after calving

Rys. 1. Zmiany poziomu immunoglobulin klasy G1 w siarze krów rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej, krów montbeliarde i mieszańców tych ras w pierwszej dobie po wycieleniu

Compared to the colostrum of crossbreeds and Montbéliarde cows, the colostrum Polish Holstein-Friesian Black-and-Whites in the first and third milkings were characterized by the lowest acidity: 6.46 and 6.50, respectively (Table 2). In addition, the low pH in the colostrum of Polish Holstein-Friesian cows was associated with an increased immunoglobulin concentration and basic components. The highest value of titratable acidity was determined in the colostrum of crossbreeds collected at two hours and 24 hours after calving: 19.45 and 11.26°SH, respectively.

The highest density was determined in the colostrum of crossbreeds in the first and third milkings after calving (1.063 g · cm^{-3} and 1.040 g · cm^{-3}, respectively), and the lowest in the colostrum of Montbéliarde cows (1.058 g · cm^{-3} and

Table 2. The physicochemical properties of colostrum of Black-and-White Polish Holstein-Friesian cows, Montbéliarde cows and their crossbreeds

Tabela 2. Właściwości fizykochemiczne siary krów rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej, krów montbeliarde oraz mieszańców tych ras

Breed Rasa	M	S	pH	°SH	Density, g · dm^{-3} Gęstość, g · dm^{-3}	Resistance, mOsm Oporność, mOsm	Thermostability, ml CH_3CH_2OH Termostabilność, ml CH_3CH_2OH	Coagulation time, min Czas krzepnięcia, min.
PHF HO	1	x	6.46	18.71	1.060	372.31	1.50	43:09
		SD	0.14	3.69	0.010	45.12	0.45	22:51
	3	x	6.50	10.92	1.039	387.69	1.46	16:17
		SD	0.10	1.16	0.010	25.87	0.57	12:28
PHF HO × MO	1	x	6.51	19.45	1.063	381.54	1.46	50:00
		SD	0.12	4.06	0.010	49.97	0.53	17:32
	3	x	6.52	11.26	1.040	386.15	1.59	18:09
		SD	0.10	1.43	0.010	38.63	0.56	12:23
MO	1	x	6.57	15.82	1.058	355.00	1.30	47:07
		SD	0.15	2.73	0.010	25.10	0.24	23:13
	3	x	6.58	10.00	1.038	348.33	1.55	18:33
		SD	0.10	1.13	0.003	19.41	0.21	12:11

1.038 g · cm^{-3}, respectively). In the colostrum of all tested cows, density correlated positively with immunoglobulin concentration. In addition, an increase in density was accompanied by higher titratable acidity levels and a prolonged clotting time in the Polish Holstein-Friesian Black-and-Whites, Montbéliarde cows and the crossbreeds.

Immediately after calving, resistance levels were 381.54 mOsm in the colostrum of crossbreeds, 372.31 mOsm in Polish Holstein-Friesian cows and 355 mOsm in Montbéliarde cattle. Twenty-four hours after calving, resistance levels in the colostrum of Polish Holstein-Friesian Black-and-Whites and crossbreeds increased by 15.38 and 4.61 mOsm, respectively, but dropped by 6.67 mOsm in the colostrum of Montbéliarde cows.

The colostrum of Montbéliarde cows that was collected in the early period after calving was characterized by the lowest thermostability (1.3 ml), compared to the colostrum of Polish Holstein-Friesian cows (1.5 ml) and crossbreeds (1.46 ml). In the following hours after calving, thermostability decreased in the colostrum of Polish Holstein-Friesian cows.

The average clotting time in minutes was: 50:00 in the colostrum of crossbreeds, 43:09 in the colostrum of Holstein-Frisian Black-and-Whites and 47:07 in the colostrum of Montbéliarde cattle. The shortest clotting time (16:17) was determined 24 hours after calving in the colostrum of Polish Holstein-Friesian cows.

DISCUSSION

The levels of basic components of colostrum were in the range of results obtained by other authors [Zachwieja et al. 2002a, Sobczuk-Szul et al. 2013]. The relatively high content of protein in the colostrum of crossbreeds, both in the first and the third milkings after calving, indicates an increased stability and a higher nutritional value of the colostrum. The observed increased levels of titratable acidity and lower levels of active acidity can improve the intestinal peristalsis and the absorption of the basic components of colostrum in calves. A similar trend has also been shown by Sawa et al. [2006].

Between the second and twenty-fourth hour after calving, the protein content of the colostrum of 6.25% of cows showed an increasing trend, with a simultaneous increase in dry matter content, total bacteria count and somatic cell count. In addition, lactose levels and thermostability decreased, while the clotting time was prolonged, indicating the presence of inflammation in the mammary gland. Similarly, Lipp [2005] has found a lower proportion of dry matter in the colostrum of cows suffering from mastitis.

Further analysis has shown that an increase in fat levels in crossbreeds and Montbéliarde cows is associated with a decrease in titratable acidity, thermostability and clotting time. A similar trend has been indicated by Zachwieja [2004]. In turn, Pecka [2011] shows that higher fat levels in subsequent hours are correlated with an increase in somatic cell count. Our own observations have not confirmed the above correlation.

The lactose level was the lowest in the colostrum of crossbreeds obtained from the first milking (2.43%) after calving. In the following hours, it increased (by 0.43%), but this increase was relatively small compared to the colostrum of Polish Holstein-Friesian Black-and-Whites and Montbéliarde cows. According to Georgiev [2008], a lower lactose level in the first colostrum and its gradual increase in successive milkings prevent the occurrence of diarrhoea in calves, and provide a better bioavailability of immunoglobulins. McGee et al. [2005] also point to lower lactose content in the colostrum of crossbred cows.

Dry matter content did not differ from the results obtained by other authors [Bar et al. 2010, Conte and Scarantino 2013]. The positive correlation between dry matter content, total bacteria count and coagulation in the colostrum of Polish Holstein-Friesian Black-and-Whites could indicate a higher susceptibility to mammary gland inflammation. Regardless of the breed, a significant negative correlation was identified between dry matter content and lactose level. Wroński and Sosnowska [2007] have also reported lower lactose levels in colostrum with higher dry matter contents.

Compared to the colostrum of crossbreeds and Montbéliarde cows, a smaller growth in total bacteria count (by 411.77 U $\cdot$ ml^{-1}) and a smaller decrease in the

number of somatic cells (by 984 thousand · ml^{-1}) was identified in the colostrum of Polish Holstein-Friesian Black-and-Whites from the third milking, indicating a higher susceptibility of these cows to mammary gland inflammation. According to Cziszter et al. [2008], colostrum collected from healthy cows should be characterized by a rapid decrease in somatic cell count and total bacteria count in the first few hours after calving.

The observed higher stability of antibodies in the colostrum of crossbreeds can attest to the positive impact of heterosis. A similar trend has been described by Georgiev [2008]. According to this author, the colostrum of beef cows, as well as dual-purpose (milk and meat) cows, has a higher immunological value compared to the colostrum of Holstein-Friesian cows.

The low active acidity level of the colostrum obtained from Polish Holstein-Friesian cows was synonymous with an increase inimmunoglobulin concentration and basic components. Zachwieja [2004] and Ferdowsi et al. [2010] confirm a significant negative correlation between the active acidity of colostrum and its composition. However, in all the analysed samples, along with lengthening the period after calving, a gradual increase in the value of active acidity was accompanied by a decrease in titratable acidity, which is consistent with the results obtained by Sosnowska [2005] and Zachwieja [2004].

According to Sobczuk-Szul et al. [2013], the colostrum of Jersey cows has the highest density, while Morin et al. [2001] argue that this is true for the colostrum of Holstein-Friesian cows. In our study, the colostrum of crossbreeds had the highest density, in both the first and the third milkings after calving.

According to Schichtl [2007] and Ontsouka et al. [2003], the colostrum of Holstein-Friesian cows has a lower resistance when compared to beef cows and crossbreeds, indicating their significant fragility and higher susceptibility to inflammation of the udder. The results of our study have not confirmed the above correlation, as the lowest resistance levels in both the first (355 mOsm) and the third (348.33 mOsm) milkings after calving were determined in the colostrum of Montbéliarde cows, which represent dual-purpose (milk and meat) breed.

Compared to the colostrum of crossbreeds and Montbéliarde cows, thermostability between the first and third milkings decreased (by 0.04 ml) in the colostrum of Polish Holstein-Friesian Black-and-Whites. As has been stated, this did not result from changes in the basic components of colostrum, nor was it associated with changes in its physicochemical properties. A different trend has been indicated by Zachwieja et al. [2002a]. The authors observed that a decrease in the thermostability of colostrum was accompanied by an increase in somatic cell count and an increase in whey protein levels. However, in the colostrum of Montbéliarde cows, despite an increase in alcohol level, thermostability was the lowest in both the

first (1.3 ml) and third (1.55 ml) milkings, which was associated with decreased electrical resistance and titratable acidity, as well as increased active acidity.

Zachwieja et al. [2002b] point to a close positive correlation between the thermostability of colostrum and its coagulation. This relationship has been confirmed only in the colostrum of Polish Holstein-Friesian cows, while in crossbreeds and Montbéliarde cows the clotting time shortened with increased thermostability, which may result in faster transport of colostrum to more distant sections of the digestive tract of calves. According to Gołębiewski et al. [2012], the milk of Montbéliarde cows has a higher content of casein, mainly κ-casein, when compared to that of Polish Holstein-Friesian Black-and-Whites.

CONCLUSIONS

1. The genotype of cows differs the composition and physicochemical properties of colostrum. The colostrum of crossbreeds had the highest contents of dry matter, protein and fat, as well as the lowest lactose levels in both the first and the third milkings after calving compared to the colostrum of Polish Holstein-Friesian and Montbéliarde cattle.
2. High titratable acidity, density, resistance and coagulation at a relatively low active acidity and thermostability indicate the superior quality of colostrum produced by crossbred cows.
3. Crossbreeds obtained by crossbreeding Polish Holstein-Friesian cows with Montbéliarde bulls are characterized by higher resistance and better adaptation to an intensive maintenance system, as evidenced by the production of colostrum with a favourable basic composition and higher values of physicochemical properties.

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SKŁAD I WŁAŚCIWOŚCI FIZYKOCHEMICZNE SIARY KRÓW RASY POLSKIEJ HOLSZTYŃSKO-FRYZYJSKIEJ ODMIANY CZARNO-BIAŁEJ, RASY MONTBELIARDE ORAZ MIESZAŃCÓW OBU RAS

Streszczenie. Analizą objęto 32 osobniki krów, przy czym 13 rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej, 6 rasy montbeliarde oraz 13 mieszańców międzyrasowych. Materiał do badań stanowiły próby siary, w których oznaczono skład podstawowy, liczbę komórek somatycznych, ogólną liczbę drobnoustrojów, zawartość immunoglobulin klasy G1 oraz właściwości fizykochemiczne. W przeciwieństwie do rasy polskiej holsztyńsko-fryzyjskiej i montbeliarde, w siarze pochodzącej od krów mieszańców zarówno w pierwszym jak i w trzecim doju stwierdzono wyższy poziom suchej masy, białka, tłuszczu, a niższy laktozy. Ponadto obserwowano znacznie wyższy poziom ogólnej liczby drobnoustrojów, liczby komórek somatycznych, kwasowości potencjalnej, gęstości, oporności, krzepliwości oraz niski kwasowości czynnej i termostabilności. Koncentracja immunoglobulin klasy G1 w ciągu pierwszej doby wykazywała większą stabilność w siarze krów mieszańców w porównaniu do rasy czarno-białej i montbeliarde.

Słowa kluczowe: krowy, genotyp, siara, skład podstawowy, właściwości fizykochemiczne

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