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CHANGES IN THE RELATIONSHIP BETWEEN BLOOD PLASMA GLUCOSE CONCENTRATION AND MILK PRODUCTION IN CZECH PIED COWS IN THE COURSE OF THE YEAR

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Abstract

CHLÁDEK, G., MÁCHAL, L.: *Changes in the relationship between blood plasma glucose concentration and milk production in Czech Pied cows in the course of the year*. Acta univ. agric. et silvic. Mendel. Brun., 2004, LII, No. 2, pp. 97-104

Groups of 20 to 23 dairy Czech Pied cows were observed monthly for the period of 12 months (12 test days). The cows in experimental groups were in their early lactation. The mean number of lactation was 2,8, the cows were on average 54.8 days after calving and the mean glucose concentration in blood plasma was 3.93 mmol/l. During the first 100 days of lactation milk yield amounted to 2581 kg with 3.91% fat, 3.48% protein and 4.85% lactose.
The coefficients of the correlation between blood plasma glucose and the observed milk production parameters calculated independently for each test day ranged as follows: -0.597 to 0.130 for number of lactation, -0.389 to 0.585 for days after calving, -0.462 to 0.361 for milk yield, -0.201 to 0.526 for milk fat content, -0.385 to 0.632 for milk protein content and -0.600 to 0.469 for milk lactose content. The calculated coefficients of the correlation between blood plasma glucose and milk production parameters did not reveal a clear tendency in the relationships. However, the graphic polynomial expression showed that glucose level had a positive relationship with days after calving and mainly positive relationship with milk protein content; glucose content had a negative relationship with milk yield and number of lactation and a mainly negative relationship with fat content and lactose content.

Czech Pied, cattle, cows, milk, protein, fat, lactose, blood plasma, glucose

Chládek and Máchal (2002) closely studied the relationship between blood plasma glucose and milk production in Holstein cows. In the course of one year they monthly observed several experimental groups of cows in early lactation (the first 100 days of lactation). The cows produced daily on average 33.5 kg milk with 4.07% fat, 2.98% protein and glucose concentration in blood plasma was 3.63 mmol/l. Authors concluded that the calculated coefficients of the correlation between blood plasma glucose and milk production parameters did not reveal a clear tendency in the relationships. However, the graphic polynomial expression of the relationships showed the tendency towards a positive relationship between blood plasma glucose and milk yield and a negative relationship between blood plasma glucose and milk fat content. The relationship between blood plasma glucose and milk protein content was positive, too, but less evident.

The importance of genetic merit for milk production and reproductive success in dairy cows was analysed by Snijders et al. (2001). Authors found out that high genetic merit cows had a higher milk production and a lower plasma glucose concentration than medium genetic merit cows.

Similarities in the chemical structure of carbohydrates in the diet and glucose in blood plasma suggest their close relationship. Lykos et al. (1997) investigated that relationship. They found out that the highest dietary ruminal degradation rate of total non-structural carbohydrates increased the amount of nutrient digested in the intestine and increased milk production and milk true protein content and yield, however, blood glucose and insulin concentrations were not affected. On the other hand, Dhiman et al. (1991) examined the effect of dietary forage to grain ratio on blood constituents in dairy cows and they found out that an increased percentage of forage in the diet decreased blood glucose concentration and that glucose concentration was low at the beginning of lactation and increased as DMI increased.

Milk production parameters and blood plasma glucose concentration in dairy cows during the first 100 days of lactation were presented by Zimmerly and Weiss (2001). Their study investigated effects of supplemental dietary biotin on performance of Holstein cows during early lactation. The authors found out that milk production linearly increased with biotin supplementation, but did not affect milk fat and true protein percentages; plasma glucose concentration was not affected either.

The effect of long-term infusion of glucose in cows treated with recombinant bovine somatotropin before peak milk yield was examined by Leonard and Block (1997). In their study glucose infusion increased milk yield by 3.1 kg on milk yield level 39.6 kg while serum glucose concentration was 61.9 mg/dl. They also noted that in the group, which underwent glucose infusion, the milk yield was lower probably as a result of low blood glucose which amounted only to 39.4 mg/dl.

The relationship between blood plasma glucose and milk yield is complicated due to the time lag between sample collections, as described by Lean et al. (1992). Authors observed that a significant negative relationship between milk yield and glucose on the same day is connected with the loss of glucose (in a form of lactose) in milk. A positive relationship between milk yield and glucose found 12 to 15 days later suggested that an increased milk yield acted as a stimulus to increase serum glucose concentrations later, possibly by stimulating food intake or gluconeogenic mechanisms.

In general, glucose (blood sugar) represents a transport form of saccharides (Jagoš, 1985). Lower values of glucose were detected in the following circumstances: the absence of disposable energy in feed ration, a narrow nutrients ratio, an insufficient production of propionic acid in forestomach, ketosis and a severe impairment of liver parenchyma. Increased values were detected in restless animals and in stress situations of organism. As a reference value for glucose level in blood plasma they regarded 3.00 – 3.90 mmol/l.

The aim of the study was to describe changes (in the course of the year) in the relationship between blood plasma glucose and milk production in Czech Pied cows during the first 100 day of lactation.

METHODS

The experimental groups of 20 to 23 Czech Pied cows were observed once a month in the course of one year. The cows came from one dairy herd with average milk yield 6 000 kg per lactation. All the cows were housed in the same cowshed with tethered system and straw bedding. The diet consisted of feeds typical for that region (maize and grass silage, grain meal, extracted meal, mineral and vitamins) and the ration was calculated according to recommendations of Sommer et al. (1994). The diet was not served as TMR and the concentrated feed was fed according to the milk yield.

Each month a group of cows in early lactation (20 to 100 days after calving) was chosen for observation. Each cow was blood sampled (from vena subcutanea abdominis) in the morning. On the same day blood samples were centrifuged to separate blood and glucose concentration was assessed colorimetrically using Bio-La-tests. Other milk production parameters were adopted from the database of milk production monitoring (A_4), where the samples were analysed for milk fat, protein and lactose content using Milkoscan 255 AB.

The trend in relationships between blood plasma glucose and milk production parameters was described by coefficients of correlation and by graphical expression of their values.

RESULTS

Basal values of blood plasma glucose content and some milk production parameters during the first 100 days of lactation are presented in Tab. I. The number of cows in the experimental groups ranged from 20 to 23 while the average number was 21.2 cows. Blood plasma glucose content was on average 3.93 mmol/l with maximum 4.85 mmol/l and minimum 3.38 mmol/l. The mean number of days after calving was 54.8 with minimum 49.5 days and maximum 66.4 days. The milk yield ranged from minimum 2418 kg to maximum 2830 kg while the mean was 2581 kg. Milk fat content was on average 3.91% while the highest fat content was 4.27% and the lowest was 3.62%. The mean milk protein content was 3.48% with maximum 3.87% and minimum 3.16%. Milk lactose content ranged from minimum 4.70% to maximum 5.01% while the mean was 4.85%.

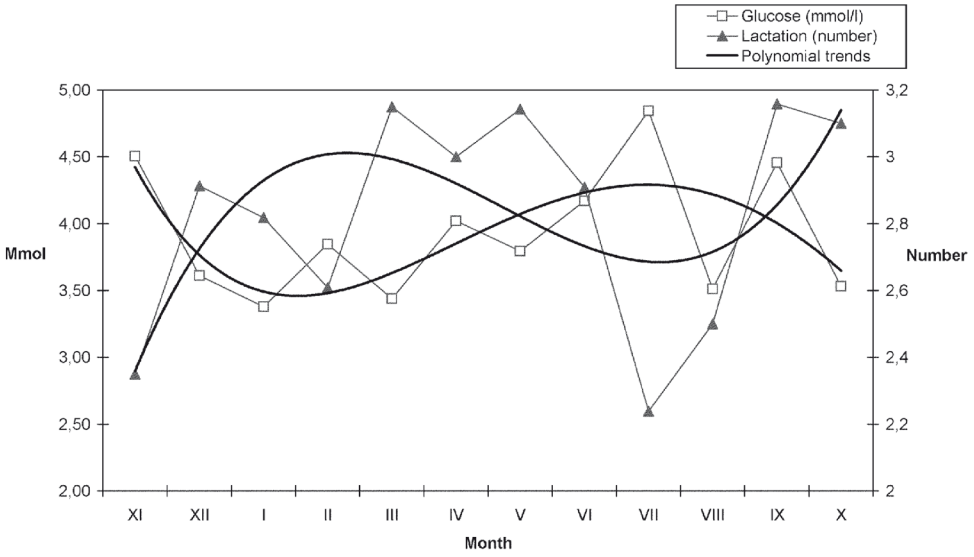
Tab. I. also shows coefficients of correlation. The

I: *Basal values of blood plasma glucose concentration and some milk production parameters during the first 100 days of lactation*

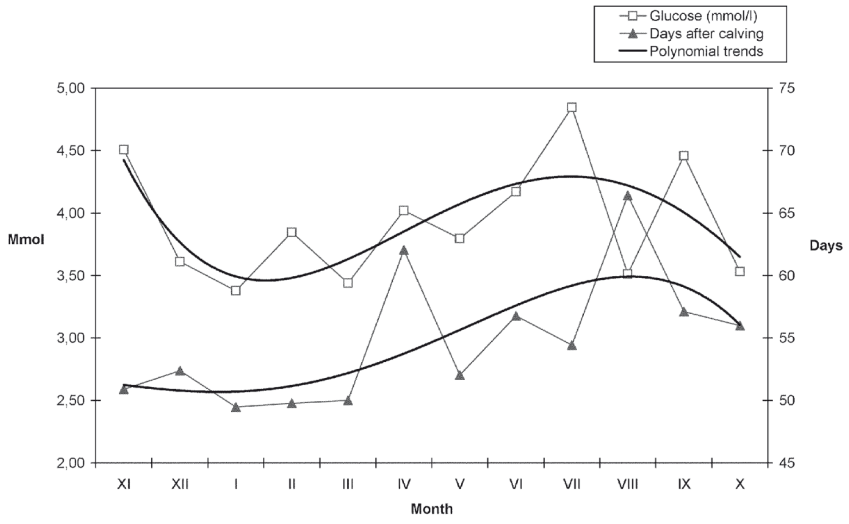
Observed parameters	**Units**		**Month of observation**												**Mean**
			XI	**XII**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**I - XII**
Number of cows			20	23	23	23	20	23	20	22	20	20	20	20	21.2
Number of lactation		$\bar{x}$	2.4	2.9	2.8	2.6	3.2	3.0	3.1	2.9	2.2	2.5	3.2	3.1	2.8
		s_x	1.6	1.6	1.6	1.5	1.5	1.9	2.0	1.9	1.6	1.4	1.5	1.5	1.7
Days after calving	days	$\bar{x}$	50.9	52.4	49.5	49.8	50.0	62.0	52.0	56.8	54.4	66.4	57.1	56.0	54.8
		s_x	18.3	22.2	18.9	18.7	21.9	17.4	18.3	17.6	16.2	21.9	19.9	22.7	19.8
Blood glucose concentration	mmol/l	$\bar{x}$	4.51	3.61	3.38	3.85	3.44	4.02	3.80	4.17	4.85	3.51	4.46	3.53	3.93
		s_x	0.93	0.59	0.66	0.56	0.70	0.50	0.99	0.61	1.04	0.95	0.76	0.77	0.87
Milk production															
Milk yield	kg	$\bar{x}$	2418	2552	2635	2475	2599	2504	2643	2609	2532	2560	2619	2830	2581
		s_x	500.0	458.8	419.7	361.6	468.9	469.6	363.9	460.9	383.5	404.7	429.9	583.9	449.9
Milk fat	%	$\bar{x}$	4.27	4.19	4.01	3.87	3.84	3.66	3.62	3.76	3.68	3.89	3.88	4.26	3.91
		s_x	0.57	0.50	0.42	0.36	0.37	0.31	0.37	0.42	0.28	0.47	0.34	0.44	0.46
Milk protein	%	$\bar{x}$	3.26	3.21	3.16	3.29	3,46	3.54	3.80	3.87	3.79	3.59	3.35	3.41	3.48
		s_x	0.25	0.21	0.16	0.18	0.24	0.18	0.20	0.19	0.37	0.32	0.20	0.23	0.32
Lactose	%	$\bar{x}$	4.92	4.89	4.85	4.88	4.87	4.79	4.70	4.73	4.82	4.80	4.98	5.01	4.85
		s_x	0.21	0.17	0.13	0.15	0.16	0‘.18	0.18	0.14	0.11	0.23	0.13	0.14	0.18
Coefficients of correlation															
Glucose concentration vs. lactation	number		0.079	0.005	-0.055	0.130	-0.075	-0.427	-0.138	-0.448	-0.597	0.063	-0.337	0.079	-0.188
Glucose concentration vs. days after calving	days		0.077	0.262	0.140	-0.212	0.361	0.466	0.331	-0.389	-0.068	0.501	0.585	0.378	0.181
Glucose concentration vs. milk yield	kg		0.109	-0.193	-0.104	-0.402	-0.462	-0.211	-0.222	-0.195	-0.171	0.361	0.010	-0.338	-0.177
Glucose concentration vs. fat content	%		0.099	-0.111	-0.015	0.202	0.526	0.243	0.234	0.279	0.051	0.369	0.157	-0.201	0.032
Glucose concentration vs. protein content	%		0.298	-0.011	0.206	0.632	-0.006	0.019	0.117	-0.040	-0.201	0.510	-0.385	-0.219	0.222
Glucose concentration vs. lactose content	%		0.057	0.136	0.218	-0.380	0.035	0.469	0.031	0.275	0.213	-0.600	0.178	-0.168	0.043

mean coefficient of the correlation between blood plasma glucose and number of lactation was –0.188 and the values ranged from -0.597 to 0.130; the coefficients of correlation between glucose and days after calving ranged from -0.389 to 0.585 with mean 0.181; the coefficients of correlation between glucose and milk production ranged from -0.462 to 0.361 with mean -0.177. The coefficients of correlation between blood plasma glucose and milk constituents were following: the mean 0.032 (minimum -0.201 and maximum 0.526) for milk fat, the mean 0.222 (minimum -0.385 and maximum 0.632) for milk protein and the mean 0.043 (minimum -0.600 and maximum 0.469) for lactose content.

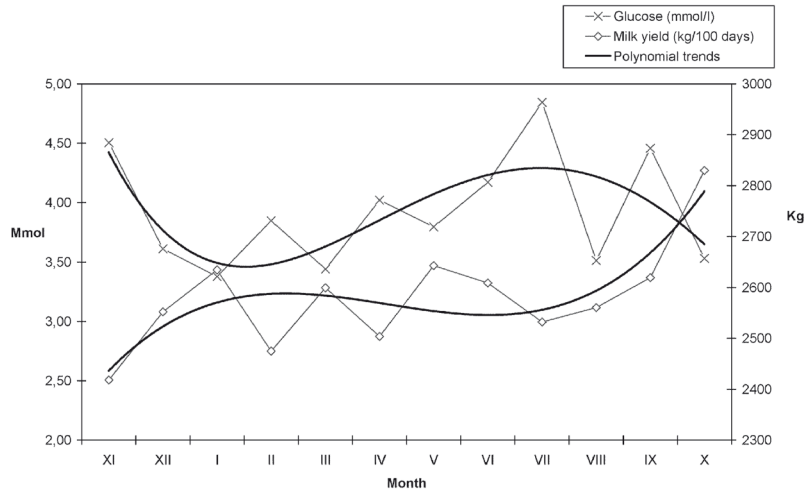
Graphical expressions of changes in blood plasma glucose and the observed parameters, including their polynomial trend, are presented in Fig. 1 (for number of lactation), in Fig. 2 (for days after calving), in Fig. 3 (for milk production per 100 days), in Fig. 4 (for milk fat content) in Fig. 5 (for milk protein content) and in Fig. 6 (for lactose content).



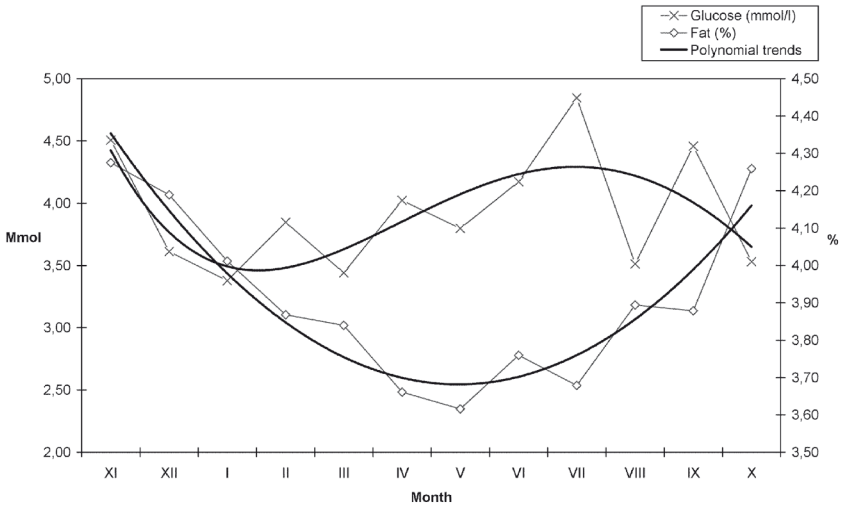
1: *Blood plasma glucose concentration and number of lactation*



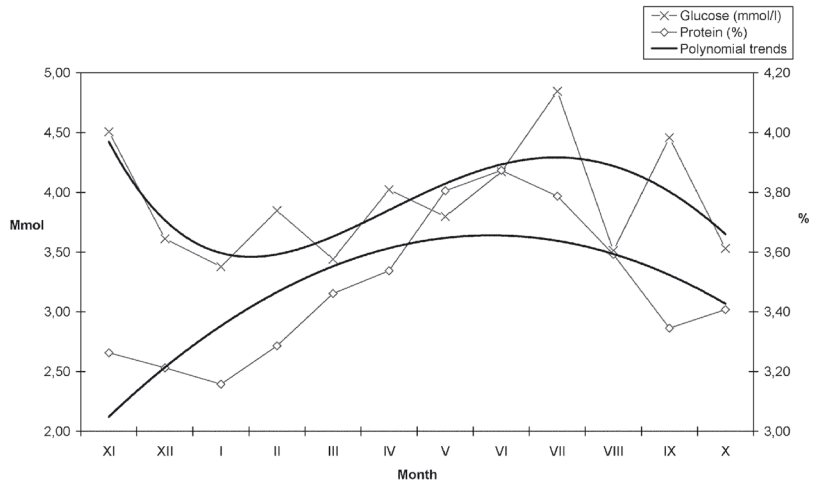
2: *Blood plasma glucose concentration and days after calving*



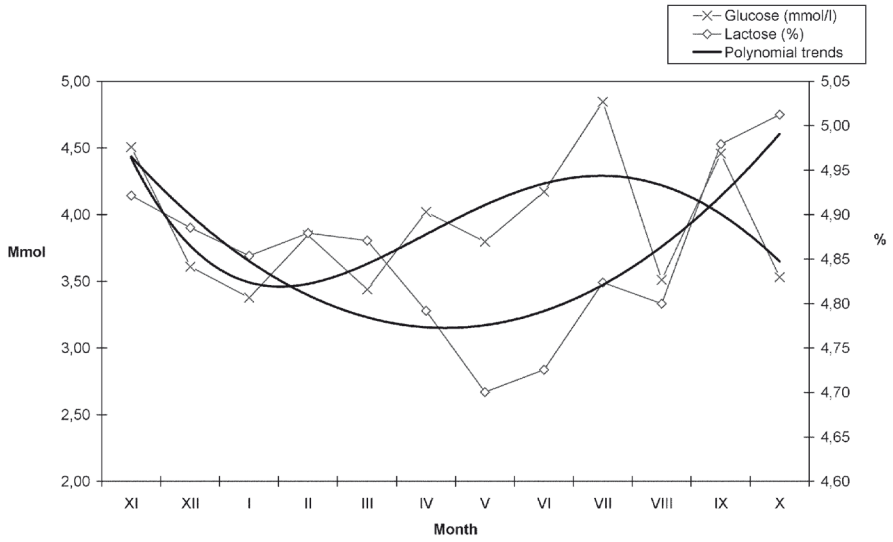
3: *Blood plasma glucose concentration and milk yield per 100 days*



4: *Blood plasma glucose concentration and fat content in milk yield per 100 days*



5: *Blood plasma glucose concentration and protein content in milk yield per 100 days*



6: *Blood plasma glucose concentration and lactose content in milk yield per 100 days*

DISCUSSION

The mean blood plasma glucose concentration was 3.93 mmol/l (70.8 mg/dl) and it ranged from 3.38 mmol/l (60.9 mg/dl) to 4.85 mmol/l (87.3 mg/dl). Generally, our values were relatively high; our mean values were comparable to the values presented by Jagoš et al. (1985) as maximum and five values out of twelve were even greater than their maximum. We agree with those authors that such results could reflect a negative impact of stress and restlessness of animals. However, Dhiman et al (1991) observed that higher levels of plasma glucose could suggest a higher proportion of concentrated feeds in feed ration which could be considered as a positive impact.

Coefficients of the correlation between milk production parameters and blood plasma glucose (calculated separately for each of the test days) did not indicate any clear tendencies in the relationships. In all cases, the coefficients varied between distinctly negative and distinctly positive values. That resulted in very low, close to zero values of overall mean coefficients of correlation for all the observed parameters. Those findings corresponded with the results of Chládek and Máchal (2002). However, the graphical expression suggested some tendency in the relationships between blood plasma glucose and milk production parameters (in agreement with Chládek and Máchal (2002). The strongest negative relationships were found between plasma glucose and number of lactation or milk yield per 100 days. The relationships which we found between plasma glucose and milk yield were similar to those found by Snijders et al (2001) and surprisingly to those presented by Lean et al. (1992) who described milk production on the same day and explained it by the loss of glucose, as lactose, in milk. Their conclusion corresponded with our mainly negative relationship between blood plasma glucose and lactose content in milk. However, a number of authors described that relationship as positive, e.g. Leonard and Block (1997), Chládek and Máchal (2002) or their results suggested a positive relationship, e.g. Lykos et al. (1997) or Dhiman et al. (1991). Our negative relationship between glucose and number of lactation could help us understand. This negative relationship could be a consequence of a feeding technique; breeders usually feed first-calvers more concentrated feed to make up for lower intake and higher nutrition requirements for growth compare to older cows. And because milk yield of first-calvers is usually lower, higher blood plasma glucose would be associated with lower milk yield compare to older cows. A significant positive relationship between blood glucose level and days after calving was in agreement with Dhiman et al. (1991).

While our milk fat content was comparable to that presented by Chládek and Máchal (2002), our milk protein content was considerably higher. This difference was most likely due to the different breed of experimental animals; while we used dual purpose Czech Pied cattle, Chládek and Máchal (2002) observed dairy Holstein cows. Nevertheless, they also found a positive relationship between glucose and milk protein content and a negative relationship between glucose and milk fat content. This fully corresponded with the results of Dhiman et al. (1991) who found that an increased percentage of forage in the diet decreased blood glucose concentration. The percentage of forage in the diet was not monitored in the study but it can be assessed from the changes in milk

fat (and milk protein content), as there is known to be a positive relationship between milk fat content (and negative relationship between milk protein content) and proportion of forage in diet.

Our results suggested that blood plasma glucose had a positive relationship with days after calving and mainly positive relationship with milk protein content; glucose content had a negative relationship with milk yield and number of lactation and mainly negative relationship with fat content and lactose content.

SOUHRN

Změny vzájemného vztahu krevní glukózy a mléčné užitkovosti dojnic českého strakatého plemene během roku

České strakaté plemeno se stále podílí největší měrou na populaci dojeného skotu chovaného v České republice. V současné době jeho chovu dominuje výrazné zvyšování mléčné užitkovosti. Dosažený nárůst užitkovosti však klade vyšší požadavky také na odpovídající zajištění dojnic živinami. Za jeden z důležitých ukazatelů jejich úrovně je považována hladina glukózy v jejich krevní plazmě.

V měsíčních intervalech po dobu jednoho kalendářního roku byly sledovány skupiny 20 až 23 kusů dojnic českého strakatého plemene, vybraných tak, aby se nacházely v prvních fázích laktace. Dojnice pocházely ze stáda s průměrnou užitkovostí 6 000 kg za laktaci a byly do sledované skupiny vždy vybrány tak, aby se nacházely mezi 20. až 100. dnem po otelení. Celé stádo bylo vazně ustájeno v jedné stáji. Krmná dávka sestávala z krmiv obvyklých v oblasti (kukuřičná a travní siláž, šroty obilovin, extrahované šroty, minerální látky a vitaminy), přičemž jejich množství bylo optimalizováno podle doporučení Somera et al. (1994). Krmiva nebyla krmena formou TMR, produkční směsi byly krmeny v závislosti na užitkovosti. Každý měsíc byla vybrána skupina dojnic, které se nacházely na začátku laktace (20 až 100 dnů po otelení). Dojnicím byla odebrána krev z vena subcutanea abdominis vždy v dopoledních hodinách. V týž den byla po separaci krevní plazmy centrifugací stanovena hladina glukózy fotometricky pomocí Bio-La-testů. Potřebné hodnoty parametrů mléčné užitkovosti byly převzaty z plemenářské dokumentace v rámci prováděné kontroly užitkovosti (A_4), v níž byly vzorky mléka analyzovány na obsah tuku, bílkovin a laktózy na přístroji Milkoscan 255 AB. Dynamika vztahu hladiny glukózy v krevní plazmě dojnic k jejich mléčné užitkovosti byla hodnocena jednak na základě koeficientů korelace, jednak na základě grafického průběhu jejich hodnot.

Základní statistické charakteristiky a vypočtené koeficienty korelace sledovaných skupin dojnic v jednotlivých měsících jsou uvedeny v Tab. I. Z tabulky vyplývá, že průměrné pořadí laktace sledovaných dojnic bylo 2,8, počet dnů od otelení 54,8 a hladina glukózy v krevní plazmě 3,93 mmol/l. Dojnice dosáhly během prvních 100 dnů laktace užitkovost 2581 kg mléka, s obsahem tuku 3,91 %, bílkovin 3,48 % a laktózy 4,85 %. Koeficienty korelace v jednotlivých dnech sledování spočtené pro hladinou glukózy v krevním séru kolísaly od -0.597 po 0.130 pro pořadí laktace, od -0.389 po 0.585 pro dny po otelení, od -0.462 po 0.361 produkci mléka, od -0.201 po 0.526 pro obsah tuku, od -0.385 po 0.632 pro obsah bílkovin a od -0.600 po 0.469 pro obsah laktózy. Z kolísání tabulkových hodnot koeficientů korelace spočtených pro jednotlivé dny sledování vyplývá, že nejsou příliš vhodné pro vyjádření sledovaných vztahů. Jako vhodnější se ukázalo grafické znázornění, které ukázalo, že hladina glukózy v krevní plazmě dojnic měla pozitivní vztah ke dnům po otelení a převážně pozitivní vztah k obsahu bílkovin v mléce, negativní byl její vztah k produkci mléka a pořadí laktace, převážně negativní byl pak její vztah k obsahu tuku a obsahu laktózy.

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