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YIELD AND COMPOSITION OF MILK FROM JERSEY COWS AS DEPENDENT ON THE GENETIC VARIANTS OF MILK PROTEINS

Jan Miciński, Janusz Klupczyński, Władysław Mordas, Renata Zabłotna

Department of Cattle Breeding and Milk Quality Evaluation, University of Warmia and Mazury in Olsztyn, Olsztyn

Key words: milk protein polymorphism, Jersey, lactation, fat, protein, genotype

The experiment was performed on 121 Jersey cows in the years 2003/2004. The aim of this study was to determine the yields of ECM, milk fat and milk protein as well as milk fat content and milk protein content during four successive 305-day lactations as dependent on the genotypes and polymorphic variants of milk proteins. Depending on their genotype, the cows were divided into the following groups: AA, AB, BB and BC. Four major milk proteins were obtained as a result of separation, *i.e.* LGB, CSN1S1, CSN2 and CSN3. The yields of ECM, milk fat and milk protein increased during four successive 305-day lactations. Cows with the polymorphic fractions LGB AA and AB, CSN1S1 BC, CSN2 AB and CSN3 AA were characterised by the highest productivity. The highest increase in fat content (0.63%) was recorded between the first and second lactation. The LGB AA genotype contributed to an increase in protein concentration, by 0.14%, 0.12% and 0.19% in the second, third and fourth lactation, respectively. In the case of the other fractions these values were as follows: CSN1S1 BC - 0.13%, 0.07% and 0.11% in the second, third and fourth lactation, respectively, CSN2 AA - 0.09%, 0.20%, 0.08% and 0.04% in the first, second, third and fourth lactation, respectively, and CSN3 BB - 0.11%, 0.16% and 0.10% in the second, third and fourth lactation, respectively.

INTRODUCTION

Despite a distinct domination of Holstein-Friesians, Jersey cattle are gaining increasing popularity worldwide. Recently also Polish breeders have shown growing interest in the Jersey breed, renowned for both ease of management and high milk quality. Denmark has the largest Jersey cattle population in Europe. The 2010 national average for the purebred Jerseys in this country is expected to reach 6800 kg of milk with a fat content of 5.80% and protein content of 4.10% [Bech *et al.*, 1990; Ojala *et al.*, 1997; Skrzypek, 2002].

Milk from Jersey cows has an increased concentration of casein proteins as well as increased retention of the other milk components, mostly butterfat, which is reflected in its suitability for cheese-making [Aleandri *et al.*, 1990; Krzyżewski *et al.*, 1998; Skrzypek, 2001]. The κ-casein B gene, associated with a higher protein content of milk, occurs with higher frequency in Jersey cattle [Walsh *et al.*, 1998; Walawski *et al.,* 1994; Michalak, 1995]. Thus, proper selection may contribute to increasing the frequency of the B CSN3 allele in the population [Michalak, 1995]. According to Kamiński [1996], the polymorphism of milk protein genes may be used in order to improve the composition and technological properties of milk since bulls with the most desirable genotypes, *e.g.* CSN3 and LGB, may be selected for reproductive purposes.

The aim of this study was to determine the yield and composition of milk from Jersey cows during four successive lactations as dependent on the genotypes and polymorphic variants of milk proteins.

MATERIALS AND METHODS

The experiment was performed during the years 2003/2004, on 121 Jersey cows of three herds in the Province of Warmia-and-Mazury. The stall housing system was combined with open grazing. The diets were balanced in terms of energy and protein. Milk samples were taken from each cow and poured into 1.5 mL Eppendorf flasks. Milk protein genetic variants were determined by starch gel electrophoresis in a basic solution, according to the method developed by Schmidt [1964] and modified by Michalak [1969], and in an acid solution, as described by Peterson and Kopfler [1966]. The following milk performance traits were analysed: milk yield, milk fat yield, milk protein yield as well as fat and protein percentages for 305 days of milking during the first, second, third and fourth lactation. Fat and protein were determined using a "Milkoscan 104 AB" analyzer, at the laboratory of the National Animal Breeding Center, Branch in Olsztyn. Actual milk yield was converted into ECM yield, according to the formula:

$$\text{ECM (kg)} = \text{milk (kg)}*[(0.383*\text{fat (\%)} + 0.242*\text{protein (\%)} + 0.7832) / 3.140]$$

Depending on their genotype, the cows were divided into the following groups: AA, AB, BB and BC. Four major milk

Author's address for correspondence: dr. Jan Miciński, Department of Cattle Breeding and Milk Quality Evaluation, University of Warmia and Mazury in Olsztyn, ul. Oczapowskiego 5/150, 10-957 Olsztyn, Poland; tel.: (48 89) 523 38 64; e-mail: micinsk@uwm.edu.pl

TABLE 1. ECM yield in successive lactations (kg).

Lactation	Genotype	Milk proteins											
		LGB			CSN1S1			CSN2			CSN3		
		n	LSM	SD	n	LSM	SD	n	LSM	SD	n	LSM	SD
I	AA	32	5285^{ab}	14.09	-	-	-	79	5043	14.93	59	5114^{a}	17.21
	AB	65	4974^{a}	16.85	-	-	-	37	5130^{a}	15.57	43	5067	13.19
	BB	24	4986^{b}	11.57	88	5014	16.01	5	4788^{a}	18.81	19	4829^{a}	12.52
	BC	-	-	-	33	5171	13.14	-	-	-	-	-	-
II	AA	12	5698	13.01	-	-	-	33	5660	17.84	27	5840^{a}	20.14
	AB	28	5681	20.33	-	-	-	18	5779	14.08	21	5775^{b}	10.69
	BB	16	5768	11.14	36	5666	14.79	5	5425	15.69	8	5143^{ab}	10.39
	BC	-	-	-	20	5787	19.28	-	-	-	-	-	-
III	AA	8	6254	20.94	-	-	-	27	6103^{a}	14.14	25	6420	14.7
	AB	29	6340	16.02	-	-	-	18	6597^{ab}	15.36	17	6106	15.23
	BB	12	6194	10.02	31	6230	16.43	4	6177^{b}	22.53	7	6276	19.45
	BC	-	-	-	18	6394	13.97	-	-	-	-	-	-
IV	AA	5	6041^{a}	24.9	-	-	-	17	6395	18.01	19	6575	18.23
	AB	16	6557^{a}	20.46	-	-	-	10	6439	19.33	9	6382	19.31
	BB	11	6321	9.97	19	6107^{a}	16.34	5	6149	22.11	4	6363	18.83
	BC	-	-	-	13	6817^{a}	18.6	-	-	-	-	-	-

Values in columns between genotypes within lactation at the level of the analyzed protein differ significantly: small letters at $p \leq 0.05$

proteins were obtained as a result of separation, *i.e.* β-lactoglobulin (LGB), αs1-casein (CSN1S1), κ-casein (CSN2) and β-casein (CSN3).

The collected numerical materials were characterized using least squares means (LSM) and standard deviations (SD). The results were verified statistically by analysis of variance and Duncan's test, using Statistica 6.1 software [Statsoft, 2003].

RESULTS AND DISCUSSION

A rare variant, CSN2 BB, was recorded in the population examined in 4.13% of cows [Miciński & Klupczyński, 2006]. ECM yield increased until the fourth lactation (Table 1). The highest milk yield (6817 kg) was observed during the fourth lactation for the protein CSN1S1 BC. It was by 2029 kg higher than the lowest yield (4788 kg) recorded during the first lactation for the protein CSN2 BB. Cows with the polymorphic fractions LGB AA and AB, CSN1S1 BC, CSN2 AB and CSN3 AA were characterised by the highest productivity, irrespective of lactation. No AA and AB genotypes occurred in cows with the protein CSN1S1. Only the BC genotype was recorded in this group. Differences between genotypes during particular lactations, concerning a given milk protein, were found to be statistically significant ($p \leq 0.05$).

Klupczyński & Miciński [2000] studied the milk performance of Jersey cows in two consecutive lactations. The results obtained by these authors were slightly lower, compared to the present experiment, *i.e.* 4127.8 and 5560.6 kg of ECM in the first and second lactation, respectively. Sowiński [1993] and Litwińczuk *et al.* [1996] analysed milk from primiparous Holstein-Friesian cows as dependent on polymorphic variants of milk proteins and reported that among LGB variants the highest milk yield was observed in AA homozygotes, followed by AB heterozygotes and BB homozygotes.

The correlation between polymorphic variants of milk proteins and their genotypes and a sum of fat and protein yields was also determined (Table 2). Similarly as with ECM yield, also in this case the best results were achieved for the AA genotype (LGB, CSN2 and CSN3) and the BC genotype (CSN1S1) at particular stages of successive lactations. The highest value of this index (532 kg) was obtained during the fourth lactation for the protein CSN1S1 BC, while the lowest (370 kg) during the first lactation for the protein CSN2 BB. Litwińczuk *et al.*, [1996] also observed a tendency towards higher yields of milk, milk fat and milk protein in cows with the BC genotype. Krzyżewski *et al.*, [1998] noted the highest yields of protein and fat in cows with the CSN2 AA genotype.

Milk fat concentrations were high in particular lactations (Table 3) and increased to the third lactation. The highest increase in fat content (0.63%) was recorded between the first and second lactation (LGB AB). The difference between the lowest milk fat content (5.63%, 2nd lactation, CSN3 BB) and the highest milk fat content (6.66%, 4th lactation, CSN2 BB) was 1.03%.

The highest fat concentration was observed for the following genotypes: LGB AB and BB, CSN1S1 BB, CSN2 BB, CSN3 AB. However, the differences were statistically non-significant. Kamiński *et al.* [1994] demonstrated that milk from BB cows had a higher fat content and yield. In the study conducted by Sowiński, [1993] fat percentage was higher in BB cows, compared to AA homozygotes.

The following genotypes affected an increase in the protein content of milk: LGB AA, CSN1S1 BC, CSN2 AA and CSN3 BB (Table 4).

TABLE 2. Yields of milk fat and milk protein in successive lactations (kg).

Lactation	Genotype	Milk proteins											
		LGB			CSN1S1			CSN2			CSN3		
		n	LSM	SD	n	LSM	SD	n	LSM	SD	n	LSM	SD
I	AA	32	409	14.00	-	-	-	79	397	15.11	59	395	17.29
	AB	65	385	17.01	-	-	-	37	391	15.37	43	393	13.15
	BB	24	387	11.38	88	388	16.00	5	370	18.39	19	375	12.57
	BC	-	-	-	33	400	13.32	-	-	-	-	-	-
II	AA	12	446	12.87	-	-	-	33	451	18.06	27	455[a]	20.39
	AB	28	443	20.77	-	-	-	18	440	14.30	21	450	11.18
	BB	16	443	11.18	36	440	14.68	5	421	16.31	8	399[a]	10.67
	BC	-	-	-	20	453	19.94	-	-	-	-	-	-
III	AA	8	490	21.29	-	-	-	27	478	14.18	25	499	14.21
	AB	29	490	15.48	-	-	-	18	511	14.87	17	476	15.46
	BB	12	483	10.03	31	485	15.97	4	483	22.80	7	491	19.25
	BC	-	-	-	18	499	14.07	-	-	-	-	-	-
IV	AA	5	472[a]	24.51	-	-	-	17	502	17.30	19	496	18.53
	AB	16	510[a]	20.75	-	-	-	10	502	19.25	9	498	18.97
	BB	11	492	9.84	19	475[a]	16.41	5	480	22.10	4	510	18.78
	BC	-	-	-	13	532[a]	18.54	-	-	-	-	-	-

Values in columns between genotypes within lactation at the level of the analyzed protein differ significantly: small letters at $p \leq 0.05$

TABLE 3. Milk fat content in successive lactations (%).

Lactation	Genotype	Milk proteins											
		LGB			CSN1S1			CSN2			CSN3		
		n	LSM	SD	n	LSM	SD	n	LSM	SD	n	LSM	SD
I	AA	32	5.96	10.26	-	-	-	79	5.90	10.01	59	5.92	10.47
	AB	65	5.94	10.90	-	-	-	37	6.04	11.53	43	6.05	10.22
	BB	24	5.99	6.16	88	5.96	10.02	5	6.10	2.25	19	5.78	9.60
	BC	-	-	-	33	5.93	11.10	-	-	-	-	-	-
II	AA	12	6.17	10.45	-	-	-	33	6.10	10.67	27	6.21	11.88
	AB	28	6.57	13.43	-	-	-	18	6.08	14.65	21	6.23	10.89
	BB	16	6.08	11.56	36	6.18	11.62	5	6.58	11.73	8	5.63	14.56
	BC	-	-	-	20	6.05	13.26	-	-	-	-	-	-
III	AA	8	6.20	13.08	-	-	-	27	6.18	14.34	25	6.27	11.96
	AB	29	6.23	14.68	-	-	-	18	6.34	11.56	17	6.43	16.96
	BB	12	6.46	12.37	31	6.31	13.93	4	6.76	18.66	7	6.00	9.98
	BC	-	-	-	18	6.27	13.68	-	-	-	-	-	-
IV	AA	5	5.92	10.08	-	-	-	17	6.11	12.31	19	6.25	12.53
	AB	16	6.27	14.00	-	-	-	10	6.16	13.99	9	6.30	14.38
	BB	11	6.25	12.57	19	6.22	11.90	5	6.66	12.48	4	5.82	11.68
	BC	-	-	-	13	6.20	14.59	-	-	-	-	-	-

Barłowska & Litwińczuk [2001] found that the CSN3 BB genotype was associated with higher concentrations of fat and protein, and caused an increase in milk fat content and milk protein content on average by 0.5% and 0.1%, respectively.

The LGB AA genotype contributed to an increase in protein concentration, by 0.14%, 0.12% and 0.19% in the second, third and fourth lactation, respectively. In the case of the other fractions these values were as follows: CSN1S1 BC – 0.13%, 0.07% and 0.11% in the second, third and fourth lactation,

TABLE 4. Milk protein content in successive lactations (%).

Lactation	Genotype	Milk proteins											
		LGB			CSN1S1			CSN2			CSN3		
		n	LSM	SD	n	LSM	SD	n	LSM	SD	n	LSM	SD
I	AA	32	3.99	5.74	-	-	-	79	4.00	6.07	59	3.93	6.05
	AB	65	3.98	5.94	-	-	-	37	3.98	7.09	43	4.03	5.72
	BB	24	4.01	7.78	88	4.00	6.27	5	3.91	3.57	19	4.07	7.96
	BC	-	-	-	33	3.97	5.06	-	-	-	-	-	-
II	AA	12	4.15	6.81	-	-	-	33	4.14	7.14	27	4.01	7.6
	AB	28	4.11	6.86	-	-	-	18	4.06	7.04	21	4.09	6.17
	BB	16	4.01	7.19	36	4.05	7.38	5	3.94	3.64	8	4.12	7.57
	BC	-	-	-	20	4.18	5.88	-	-	-	-	-	-
III	AA	8	4.21	5.92	-	-	-	27	4.15	5.18	25	4.07	5.73
	AB	29	4.09	5.34	-	-	-	18	4.07	5.07	17	4.14	3.71
	BB	12	4.11	2.85	31	4.09	5.4	4	4.08	2.29	7	4.23	4.24
	BC	-	-	-	18	4.16	4.13	-	-	-	-	-	-
IV	AA	5	4.25	6.22	-	-	-	17	4.12	6.5	19	4.13	5.31
	AB	16	4.06	5.21	-	-	-	10	4.09	3.58	9	4.09	4.86
	BB	11	4.07	4.04	19	4.05	4.7	5	4.08	2.15	4	4.13	5.84
	BC	-	-	-	13	4.16	5.47	-	-	-	-	-	-

respectively, CSN2 AA – 0.09%, 0.20%, 0.08% and 0.04% in the first, second, third and fourth lactation, respectively and CSN3 BB – 0.11%, 0.16% and 0.10% in the second, third and fourth lactation, respectively.

The correlation between milk protein genetic variants and the milk performance traits of cows indicates that the so called genotyping of cows and bulls may be used as a selection factor. Therefore, animals can be selected so as to increase the frequency of the desired protein alleles in the population, thus improving the composition and properties of milk.

CONCLUSIONS

1. The yields of ECM, milk fat and milk protein increased during four successive 305-day lactations. Cows with the polymorphic fractions LGB AA and AB, CSN1S1 BC, CSN2 AB and CSN3 AA were characterised by the highest productivity.

2. The highest increase in fat content (0.63%) was recorded between the first and second lactation (LGB AB). The difference between the lowest milk fat content (2nd lactation, CSN3 BB) and the highest milk fat content (4th lactation, CSN2 BB) was 1.03%. The highest fat concentration was observed for the following genotypes: LGB AB and BB, CSN1S1 BB, CSN2 BB, CSN3 AB.

3. The LGB AA genotype contributed to an increase in protein concentration, by 0.14%, 0.12% and 0.19% in the second, third and fourth lactation, respectively. In the case of the other fractions these values were as follows: CSN1S1 BC – 0.13%, 0.07% and 0.11% in the second, third and fourth lactation, respectively, CSN2 AA – 0.09%, 0.20%, 0.08% and 0.04% in the first, second, third and fourth lactation, respectively and CSN3 BB – 0.11%, 0.16% and 0.10% in the second, third and fourth lactation, respectively.

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CHARAKTERYSTYKA WYDAJNOŚCI I SKŁADU MLEKA KRÓW RASY JERSEY W ZALEŻNOŚCI OD GENETYCZNEGO UKŁADU BIAŁEK MLEKA

Jan Miciński, Janusz Klupczyński, Władysław Mordas, Renata Zabłotna

Katedra Hodowli Bydła i Oceny Mleka, Uniwersytet Warmińsko-Mazurski w Olsztynie, Olsztyn

Badania obejmujące 121 krów rasy jersey przeprowadzono w latach 2003/04. Celem badań było określenie wydajności mleka przeliczonego na zawartość ECM, tłuszczu i białka (T+B) oraz zawartości tłuszczu i białka w kolejnych 4 laktacjach 305 dniowych w zależności od genotypów i polimorficznych wariantów białek badanego mleka. W wyniku rozdziału uzyskano grupy krów o genotypach AA, AB, BB i BC oraz białkach mleka LGB, CSN1S1, CSN2, CSN3. Wykazano wzrost wydajności mleka przeliczonego na zawartość ECM oraz wydajności „T+B" w czterech kolejnych laktacjach 305 dniowych. Najwyższą wydajnością odznaczyły się krowy z polimorficzną frakcją LGB AA i AB, CSN1S1 BC, CSN2 AB i CSN3 AA. Wzrost zawartości tłuszczu odnotowany pomiędzy I a II laktacją był najwyższy i wynosił 0,63%. Genotyp LGB AA przyczynił się do zwiększenia zawartości białka w laktacji II o 0,14%, w laktacji III o 0,12% i w laktacji IV o 0,19%. Następnie: CSN1S1 BC odpowiednio o 0,13%, o 0,07% i o 0,11%; CSN2 AA w laktacji I o 0,09%, w II o 0,20%, w III o 0,08% i w IV 0,04% oraz CSN3 BB odpowiednio o 0,11%, o 0,16% i 0,10%.