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Factors affecting milk fat variability in primiparous Simmental cows: housing methods, origin, and calving season

Dragan Nikšić[1*], Nenad Mićić[1], Dušica Ostojić-Andrić[1], Predrag Perišić[2], Marina Lazarević[1], Veselin Petričević[1], Ljiljana Samolovac[1]

[1] *Institute for Animal Husbandry, Autoput 16, P. Box 23, 11080, Belgrade-Zemun, Republic of Serbia*
[2] *Faculty of Agriculture, Nemanjina 6, 11080, Belgrade-Zemun, Republic of Serbia*

**Corresponding author: draganniksic84@gmail.com*

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A B S T R A C T

Milk fat content stands out as a crucial production trait in cows, and this study delves into its variability based on various factors. The research investigated how the housing method (large farm or individual producers), origin (domestic-rearing or imported cows), and calving season collectively impact this trait. Cows reared on the farm exhibited a higher milk fat content compared to those raised by individual producers. Additionally, primiparous cows from domestic rearing displayed lower milk fat content than their counterparts of imported origin. Among primiparous cows on the farm, those calving in the summer and autumn produced the highest milk fat content. Conversely, primiparous cows calving in the spring season and raised by individual producers recorded the lowest milk fat content. The statistical analysis revealed a highly significant influence of calving season, with a noteworthy interaction among housing method and origin on the observed trait. The significance ranged from statistically highly significant ($P \leq 0.01$) to statistically very highly significant ($P \leq 0.001$).

Keywords: milk fat content, Simmental cow breed, housing method, origin, calving season.

И З В О Д

Садржај млечне масти представља једну од најважнијих производних особина код крава. У раду је испитивана њена варијабилност под утицајем начина држања животиња (велики фармски начин или индивидуални произвођачи), њиховог порекла (домаћи одгој или грла из увоза), сезоне тељења, као и интеракцијом ових фактора. Грла гајена на фарми имала су већи садржај млечне масти од грла гајених код индивидуалних произвођача, док су првотелке из домаћег одгоја остварile мањи садржај млечне масти од грла пореклом из увоза. Првотелке које су се телиле у лето и јесен гајене на фарми имале су највећи садржај млечне масти, док су најмањи садржај млечне масти имале првотелке које су се телиле у пролећној сезони гајене код индивидуалних произвођача. Што се тиче утицаја сезоне тељења, обједињених фактора начина држања и порекла и њихове интеракције на посматрану особину, он је био статистички високо значајан ($P \leq 0{,}01$) до статистички врло високо значајан ($P \leq 0{,}001$).

Кључне речи: садржај млечне масти, сименталска раса, начин држања, порекло, сезона тељења.

1. Introduction

Milk fat, alongside protein, constitutes one of the most crucial components of milk. Comprising a mixture of a large number of lipid substances, milk fat is predominantly composed of triglycerides (95–96%). Its significance is multifaceted, as half of the milk's total energy value is attributed to milk fat, owing to its elevated biological value compared to other fats. Traditional selection practices in animal husbandry underscore its importance, particularly in the production of dairy products such as cream, butter, and ghee.

Authors exploring the production characteristics of cows have consistently included investigations into milk fat content as part of their research. For instance, Perišić (1998) examined reproductive and production traits in cows of different genotypes - the domestic variegated breed and cows imported from Slovenia and Germany. The study, conducted in the region encompassing the upper reaches of the Kolubara River, yielded results indicating an average milk fat proportion of 3.83% throughout the entire lactation period for all the examined cows. The average milk fat yield was 165.06 kg. Medić et al. (2006) investigated differences between a highly productive herd in Serbia and a primiparous Simmental cow breed imported from Austria from 2004–2005. Their results revealed that cows imported from Austria exhibited significantly higher average milk fat content by +0.49% and a milk fat yield higher by +73 kg. In Kostić (2014) examination of the impact of imported cows from Germany on the outcomes of the breeding program in the Šumadija district, Serbia, he notes that the milk fat content in the first lactation is lower by 0.05% while experiencing a slight increase of 0.01% in both the second and third

years for domestic cows. Examining the phenotypic variability of bull mothers within the Simmental breed, Pantelić et al. (2013) reported a production figure of 5 754.49 kg for milk with 3.98% milk fat. In a study investigating the production results of primiparous cows over a four-year period (2007–2010) in the individual producer sector in Serbia, Nikšić et al. (2011) found that the average milk production reached 4 348 kg with 3.93% milk fat and a yield of 171.1 kg of milk fat. Examining the production outcomes of the primiparous cows from identical bulls in both Germany and Serbia, Kučević et al. (2005) discovered a statistically highly significant difference ($P \leq 0.01$) in both quantity and milk fat content traits. Exploring the impact of external temperature on cow production characteristics, Mićić et al. (2022) found that cows calved in the fall season exhibited a maximum milk fat content of 3.99%, while those calved in the spring season had a minimum of 3.94%. Similar findings (3.94%) were reported by Stanojević et al. (2022) in their investigation of various factors influencing production traits in Simmental cows in Serbia. Reflecting agricultural producers' shift from conventional to automated robotic milking systems, Mijić et al. (2021) observed a higher milk fat content, reaching 4.00%. In highly milky breeds, Lazarevic et al. (2021) reported a significantly lower milk fat content of 3.49% for the Holstein-Friesian breed, whereas Stanojević et al. (2015) noted a slightly higher content of 3.58%. Rincon et al. (2015) reported an even higher milk fat content of 3.88% in their research on the Holstein-Friesian breed. Similarly, Pantelić et al. (2014) found a milk fat content of 3.88% in Simmental primiparous cows. Examining the influence of calving season on milk fat content in the Holstein-Friesian breed, Lazarevic et al. (2013) determined that it was statistically significant ($P < 0.05$). Cows calved in November, December, and January exhibited a higher milk fat content by 0.9% compared to the average of all four examined seasons.

As per data from the leading association of cattle breeders in Germany in 2014 (http://vvv.fleckvieh.de/Englisch/Fleckvieh_Zuchtziele.htm), the Simmental cow population was reported at 3.66 million. Their milk production averaged 6 852 kg, featuring 4.14% milk fat and 3.49% protein content. Additionally, bull mothers in Austria, according to data from the Austrian Association, which encompassed 1495 cows in 2012 (http://vvv.fleckvieh.at/), indicated a production of 9 366 kg of milk, accompanied by 4.20% milk fat and 3.54% protein.

The Czech Cattle Breeders' Association reported the average production of Simmental cows under control in the Czech Republic in 2008 as 6 438 kg of milk with 4.43% protein and 4.02% milk fat. Simultaneously, in the same year, the average production of bull mothers in the Czech Republic was 9 225 kg of milk, with 3.43% protein and 3.90% milk fat content (http://vvv.cestr.cz/).

2. Materials and methods

This research was conducted using data obtained from the "Lazar" farm in Blace, Serbia, where some of the cows included in this research were located. Situated in the Toplički district, the "Lazar" farm stands out as one of Serbia's most extensive and contemporary Simmental cow farms. Information on individual producers' production characteristics and milk fat content was extracted from family farms in close proximity to the "Lazar" farm within the Toplički district. This collaborative effort involved coordination between producers and local breeding organizations actively implementing the breeding program within this region. The total number of animals (n = 954) which were the subject of this research was categorized into two groups according to their housing method and two groups based on their origin, as outlined below:

Table 1.
The number of primiparous cows categorized by group

	Group name	Number of primiparous cows
Housing method	Group 1	504
	Group 2	450
Origin	Group 1	718
	Group 2	235
Total number of primiparous cows		**954**

The following models were used to determine the variability of milk fat content under the influence of various factors:

1) The model with fixed effects of housing method and origin and their interaction (the model used in cows and primiparous cows):

$Y_{ijk} = \mu + N_i + P_j + NP_{ij} + e_{ijk}$,

where: Y_{ijk} = the investigated trait; μ= average of the population for the given trait; N_i = fixed influence of the i-th housing method (i =1, 2); P_j = fixed influence of the j-th origin (j = 1, 2); NP_{ij} = the influence of the interaction of factors (the housing method and the origin of the cows); e_{ijk}= random error.

2) The model with fixed effects of season and housing method:

$Y_{ijk} = \mu + C_i + N_j + C_i x N_j + e_{ijk}$,

where: Y_{ijk} = the investigated trait; μ = average of the population for the given trait; C_i = fixed influence of the calving season – beginning of lactation (i=1,2,3,4); N_j = fixed influence of the j-th housing method (j =1, 2); $C_i x N_j$= interaction of two factors (season and the housing method); e_{ijk} = random error.

3) The model with a fixed effect of calving season-beginning of lactation and the combined effect of the housing method and origin (used for cows and primiparous cows):

$Y_{ijk} = \mu + C_i + NP_j + CNP_{ij} + e_{ijk}$,

where: Y_{ijk} = the investigated trait; μ= average of the population for the given trait; C_i = fixed influence of the calving season – beginning of lactation (i=1,2,3,4);

NP_j = fixed combined effect of the housing method and origin (j =1,2,3,4); CNP_{ij} = the interaction of the season and the combined influence of the housing method and origin; e_{ijk} = random error.

Data processing for this research was conducted using SPSS Statistics for Windows, Version 23.0, to derive the study results.

3. Results and discussions

Table 2 presents the milk fat contents attained by the primiparous cows of the Simmental breed, the focal point of this study, categorized by the housing method and origin. The table reveals that animals raised on the farm exhibited a 0.02% higher milk fat content compared to those raised by individual producers. Moreover, primiparous cows from domestic rearing displayed a 0.04% lower milk fat content than their counterparts of imported origin. Medić et al. (2006) reported a notably more significant difference in milk fat content between domestic and imported cows, while Kostić (2014) observed an approximately identical difference.

Table 2.
The influence of the housing method and origin of primiparous cows on milk fat content

Milk fat content		Number of lactations	x̄	SD
Housing method	Individual producers	504	3.88	0.121
	Farm	450	3.91	0.108
Origin	Domestic	718	3.88	0.107
	Imported	236	3.92	0.136
Housing method	F = 20.133***	P = 0.000		
Origin	F = 0.150^{ns}	P = 0.686		
Housing method x Origin	F = 16.186***	P = 0.000		

Where: SD = standard deviation; x̄ = mean; *** = $P \leq 0.001$; ** = $P \leq 0.01$; * = $P \leq 0.05$; ns (non-significant) = $P > 0.05$.

As indicated in Table 1, the origin of the cows exhibited no statistically significant effect (P > 0.05) on the milk fat content of primiparous cows. However, the housing method and its interaction with the origin of the cows were deemed highly significant (P ≤ 0.001).

Table 3 displays the average values of milk fat content in primiparous cows, classified by the calving season and the rearing method (individual producers or farms). The highest milk fat content was observed in primiparous cows that calved in summer and autumn and were reared on the farm (3.92%). On the contrary, those calving in the spring season and raised by individual producers exhibited the lowest milk fat content (3.87%). Regarding the variability of milk fat content under the influence of the investigated factors, Table 2 highlights that the housing method significantly impacted the observed trait (P ≤ 0.001). However, the calving season and its interaction with the housing method did not yield statistically significant effects (P > 0.05) on the milk fat content of the observed primiparous cows.

Table 3.
The influence of the calving season and the housing method of primiparous cows on milk fat content

Calving season	Housing method	Number of lactations	x̄	SD
1	Individual producers	153	3.89	0.136
	Farm	149	3.91	0.098
2	Individual producers	135	3.87	0.117
	Farm	124	3.89	0.107
3	Individual producers	104	3.89	0.104
	Farm	101	3.92	0.103
4	Individual producers	112	3.89	0.121
	Farm	76	3.92	0.132
Calving season		F = 3.125 ^{ns}		P = 0.064
Housing method		F = 10.361***		P = 0.000
Calving season x Housing method		F = 0.034 ^{ns}		P = 0.991

Where: SD = standard deviation; x̄ = mean; *** = $P \leq 0.001$; ** = $P \leq 0.01$; * = $P \leq 0.05$; ns (non-significant) = $P > 0.05$.

Table 4 presents the average milk fat content and its standard deviations for the observed population of primiparous cows categorized by groups and calving seasons. The impact of the calving season, the combined factors of housing method and origin, and their interaction on the observed trait were found to be statistically highly significant ($P \leq 0.01$) to statistically very highly significant ($P \leq 0.001$), as indicated in the following table.

Table 4.
The influence of the calving season and combined effect of the housing method and origin categorized by groups of primiparous cows on milk fat content

Calving season	Group	Number of lactations	x̄	SD	Calving season	Group	Number of lactations	x̄	SD
winter	1	131	3.87	0.085	summer	1	88	3.88	0.111
	2	22	4.02	0.261		2	16	3.90	0.048
	3	92	3.90	0.093		3	52	3.93	0.098
	4	57	3.93	0.103		4	49	3.90	0.107
spring	1	117	3.86	0.120	autumn	1	100	3.87	0.100
	2	18	3.88	0.096		2	12	4.01	0.197
	3	91	3.88	0.099		3	47	3.94	0.147
	4	33	3.91	0.125		4	29	3.88	0.097
(housing method x origin)				F = 12.526 ***			P = 0.000		
Calving season				F = 3.174**			P = 0.002		
Calving season x (housing method x origin)				F = 2.127***			P = 0.001		

Where: SD = standard deviation; x̄ = mean; *** = $P \leq 0.001$; ** = $P \leq 0.01$.

4. Conclusions

As indicated in Table 1, the origin of the cows exhibited no statistically significant effect ($P > 0.05$) on the milk fat content of primiparous cows. However, the housing method and its interaction with the origin of the cows were deemed highly significant ($P \leq 0.001$).

Domestically bred cows exhibited the highest milk fat content at 3.94%, while imported cows, whether raised on farms or by individual producers, registered a slightly lower milk fat content at 3.92%. In contrast, the lowest milk fat content was observed in domestic cows raised by individual producers, 3.89%.

Comparing farm-raised cows to those raised by individual producers, the farm-raised cows displayed a 0.03% higher milk fat content, and imported cows showed a 0.02% higher milk fat content than domestically raised cows.

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Declaration of competing interest

The authors declare that they have no competing interests.

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