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CHEMICAL COMPOSITION AND SOMATIC CELL EVOLUTION DURING LACTATION IN ROMANIAN BLACK AND WHITE COWS

EVOLUȚIA COMPOZIȚIEI CHIMICE ŞI A NUMĂRULUI DE CELULE SOMATICE DIN LAPTE PE PARCURSUL UNEI LACTAȚII LA VACILE DE RASĂ BĂLȚATĂ CU NEGRU ROMÂNEASCĂ

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The aim of the paper was to study the evolution of the chemical composition and somatic cell count during lactation in Romanian Black and White cows and effect of calving season on the shape of the lactation curve. Lactations form 125 multiparous cows were studied. Milk yield and sampling were carried out using the official performance control method A4. Milk was analyzed for composition in infrared spectrometry and for SCC using a viscosimeter. Results were modeled using Wood's incomplete gamma function $y=ab^{x}e^{(-cx)}$*, and season effect was assessed using ANOVA/MANOVA. A discussion was carried out regarding the shape of the lactation curves for milk yield, each milk component and SCC. The calving season had a significant effect (p<0.005) on the shape of the lactation curve for milk yield, milk chemical composition and milk somatic cell count. Summer calving cows had flatter lactation curves for milk yield and composition compared to winter calving cows. For somatic cell count spring calving cows had the flattest lactation curve while autumn calving cows has the steepest lactation curve.*

Key words: lactation curve, milk yield, chemical composition, somatic cell count, calving season, cows, Romanian Black and White

Introduction

A general accepted goal of dairy breeding throughout the world is to improve the efficiency of milk production (Tekerli et al., 2000). Costs of milk production depend to a large extent on the persistency of lactation that is the expression of the ability of the cow to produce milk at a peak level throughout lactation. An abrupt decline in milk yield after the peak increases production costs because yield is distributed less equally over the lactation (Appuhamy et al., 2007). Persistent lactations are characterized by lower peak yield reached at a later DIM, indicating their association with reduced metabolic stress in early lactation (Ferris et al., 1985; Dekkers et al., 1998).

Gamma function described by Wood, 1967 is one of the most popular models used to describe the lactation curve. A large number of factors such as farm, calving year, calving season, calving age, parity, service period, and interval from calving to first test day were reported to earlier to have an impact on lactation traits (Tekerli et al., 2000; Cziszter et al., 1996a, 1996b, 1997, 1998; Szűcs, 1997).

The aim of the present paper was to study the evolution of the chemical composition and somatic cell count during lactation in Romanian Black and White cows and the influence of calving season on the shape of the lactation curve.

Materials and Methods

Researches were carried out on 125 Romanian Black and White multiparous cows from the university research farm that calved in years 2005 and 2006. Milk production was recorded and milk samples were collected in parallel with the official performance recording, method A4. Milk samples were immediately analyzed for chemical composition (fat, protein, lactose, and solids non-fat) using the infrared device MilkoScan S54B and for somatic cell count by using the viscosity device MT-02. Adding the fat content to the solids non-fat content total solids was obtained.

Gamma function described by Wood, 1967 was fitted to milk yield and components for each lactation:

$$y=ab^{x}e^{(-cx)}$$

where *y* is the yield or component at time *x*; *a*, *b*, and *c* are parameters of the function and; and *e* is the base of natural logarithm.

DIM at peak (nadir) was defined as b/c, and y_{max} (y_{min}) was calculated as $a(b/c)^{b}e^{-b}$.

Effect of calving season was analyzed using ANOVA/MANOVA. Graphs were plotted using the results of modeling in order to describe the evolution of components and milk yield.

Results and Discussion

Parameters for the incomplete gamma model resulted from the modeling process are presented for each studied trait in Table 1.

Figures 1 to 7 show the evolution of the milk yield and composition according to calving season.

Generally, calving season had a significant ($p<0.05$) effect on the shape of the lactation curve for all studied milk traits. From Table 1 and Figures 1-7 it is obvious that the way milk yield is produced and the composition content is influenced in large extent by the calving season.

Milk yield evolution strongly differed among seasons. (Figure 1) Spring and winter calving cows started at lower initial milk (around 15 kg, Table 1), but had higher increasing rates up to the peak (parameter b, Table 1). They reached higher production at peak (18.9 and 18.8 kg, respectively) at higher DIM (31.4 and 35 days, respectively). These characteristics led to steeper lactation curve compared to summer and autumn calvers.

Summer and autumn calving cows started the lactation at a higher production (17.09 and 16.73 kg, respectively), has lower increasing rates up to peak production, lower peaks (about 17 kg) that was reached earlier (5.6 and 14.4 day, respectively, Table 1). These features conducted to flatter lactation curves.

Table 1

Average values of the incomplete gamma equation parameters for the milk production traits

Trait	Season	a	b	c	Y_{max}/y_{min}	b/c (days)
Milk yield (kg)	Spring	14.75559	0.101579	0.003235	18.9	31.4
	Summer	17.09230	0.011100	0.001974	17.2	5.6
	Autumn	16.73444	0.023591	0.001639	17.4	14.4
	Winter	14.96483	0.089869	0.002566	18.8	35.0
Fat (%)	Spring	4.260597	-0.008619	-0.000333	4.18	25.9
	Summer	4.287783	-0.032127	-0.000390	3.84	82.3
	Autumn	4.789675	-0.056645	-0.000367	3.81	154.2
	Winter	5.155772	-0.044698	-0.000302	4.31	147.9
Protein (%)	Spring	3.176655	-0.007108	-0.000254	3.12	28.0
	Summer	2.771735	-0.044261	-0.000111	2.22	400.1
	Autumn	2.996965	-0.029347	-0.000110	2.62	266.6
	Winter	3.961140	-0.047309	-0.000434	3.33	109.1
Lactose (%)	Spring	4.685938	0.008171	0.000079	4.83	103.0
	Summer	4.781701	0.001359	0.000070	4.79	19.4
	Autumn	4.717346	0.004296	0.000060	4.78	71.6
	Winter	4.581603	0.011395	0.000074	4.80	154.4
Solids non-fat (%)	Spring	8.487346	-0.007072	-0.000013	8.18	524.9
	Summer	8.688650	-0.008593	-0.000130	8.45	66.3
	Autumn	9.338241	-0.013790	-0.000153	8.90	89.9
	Winter	8.325233	-0.015544	-0.000064	7.76	241.3
Total Solids (%)	Spring	12.81635	-0.010300	-0.000125	12.37	82.7
	Summer	13.19479	-0.011097	-0.000152	12.72	73.1
	Autumn	14.22964	-0.027387	-0.000282	12.90	97.2
	Winter	12.50579	-0.023953	-0.000135	11.31	177.8
Somatic cell count (ln SCC/ml)	Spring	12.30460	-0.003280	-0.000150	12.22	21.3
	Summer	12.66012	-0.017530	-0.000230	12.34	74.7
	Autumn	12.57228	-0.021680	-0.000300	12.19	72.3
	Winter	12.36776	-0.013570	-0.000260	12.15	51.8

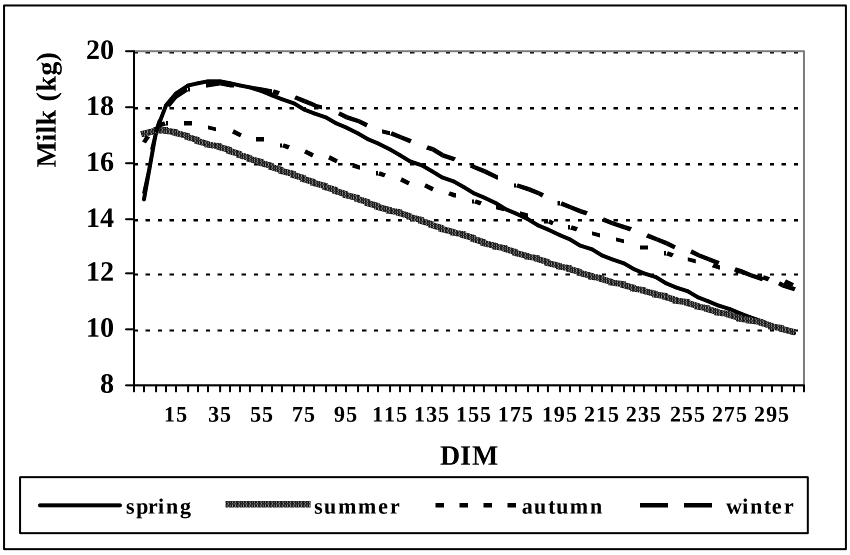

Figure 1. Daily milk yield evolution during lactation by calving season

The lactation curve for **milk fat percentage** according to the calving season is presented in Figure 2. The milk fat percentage was high at the beginning of lactation, decreased to a nadir and then increased again at the end of lactation.

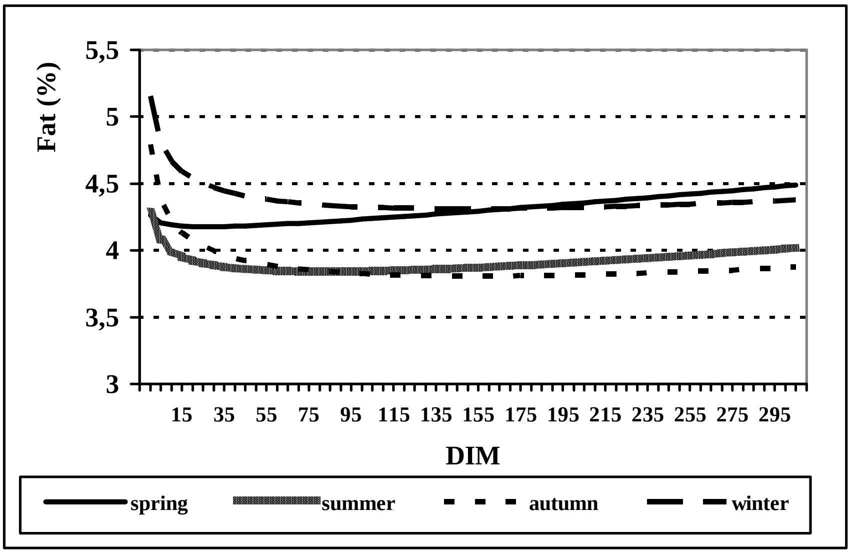

Figure 2. Milk fat percentage evolution during lactation by calving season

Winter and autumn started lactation at a very high milk fat percentage (5.15% and 4.79%, respectively), but while winter calvers maintained this traits at a higher value until nadir point (4.31%) autumn calvers dropped to 3.81% fat at nadir. In both seasons the nadir point was reached very late in lactation, 147.9 DIM for winter and 154.2 in autumn.

Spring and summer calving cows stated lactation at the same level (4.26% and 4.29%, respectively), but spring calvers reached nadir earlier with higher value (25.9 DIM and 4.18% fat) while summer calvers reached nadir later at lower value (82.3 DIM with 3.84% fat).

For **protein percentage** the lactation curve showed very large differences between seasons (Figure 3).

Summer and autumn calving cows had a very atypical lactation curve for protein content of milk. They started lactation at a low value (2.77 for summer and 2.99 for autumn) and reached nadir very late. Actually for summer calving cows the lowest percentage was obtained outside the normal lactation (400.1 DIM) while for autumn calvers it was reached at the end of lactation (266.6 DIM).

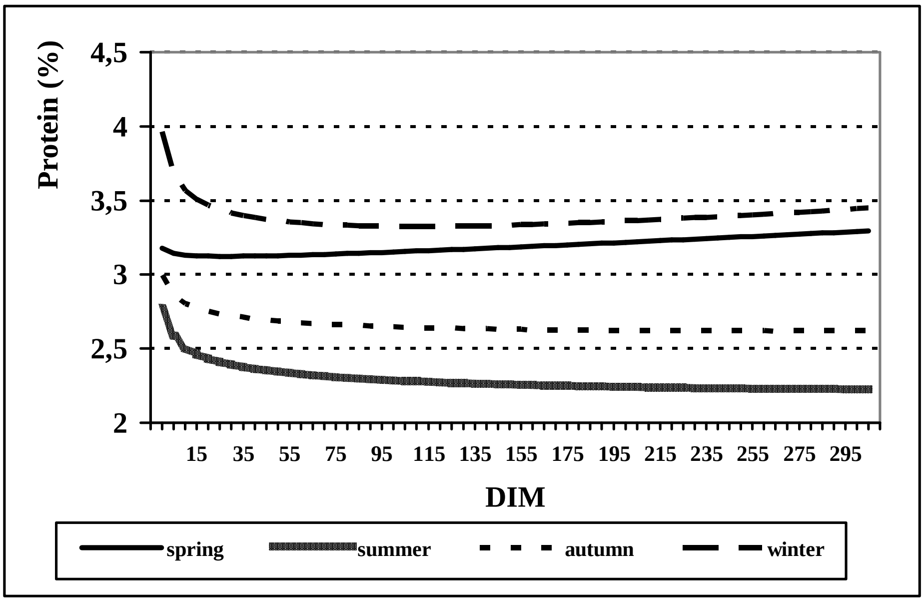

Figure 3. Milk protein percentage evolution during lactation by calving season

Winter calving cows started the lactation with a high milk protein percentage (3.96%), decreased slowly at a higher nadir value (3.33% at 109.1 DIM) and rapidly increased after that (c=-0.000434). Spring calving cows had the flattest curve for milk protein percentage. Started at 3.18% protein, reached nadir a very close value and early in lactation (3.12% at 28 DIM) and increased after that with a moderate rate.

The lactation curve for **milk lactose percentage** followed a shape similar to that for milk yield, with large differences among calving seasons (Figure 4).

The shape of lactation for summer calving cows was very different compared to the lactation curve for the other seasons. It was the flattest curve, starting at the highest point (4.78%), reaching the peak very early in lactation (19.4 DIM), with a value close to starting point (4.79%) and a high rate of decrease after that (c=0.000079).

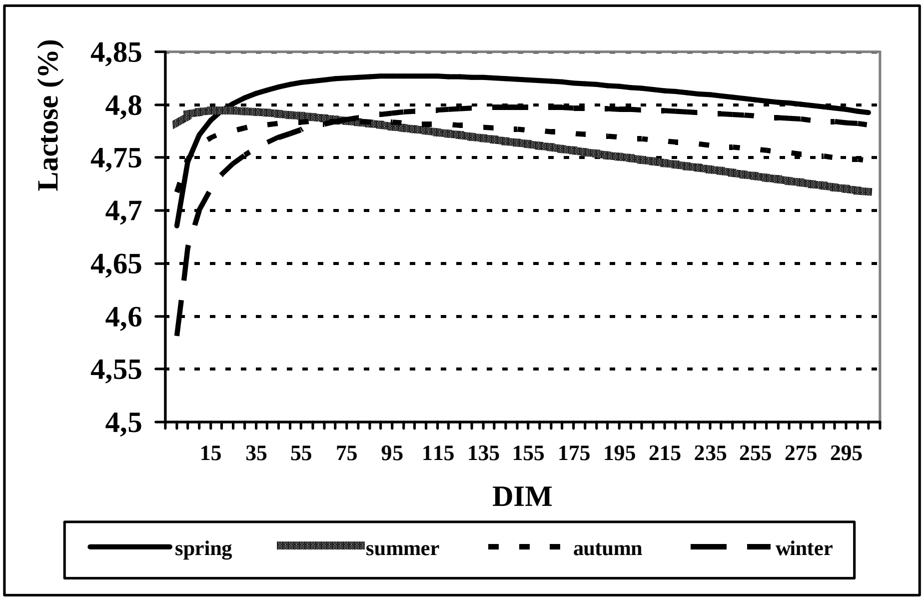

Figure 4. Milk lactose percentage evolution during lactation by calving season

On the opposite were winter calving cows that started a low lactose percentage (4.58%), reached peak later in lactation (154.4 DIM) with a high lactose percentage (4.80%) and a relatively high rate of decrease after peak (b=0.000074). These characteristics led to steeper lactation curve for lactose percentage in winter.

Lactation curve for **solids non-fat** and **total solids** had similar shapes (Figures 5 and 6), therefore we shall discuss only the shapes of the lactation curve for total solids.

Total solids percentage was high at the beginning of lactation decreased to nadir point and then increased again toward the end of lactation.

Autumn calving cows had the steeper lactation curve for total solids. They started lactation at the highest value (14.23%), then decreased at the highest rate to the nadir point (b=-0.027387 with 12.90% TS at 97.2 DIM) and had the highest increasing rate after nadir (c=-0.000282).

Spring and summer calving cows had the flattest lactation curve for total solids in milk. They started at a relatively high value (12.82 and 13.19%, respectively), had low decreasing rates to the nadir point that was close to the starting values (12.37 and 12.72%, respectively) reached at about 2.5 months after calving (82.7 and 73.1 DIM, respectively).

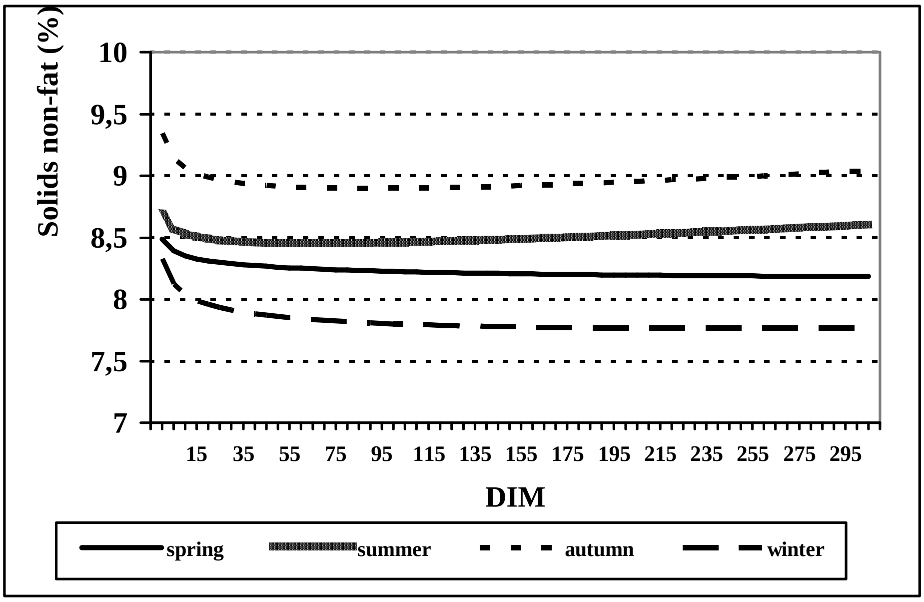

Figure 5. Milk solids non-fat percentage evolution during lactation by calving season

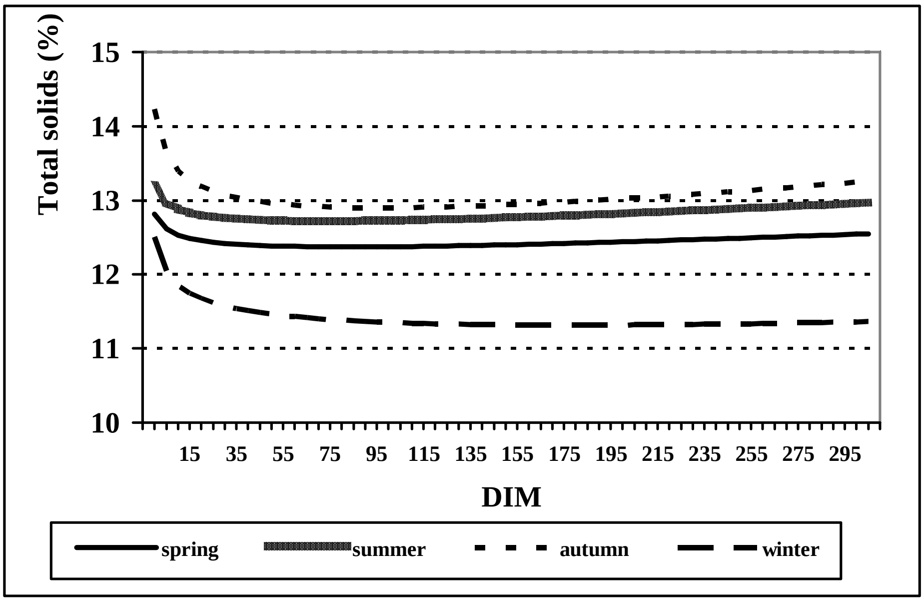

Figure 6. Milk total solids percentage evolution during lactation by calving season

Lactation curve for somatic cell count in milk is shown in Figure 7. Generally, SCC was high at the beginning of lactation decreased to a nadir value and then increased again towards the end of lactation. Season had a large influence on the shape of the lactation curve for SCC.

Spring calving cows had the flattest lactation curve for SCC. It started at the lowest value 220,891 cells/ml, had the lowest decreasing rate (b=-0.003280) to the highest nadir point (202,805 cells/ml) reached very early in lactation (21.3 DIM) and the lowest increase after nadir (c=-0.000150). Also, the value at the end of lactation was higher than that observed at the beginning (256,798 cells/ml).

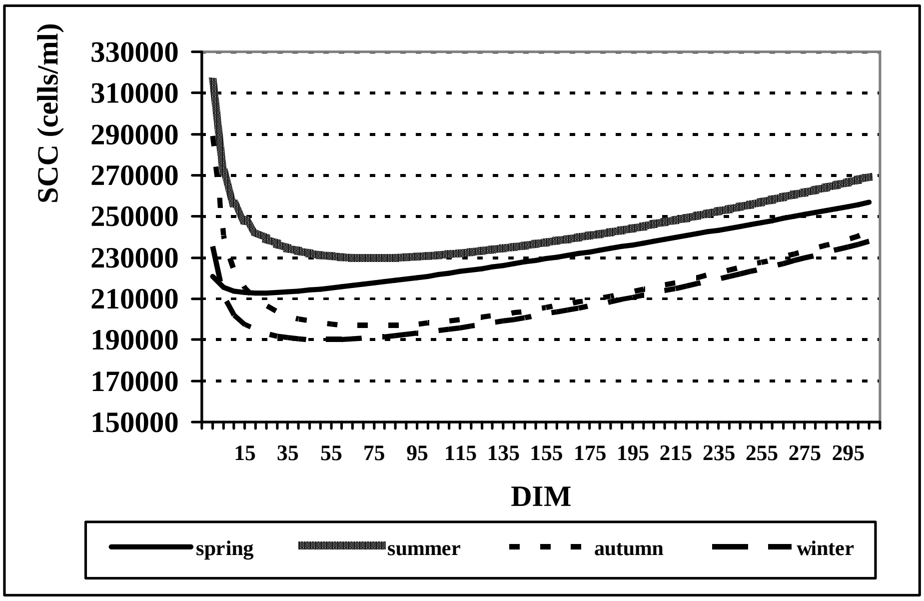

Figure 7. Milk somatic cell count evolution during lactation by calving season

Summer calvers had the highest SCC values during lactation. They started lactation at the highest value (315,341 cells/ml), reached nadir point after 2.5 months (74.7 DIM) at 229,760 cells/ml.

Autumn calving cows had the steepest lactation curve for SCC. They started at 288,450cells/ml, decreased with a high rate (b=-0.02168) to a value of 196,778 cells/ml at the nadir point reached at 72.3 DIM and had the highest increasing rate after that (c=-0.000300).

Winter calving cows started the lactation at 235,099 cells/ml milk, reached the nadir point at 51.8 DIM with a value of 189,985 cells/ml. The decreasing and increasing rates before and after nadir had intermediate values. The value at the end of lactation was similar to that from the beginning of lactation (237,912 cell/ml milk).

Conclusions

The calving season had a significant effect ($p<0.005$) on the shape of the lactation curve for milk yield, milk chemical composition and milk somatic cell count.

Summer calving cows had flatter lactation curves for milk yield and composition compared to winter calving cows.

For somatic cell count spring calving cows had the flattest lactation curve while autumn calving cows has the steepest lactation curve.

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