Original scientific paper

UDK: 637.112.2/65.011.4

The effect of calf gender on milk lactation traits and lactation gain of Holstein and Simmental cows

DOI: 10.15567/mljekarstvo.2022.0301

Mato Čačić[1], Zoran Grgić[2], Marija Špehar[3], Ante Ivanković[4]*

[1]Ministry of Agriculture, Sector for Livestock Production, Ilica 101, 10000 Zagreb, Croatia
[2]University of Zagreb, Faculty of Agriculture, Division of Agroeconomy and Informatics, Department of Management and Rural Entrepreneurship, Svetošimunska 25, 10000 Zagreb, Croatia
[3]Croatian Agency for Agriculture and Food, Svetošimunska 25, 10000 Zagreb, Croatia
[4]University of Zagreb, Faculty of Agriculture, Division of Animal Science, Department of Animal Science and Technology, Svetošimunska 25, 10000 Zagreb, Croatia

Received: 09.03.2022. **Accepted**: 24.05.2022.

*Corresponding author: mato.cacic@mps.hr

Abstract

Considering the challenging market conditions for dairy farms, calf gender management should be one of the tools used to increase profitability. The objective of this paper was to examine the effect of calf gender on lactation milk traits in Holstein and Simmental cows. Holstein cows that calved a female calf had a higher milk yield ($p<0.0001$) and lower milk fat and protein content ($p<0.01$) in the first lactation. The favourable effect of female calf on milk yield was also found in the second lactation of Holstein cows ($p<0.0001$). Simmental cows that calved female calves in the first and the second lactation also had higher milk yield and lactation gain, however the differences were not significant. Although no statistically significant effect of calf gender on milk yield was determined in the Simmental population, indications of positive effect of female calf gender on lactation milk yield impose the need for further research. Using gender selected semen as a tool for calf gender management could enable to increase the milk yield of Holstein cows and the profitability of Holstein farms as well.

Key words: dairy farms; gender of calf; milk production; lactation gain; profitability

Introduction

Reproductive technologies accelerated genetic gain during the past century by allowing an increased number of offspring, consequently leading to a positive outcome in the dairy industry. An artificial insemination has proven to be of priceless value (Dalton, 1980). In the past, a lower rate of conception was a restrictive factor for wider use of sexed semen as a tool for gender ratio control. Given that, the efficacy of conception by insemination with sexed semen has been increased over the past decades. The use of such semen has become a common technological practice in many countries, (Beavers and Van Doormall, 2014).

Numerous studies of calf gender effect on lactogenesis, milk production and milk composition in lactation have been encouraged following the fact that milk synthesis is significantly influenced by the cow hormonal status in lactation. Differences of hormonal levels in udder of dams having different calf gender can affect milk component synthesis, probably due to difference of mammary gland development in cows (Ivell and Bathgate, 2002). According to Hadsell (2004) the gender of the first parity calf can have an effect on milk yield in later lactations if the abundance of hormones in the first parity has a favourable effect on the mammary gland development.

More O'Ferrall and Ryan (1990) were among the first researchers who determined that Holstein first calving cows having female calves had a higher milk yield for 4 % in the first and second lactation compared to cows who had male calves. Beavers and Van Doormall (2014) studied the benefits of sexed semen, while Hinde et al. (2014) also came to the same conclusions. Chegini et al. (2015) reported that Holstein cows having female calves in the first parity had a higher milk yield and fat, longer lactation and longer lactation persistence for milk yield and milk fat. On the other hand, cows calved male calves in the first parity had shorter calving interval and longer production life. The authors concluded that gender control should be included in the bovine breeding value prediction model for milk traits. Hess et al. (2016) determined that Holstein first calving cows had a higher milk production in the first lactation from up to 11 % and 0.24 % in the second lactation ($p<0.01$) if calved female calves. Hinde et al. (2014) noticed that calf gender order in the first and the second lactation also affected milk yield. Cows having female calves in the first and the second parity had higher milk yield in the first two lactations compared to cows that first calved female followed by male calf. Cows that calved in the first and second parity either female and male calves or both female calves, had a higher milk yield ($p<0.001$) compared to cows that calved two male calves, or first male than a female calf. Djedović et al. (2021) also found the highest milk and fat yield in the first and the second standard lactations initiated by calving of a female calf in first parity for the Holstein and Holstein crossbreed cows in the Republic of Serbia. The authors also stated the importance of inclusion of additional data such as calf body weight, calving ease, gestation length and the effect of management, which is extremely important for the level of milk production in dairy farms.

Opposite to the above mentioned studies, Græsbøll et al. (2015) observed that cows which calved male calves in the first two parities had a higher milk production by 0.52 % compared to other calves' gender combinations in the first two parities in Danish Holstein. The use of sexed semen in the insemination programme of Holstein herds having either moderate (30 % heifers + 30 % first calving cows) or intensive level (100 % heifers and 50 % first calving cows), had respective economic implications of gender for 4.0 € and 9.9 €/cow/year compared to exclusive use of conventional semen, (Ettema and Østergaard, 2015).

The impact of calf gender effect on lactation milk traits has not been extensively studied in Croatian dairy cattle population so far. The goal of this study was to determine the calf gender effect on standard lactation milk traits in the first and the second parity and lactation gain of Holstein and Simmental cows.

Material and methods

The study was conducted using standard lactation records (305 days) of the first and the second lactating Holstein (HOL) and Simmental (SIM) cows for the period from December 2008 to June 2016. All data used in this study was obtained from the central database of the Ministry of Agriculture. Standard lactation records included in the analysis were milk, milk fat, and protein yield and milk fat and protein content. Prior to the estimation of the gender effect on the examined milk traits, several adjustments of the original data were performed as follows. Records from the first and the second lactation were included in the analysis. Age at calving was calculated as a difference between calving and birth date and expressed in months. For the first parity SIM cows, the limits for age at calving were between 20 and 35 months, while for HOL cows it was set between 20 and 40 months. For the second calving cows, the age at calving was between 32 and 54 months (SIM) and between 32 and 56 months (HOL). Calving season was determined as year-season (three consecutive calving months) interaction. Four seasons are used: winter (from December to February), spring (from March to May), summer (from June to August), and autumn (from September to November). Calving season with less than 30 records per class was joined with the previous or next adjacent calving season. Regions represent counties of Croatia. Farm type included farms rearing SIM, HOL or both breeds. Herds ranged in size from small to large farms and the classes of herd size were set as follows: 1 - less than 20 cows per herd; 2 - between 21 and 30; 3 - between 31 and 40; 4 - between 41 and 50; 5 - between 51 and 100; 6 - between 101 and 150; 7 - between 151 and 200; 8 - between 201 and 300;

9 - between 301 and 500; 10 - between 501 and 1000; 11 - more than 1000 cows. After pruning of the original data set, a total of 158,167 records obtained from 39,656 SIM and 74,415 HOL cows were retained and used in the statistical analysis.

Statistical analysis

Statistical model used for the determination of sources of variability on the analysed milk traits by breed included the following fixed effects with classes: gender, lactation number, calving season, county, and herd size. The effect of age at the first calving is described by quadratic regression. Model shown in scalar notation is:

$$y_{ijklmn} = \mu + G_i + L_j + S_k + C_l + H_m + b_1(x_{ijklmn} - \bar{x}) + b_2(x_{ijklmn} - \bar{x})^2 + e_{ijklmn} \quad (1)$$

where: y_{ijklmn} - analysed trait (milk, milk fat, and protein yield, milk fat and protein content); μ - mean value, G_i - gender (i = 1, 2), L_j - lactation number (j = 1, 2), S_k - calving season (k = 1,2,..., 28), - C_l - county (l = 1, ..., 16), H_m - herd size (m = 1, ..., 6), x_{ijklmn} - age at first calving, and e_{ijklmn} - residual. To test statistical significance and inclusion of effect in the model, least square method and GLM (general linear model) procedure in the statistical package SAS (SAS Inst. Inc., 2009) was used. For milk production traits (milk yield, milk fat and milk protein yield, fat and protein content in standard lactation of 305 days), the corrected mean value (LSM - Least Square Means) was calculated.

Additionally, the calf gender effect on lactation gain was also calculated based on basic milk price following the proportion of milk fat and protein content and their monetary value. For this purpose, the methodology of Regulation on the target price of fresh raw milk of the Government of the Republic of Croatia ("Official Gazette": number 156/2002, with Regulations on modification on the target price of fresh raw milk ("Official Gazette" No. 153/2005; 123/2007; 81/2008) has been used according to the equation:

$$OCM = (M \times v1) + (B \times v2) \quad (2)$$

where:
OCM = basic milk price; *M* = proportion (%) milk fat weight fraction value; *B* = percent (%) milk protein weight fraction value; *v1* = monetary value of fat unit in milk in amount of 0.217 kuna; *v2* = monetary value of protein unit in amount of 0.328 kuna.

Results and discussion

The proportion of milk yield variation explained by the fixed effects ranged from 4.63 % (model for milk fat protein) to 23.31 % (model for milk protein yield) for Holstein breed. All examined effects had significant effect on the analysed milk traits (Table1).

The proportion of milk yield variation explained by the fixed effects ranged from 4.55 % (model for milk fat content) to 19.69 % (model for milk protein yield) for Simmental breed. All of the examined effects except gender had a significant effect on the analysed milk traits (Table 2).

Calf gender effect on milk production traits in the first and second lactation

Milk production traits of the first lactating Holstein cows having female calves produced a significantly higher ($p<0.01$) milk yield (38.56 kg; 0.58 %), milk fat (0.93 kg; 0.35%) and protein yield (0.7 kg; 0.31 %), but with lower milk fat (0.008 %) and protein content (0.007 %) (Tables 3 and 5). Holstein cows that calved males in the second parity had a significantly higher milk yield (225.4 kg; 3.2 %; $p<0.01$), milk fat (6.46 kg; 2.23 %; $p<0.05$) and milk protein yield (5.34 kg; 2.21 %; $p>0.01$) in the second lactation. In summary, cows that calved female calves in the first lactation had a higher average milk production in the first and the second lactations for 263 kg (1.89 %) compared to

Table 1. *Statistical significance of effects on milk traits in Holstein breed*

Model	Trait				
	Milk yield (kg)	Milk fat (kg)	Milk protein (kg)	Milk fat (%)	Milk protein (%)
R^2	19.45	19.36	23.31	5.26	4.63
DF	56	56	56	56	56
G_i	<.0001	<.0001	<.0001	<.0001	<.0001
L_j	<.0001	<.0001	<.0001	0.0022	<.0001
S_k	<.0001	<.0001	<.0001	<.0001	<.0001
C_l	<.0001	<.0001	<.0001	<.0001	<.0001
H_m	<.0001	<.0001	<.0001	<.0001	<.0001
b_1	<.0001	<.0001	<.0001	0.0005	<.0001
b_2	<.0001	<.0001	<.0001	0.0027	0.0002

R^2- coefficient of determination; DF - degrees of freedom

Table 2. Statistical significance of effects on milk traits in Simmental breed

Model	Trait				
	Milk yield (kg)	Milk fat (kg)	Milk protein (kg)	Milk fat (%)	Milk protein (%)
R^2	16.06	16.10	19.69	4.55	9.89
DF	56	56	56	56	56
G_i	0.2799	0.6692	0.5645	0.0756	0.0647
L_j	<.0001	<.0001	<.0001	0.0022	<.0001
S_k	<.0001	<.0001	<.0001	<.0001	<.0001
C_l	<.0001	<.0001	<.0001	<.0001	<.0001
H_m	<.0001	<.0001	<.0001	<.0001	<.0001
b_1	<.0001	<.0001	<.0001	0.0005	<.0001
b_2	<.0001	<.0001	<.0001	0.0027	0.0002

- coefficient of determination; DF - degrees of freedom

Table 3. Milk production traits (milk yield, milk fat yield and content, milk protein yield and content) of Holstein cows in the first and the second lactation by calf gender

Trait		Gender of calf	First lactation			Second lactation		
			Number of calf (%)	Mean	SD	Number of calf (%)	Mean	SD
Milk yield	kg	Male	19719 (46.1)	6635.35	1790.83	13274 (47.3)	7033.97	1982.34
Milk fat	kg			263.80	75.86		289.35	92.43
	%			3.95	0.551		4.00	0.591
Milk protein	kg			221.92	57.80		241.89	69.86
	%			3.29	0.237		3.32	0.256
Milk yield	kg	Female	23066 (53.9)	6673.91	1862.98	14803 (52.7)	7259.37	2164.18
Milk fat	kg			264.73	77.39		295.81	96.82
	%			3.94	0.558		3.99	0.595
Milk protein	kg			222.62	59.79		247.23	73.86
	%			3.28	0.233		3.31	0.255

SD - standard deviation

Table 4. Milk production traits (milk yield, milk fat content and yield, milk protein content and yield) of Simmental cows in the first and the second lactation by calf gender

Parameters		Gender of calf	First lactation			Second lactation		
			Number of calf (%)	Mean	SD	Number of calf (%)	Mean	SD
Milk yield	kg	Male	17122 (48.8)	4630.98	1271.29	15794 (48.8)	4851.64	1389.21
Milk fat	kg			190.46	55.90		199.93	60.42
	%			4.04	0.490		4.05	0.523
Milk protein	kg			157.55	42.53		167.37	46.65
	%			3.32	0.256		3.37	0.265
Milk yield	kg	Female	17971 (51.2)	4639.91	1242.98	16568 (51.2)	4858.55	1399.19
Milk fat	kg			190.24	54.83		200.64	60.67
	%			4.04	0.495		4.06	0.518
Milk protein	kg			157.39	41.60		167.83	46.54
	%			3.31	0.256		3.37	0.263

SD - standard deviation

Table 5. Comparison of milk production traits of Holstein and Simmental cows in the first two lactations by calf gender (P-value is pointed out in column of calf gender which had higher value of analysed lactation)

Breed		Holstein				Simmental			
Lactation		First lactation		Second lactation		First lactation		Second lactation	
Gender of calf		male	female	male	female	male	female	male	female
Milk yield	kg	-	< 0.0001**	-	< 0.0001**	-	0.0029**	-	0.3630
Milk fat	kg	-	0.0038**	-	< 0.0001**	0.0111*	-	-	0.6041
	%	0.0524	-	0.4184	-	0.1813	-	-	0.2748
Milk protein	kg	-	< 0.0001**	-	< 0.0001**	0.0039**	-	-	0.7671
	%	0.0210*	-	0.6898	-	0.8762	-	-	0.4523

**significant difference p<0.05; ** significant difference p<0.01*

the average milk production of cows having male calves (p<0.01). Higher milk production of Holstein cows in the first and the second lactations which started after calving female calves was also observed by More O'Ferral and Ryan (1990; 4 %), Beavers and Van Dormall (2014; 0.3 % and 0.6 %), and Hess et al. (2016; 0.33-1.1 % and 1.1 %).

The observed positive effect of a female calf on the milk production traits in Simmental cows was not so pronounced compared to the Holstein cows. Simmental first calving cows that calved female calves showed a higher milk yield (8.93 kg; 0.14 %; p<0.01) with lower milk fat yield (0.22 kg; p<0.05) and milk protein yield (0.16 kg; p<0.01; Tables 4 and 5). In the second lactation, cows that calved female calves showed better production indicators, but the obtained differences were not significant. In summary, dairy cows which started the first and the second lactation after calving female calves reached higher production (15.84 kg) compared to cows which started the first and the second lactation after calving male calves. However, the observed differences were not significant.

Effect of gender on milk production traits in the second lactation regarding the gender of the first and the second calf

Holstein cows that calved male calves in the first and the second lactations had significantly lower (p<0.01) milk yield (248.84 kg; 3.35 %), milk fat (8.02 kg; 2.64 %) and protein yield (6.03 kg; 2.37 %) than cows who first calved male, then female calf (Table 6 and Table 7). Cows that first calved female calf followed by male calf, produced less milk (107.17 kg; 1.42 %), milk fat (4.82 kg; 1.57 %) and protein yield (5.17 kg; 2,01 %) in both lactations, but had

Table 6. *Holstein and Simmental cow's milk traits (milk yield, milk fat yield and content, milk protein yield and content) in the second lactation considering the first and the second calf gender*

		Breed		Holstein			Simmental		
Gender of the first calf	**Gender of the second calf**	**Parameters**		**Number of lactations**	**Mean**	**SD**	**Number of lactations**	**Mean**	**SD**
Male	Male	Milk yield	kg	2963	7178.55	2001.37	3707	4890.05	1409.65
		Milk fat	kg	3040	295.35	93.07	3627	201.53	61.39
			%		3.99	0.588		4.04	0.525
		Milk protein	kg	3022	248.26	70.66	3568	168.84	47.06
			%		3.32	0.251		3.37	0.266
	Female	Milk yield	kg	3121	7427.39	2189.14	3528	4890.89	1421.77
		Milk fat	kg	3192	303.37	98.46	3464	201.94	61.78
			%		3.99	0.589		4.07	0.519
		Milk protein	kg	3176	254.29	74.60	3409	168.39	47.48
			%		3.32	0.249		3.37	0.268
Female	Male	Milk yield	kg	3728	7418.40	2189.85	3689	4882.98	1433.17
		Milk fat	kg	3793	303.14	98.83	3612	201.80	61.76
			%		4.01	0.598		4.06	0.515
		Milk protein	kg	3782	252.24	74.09	3550	168.68	47.62
			%		3.31	0.249		3.37	0.266
	Female	Milk yield	kg	3551	7525.57	2237.94	3594	4900.11	1391.32
		Milk fat	kg	3631	307.96	100.39	3529	201.78	61.07
			%		3.99	0.587		4.06	0.524
		Milk protein	kg	3625	257.41	75.52	3485	168.45	47.44
			%		3.31	0.249		3.36	0.264

SD - standard deviation

Table 7. *Comparison of milk traits of Holstein and Simmental cows in the second lactation regarding the first calf gender (P-value is pointed out in column of calf gender which had higher value of researched lactation properties)*

Breed		**Holstein**				**Simmental**			
Gender of the first calf		**male**		**female**		**male**		**female**	
Gender of the second calf		**male**	**female**	**male**	**female**	**male**	**female**	**male**	**female**
Milk yield	kg	-	< 0.0001**	-	0.1900	-	0.6066	-	0.0739
Milk fat	kg	-	0.0017**	-	0.3397	-	0.7066	0.4964	-
	%	-	0.9183	0.2630	-	-	0.4972	0.3227	-
Milk protein	kg	-	0.0026**	-	0.2462	0.6028	-	0.8229	-
	%	0.5991	-	0.9673	-	-	0.6925	0.7226	-

**significant difference p<0.05; **significant difference p<0.01*

a higher milk fat and protein content compared to cows that calved female calves after the first two lactations. The total production in the first and the second lactations, that started by calving female calves was by 1.89 % (263 kg) higher compared to the total milk production of cows that started by calving males, which was in accordance (1.86 %) with findings of Hinde et al. (2014).

Simmental cows that calved female calves in the first two lactations achieved higher production of milk (9.22 kg) and milk protein (0.06 kg), but a lower milk fat yield (0.16 kg; Tables 6 and 7), compared to cows that first calved male followed by female calf, in the second lactation. However, these differences were not significant. Cows having in the first two lactations the first female, then male calf had a higher milk production (17.13 kg), lower milk fat (0.02 kg) and milk protein yield (0.23 kg) compared to cows having female calves in the first two lactations. Again, the differences were not significant. The insignificant difference was observed when compared the total milk production in the first two lactations for cows that calved female calves compared to cows that calved male calves.

Calves gender effect on dairy cows lactation

The calf gender effect in the first and the second pregnancies on lactation milk traits in Holstein and Simmental cows could be expressed through financial value or profit (Table 8 and Table 9). Holstein cows that started the first lactation by calving female calves reached higher profit (74.80 kn/lactation; $p<0.05$) compared to cows that first calved male calves. Holstein cows that started the second lactation by calving female calves also achieved significant lactation profit (369.19 kn; $p<0.01$). In Holstein cows having male calves in the first two pregnancies, profit was lower by 1039.43 HRK compared to cows that first calved male, and second female calves ($p<0.01$; Table 9). Cows having female calves in the first two parities, compared to cows that calved the first female and then male calves achieved higher profit by 166.51 HRK ($p<0.05$). In Simmental cows, differences in financial profit regarding calf gender in the first and the second lactation were not significant (Table 9).

Table 8. *Basic fresh raw milk price and lactation profit of Holstein and Simmental cows in the first and the second lactation regarding calf gender*

Breed	Ordinal number of lactation	Gender of calf	M	M × v1	B	B × v2	OCM	Average milk yield (kg)	Average lactation gain (kn)	Difference in the average milk yield (in kg)	Difference in average lactation gain (in kn)
HOL	First	M	3.950	0.857	3.292	1.080	1.94	6635.35	12872.58	38.56	74.80
		F	3.948	0.857	3.290	1.079	1.94	6673.91	12947.39		
	Second	M	4.001	0.868	3.319	1.089	1.96	7033.97	13786.58	225.40	369.19
		F	3.992	0.866	3.313	1.087	1.95	7259.37	14155.77		
SIM	First	M	4.043	0.877	3.316	1.088	1.96	4630.98	9099.78	8.93	13.50
		F	4.042	0.877	3.314	1.087	1.96	4639.91	9113.28		
	Second	M	4.052	0.879	3.370	1.105	1.98	4851.64	9628.78	6.91	28.52
		F	4.060	0.881	3.374	1.107	1.99	4858.55	9657.30		

M - male; F - female; OCM - basic milk price; M - percent (%) milk fat weight fraction value; B - percent (%) milk protein weight fraction value; v1 - cow milk fat unit monetary value of 0.217 kuna; v2 - protein unit monetary value of 0.328 kuna; kg - kilogram; kn - kuna

Table 9. *Basic fresh raw milk price and lactation profit of Holstein and Simmental cows in the second lactation regarding calf gender in the first and the second parity*

Breed	Gender of calf I.	Gender of calf II.	M	M × v1	B	B × v2	OCM	Average milk yield (kg)	Average lactation gain (in kn)	Difference in the average milk yield (kg)	Difference in average lactation gain (in kn)
HOL	M	M	3.995	0.867	3.324	1.090	1.96	7178.55	14049.92	248.84	1039.43
		F	3.323	0.721	3.995	1.310	2.03	7427.39	15089.35		
	F	M	4.011	0.870	3.315	1.087	1.96	7418.40	14523.05	107.17	166.51
		F	3.986	0.865	3.314	1.087	1.95	7525.57	14689.57		
SIM	M	M	4.045	0.878	3.368	1.105	1.98	4890.05	9694.37	0.84	35.68
		F	4.071	0.883	3.372	1.106	1.99	4890.89	9730.05		
	F	M	4.062	0.881	3.368	1.105	1.99	4882.98	9698.37	17.13	22.28
		F	4.057	0.880	3.364	1.103	1.98	4900.11	9720.65		

M - male; F - female; I. - parity/lactation: II. - parity/lactation; OCM = basic milk price; M - percent (%) milk fat weight fraction value; B - percent (%) milk protein weight fraction value; v1 - cow milk fat unit monetary value of 0.217 kunas; v2 - cow milk protein unit monetary value of 0.328 kunas; kg - kilogram; kn - kuna

A positive effect of female calves on milk production traits was observed in the population of Holstein and Simmental cows. Differences were more pronounced in the Holstein population. Ivel and Bathgate (2002) explained the positive effect of female calves with higher levels of female hormones having a positive effect on mammary gland development in heifers and the first calving cows, which have not reached the final development of mammary gland during the first pregnancy. Chegini et al. (2015) reported a positive effect of female calf hormones on cow's physical development and milk production traits and noted that cows that calved female calves, had longer lactation persistency. Cows that calved female calves in the first two parities had higher milk production traits in the first and the second lactation. In Holstein cows, all lactation traits (milk yield, fat and protein yield) were more favourable in cows which calved female calves. On the other hand, Simmental cows had higher milk yield in lactation when started by calving female calves, but milk fat and protein yield were more favourable in lactations that started by calving male calves. Gender ratio control, compared to other livestock production had the greatest importance and benefit in dairy production because of the continuous need for quality herd replacement (Norman et al., 2010). The results obtained on the positive effect of female calves on milk yield in the first and the second lactation can be successfully applied and combined with greater use of sexed semen (Djedović et al., 2021). Sexed semen application in artificial insemination was known for many decades and became part of the regular reproductive practice in developed countries. Sexed semen has two major advances for the dairy farm compared to the conventional semen (Hossein - Zadeh et al., 2010). Due to the influence of the female calf, milk production is higher. Since the heifer is much more important for the dairy management than the male calf, a higher overall economic profit is achieved for the dairy farm (Hossein - Zadeh et al., 2010). This suggests that the use of sexed semen in the first insemination of heifers reduces the cost of breeding a female calf for herd replacement, positively affects the milk traits and provides a faster return on investment. A significant factor why managers are unlikely to use sexed semen is the higher price compared to conventional semen (Hibma, 2010). The economic benefit from sexed semen application significantly depends on the cow's basic fertility, because in case of a low fertility rate, more doses of semen must be used till reaching successful conception (Seidel, 2003).

Conclusion

The results of this study suggest that the first and the second calf gender affected milk lactation traits in Holstein and Simmental dairy cows. Holstein cows that calved female calves in the first and the second lactations produced more milk, milk fat, and protein yield in the first and the second lactation and also achieved higher financial profit. Simmental cows that started the first lactation by calving female calves also produced higher milk yield, but in second lactation the effect of calf gender on milk production was not observed. The positive effect of female calf gender on milk production traits and lactation gain was more pronounced in Holstein compared to Simmental cows. Calf gender management through more considerable application of sexed semen could be useful tool for increased profitability of dairy farms.

Utjecaj spola teleta na svojstva mliječnosti i laktacijsku dobit holstein i simentalskih krava

Sažetak

Istražen je utjecaj spola teleta na svojstva mliječnosti holštajn i simentalskih krava. Utvrđeno je da su holštajn krave koje su otelile žensku telad u prvoj laktaciji imale veću mliječnost ($p<0,0001$), te manji udio mliječne masti i mliječnih proteina ($p<0,01$). Utvrđen je povoljan utjecaj ženskog spola teleta na mliječnost holštajn krave u drugoj laktaciji ($p<0,0001$). Simentalske krave koje su prvu i drugu laktaciju započele nakon oteljenja ženske teladi također su imale veću mliječnost i laktacijsku dobit, no utvrđene razlike nisu statistički značajne. Upravljanjem spolom teladi uporabom seksiranog sjemena moguće je povećati mliječnost holštajn krava i dohodovnost holštajn mliječnih farmi. Premda u simentalskoj populaciji nije uočen značajan utjecaj spola teleta na svojstva mliječnosti, zapažene indicije pozitivnog utjecaja ženskog spola na mliječnost nameću potrebu daljnjih istraživanja. U vremenu otežanog poslovanja mliječnih farmi, upravljanje spolom teladi treba biti jedan od alata za postizanje povoljnije razine profitabilnosti.

Ključne riječi: mliječne farme; spol teleta; svojstva mliječnosti; laktacijska dobit; profitabilnost

References

1. Beavers, L., Van Doormaal (2014): Is sex-biased milk production a real thing? Canadian Daily Networ, https://www.cdn.ca/document.php?id=348
2. Chegini A., Hossein-Zadeh, N.G., Hosseini-Moghadam, H. (2015): Effect of calf seks on some productive, reproductive and health traits in Holstein cows. *Spanish Journal of Agricultural Research* 13 (2), 1-7. https://doi.org/10.5424/sjar/2015132-6320
3. Dalton, D.C. (1980): An introduction to practical animal breeding. London. Granada.
4. Djedović, R., Stanojević, D., Bogdanović, V., Ostojić Andrić, D., Samolovac, Lj., Stamenić, T. (2021): Bias of calf sex on milk yield and fat yield in holstein crossbreed cows. *Animals* 11 (9), 2536. https://doi.org/10.3390/ani11092536
5. Ettema, J.F., Østergaard, S. (2015): Economics of seks – biased milk production. *Journal of Dairy Science* 98, 1078-1081. https://doi.org/10.3168/jds.2014-8774
6. Græsbøll, K., Kirkeby C., Nielsen, S.S., Christiansen, L.E. (2015): Danish Holsteins favor bull offspring: Biased milk produciton as a funciton of fetal seks and calving difficulty. *Plos One* 10 (4), 1-12. https://doi.org/10.1371/journal.pone.0124051
7. Hadsell, D.L. (2004): Genetic manipulation of mammary gland development and lactation. Protecting Infants through human milk. *Advancing the Scientific Evidence* 554, 229-251. https://doi.org/10.1007/978-1-4757-4242-8_20
8. Hossein-Zadeh, N.G., Nejati-Javaremi, A., Miraei-Ashtiani, S.R., Kohram, H. (2010): Bio-economic evaluation of the use of sexed semenat different conception rates and herd sizes in Holstein populations. *Animal Reproduction Science* 121, 17-23. https://doi.org/10.1016/j.anireprosci.2010.05.012
9. Hess, MK, Hess, AS, Garrick, DJ. (2016): The Effect of Calf Gender on Milk Production in Seasonal Calving Cows and Its Impact on Genetic Evaluations. *Plos One* 11 (3). https://doi.org/10.1371/journal.pone.0151236
10. Hibma, J. (2010): Dairy replacements are valuable and necessary. Progressive Dairy. August 11, 2010., http://www.progressivedairy.com/topics/calves-heifers/dairy-replacements-are-valuable-and-necessary, 15.12.2016.
11. Hinde, K., Carpenter, A.J., Claj, J.S., Bradford, B.J. (2014): Holstein favor heifers, not bulls: Biased milk production programmed during pregnancy as a funcional of fetal seks. *Plos One* 9 (2), 1-7. https://doi.org/10.1371/journal.pone.0086169
12. Ivell, R., Bathgate, R.A.D. (2002): Reproductive biology oft he relaxin-like factor (RLF/INSL3). *Biology of Reproduction* 67 (3), 699-705. https://doi.org/10.1095/biolreprod.102.005199
13. Narodne novine (2002): Uredba o ciljnoj cijeni svježeg sirovog mlijeka. Narodne novine 156/2002, s uredbama o izmjenama o ciljnoj cijeni svježeg sirovog mlijeka: 153/2005; 123/2007; 81/2008.
14. Norman, H.D., Hutchinson, J.L., Miller, R.H. (2010): Use of sexed semen and its effect on conception rate, calf sex, dystocia, and stillbirth of Holsteins in the United States. *Journal of Dairy Science* 93 (8), 3880-3890. https://doi.org/10.3168/jds.2009-2781
15. More O'Ferrall, G.R., Ryan, M. (1990): Beef crossing: Effects of genotype of the foetus on the performance of dairy cows. *Irish Journal of Agriculutural Research* 29, 101-107.
16. SAS (2009): SAS Version 9.2, SAS Institute Inc. Cary, NC, USA
17. Seidel Jr, G.E. (2003): Economics of selecting for sex: The most important genetic trait. *Theriogenology* 59, 585-598. https://doi.org/10.1016/s0093-691x(02)01242-6