

THE INFLUENCE OF PROPYLENE GLYCOL ON BODY CONDITION AND MILK YIELD OF COWS AS WELL AS ON COLOSTRUM AND MILK COMPOSITION

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Abstract

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The research was executed on 24 high yield dairy cows divided into three groups ($n = 8$). There was the control group (I) that the propylene glycol wasn't given to cows, group II – the cows received 250 ml/day/per head of the propylene glycol, and the group III – the cows received 500 ml/day per head of the propylene glycol. The preparation was administered to cows per os beginning from 2 weeks before parturition to the end of the third week of lactation. During the research the condition of animals was estimated by BCS method, the daily yield was recorded, and analyses of the milk and colostrum composition were performed. The propylene glycol lightened the decrease of cows' condition during entering at the peak of lactation. The higher dose (500 ml) was more profitable, because it had an influence on the content of the colostrum components, low urea level in milk as well as on daily yield, which was higher of about 3.64 kg while the preparation was given, in comparison to the control group. In the 3rd week of lactation the low level of somatic cells in milk of cows that received the preparation was stated. In conclusion, our study revealed a great positive effect of propylene glycol given to the cows shortly before and after parturition on their body condition and a less significant effect on colostrum quality and milk yield.

cows, propylene glycol, colostrums, milk yield, milk composition, body condition, BCS

The perparturient period of cows is also defined as the transition period. It starts 3 weeks before parturition and it lasts 3 weeks after calving (Bertics et al., 1992). At this time the sudden growth of energy requirement and nutritional components is observed, with contemporary hormonal changes, which assure the homeostatic and homeorhetic subjection of organism to lactation process (Ballard et al., 2001; Pickett et al., 2003; Studziński et al., 2003).

The nutritional requirement, especially of high yield cows, on the beginning of lactation mostly exceeds the quantity of energy received from fodder (Heuer et al. 2000; Miyoshi et al., 2001). The negative

energy balance and excessive lipolysis of fat reserve occurs at that time. In the consequence, the sub-clinical or clinical ketosis as well as fat cow syndrome may occur (Vazquez-Anon et al., 1994; Rajala-Shultz et al., 1999; Pickett et al., 2003; Studziński et al., 2003). The nutritional malfunctions, like energy shortage in food dose at the beginning of lactation, fattening of dried cows, applying the wrong quality fodder and so on, favor to arising of these disorders.

A lot of research demonstrate, that the ketosis or fat cows syndrome appear with different frequency in herds of cows, from several to above 20% (Markusfeld et al., 1997; Rajala-Shultz et al., 1999; Gillund et

al., 2001). Discussed metabolic disorders negatively affect reproductive functions of cows, milk yield and composition and also the health of the offspring (Janeczek et al., 1996; Filar, 1999; Rajala-Schultz et al., 1999). It is also important, that in case of metabolic diseases like ketosis, the placenta does not work as a protective barrier for the fetus and as a result its intoxication by ketonic substances takes place (Janeczek et al., 1996).

The practical application in prevention and treatment of sub-clinical and clinical ketosis has the salts of propionic acid, propylene glycol and niacin (Fisher et al., 1973; STUDER et al., 1993; Grummer et al., 1994; Christensen et al., 1997; Pickett et al., 2003). The influence of propylene glycol onto metabolism is relatively well recognized as it is a glucogenic precursor. According to published data, its effect depends on mechanism, which causes the growth of glucose and insulin concentration and the drop of free fatty acids and ketone bodies in the blood (Studer et al., 1993; Grummer et al., 1994; Christensen et al., 1997). However, there are a few research in professional literature that concern the long-term application of propylene glycol in transition period of cows and its effect on milk productivity and composition (FISHER et al., 1973; GOZZI et al., 1995). There are no researches about the influence of propylene glycol on composition of cows' colostrum.

The aim of this research was the determination of the influence of propylene glycol given to cows in periparturient period on their condition, composition of colostrum and on milk yield and composition.

MATERIAL AND METHODS

The experiment was conducted on milk cows' farm with stock of 330 cows, with mean yield of 8650 kg of milk yearly. Experimental cows were kept in the same environmental conditions and fed according to the TMR system. Nutritional doses for cows were prepared according to ruminants feeding system DLG (2001). The composition and nutritional value of doses are showed in Tab. I. The nutritional value of doses was marked in laboratory of Blattin firm in Langfeld ac-

cording to currently accepted methods. Twenty four cows of HF race, which were in dry period, 2 weeks before expected term of parturition were chosen to the investigations. The animals were clinically healthy and their condition, estimated by BCS method (5 – points scale with accuracy of 0.25 point) (Edmonson et al., 1989), was comparable. Cows were divided onto 3 groups and each of group consisted of 8 cows:

- group I – the control group consisted of the cows fed with fodder without propylene glycol addition,
- group II – cows receiving 250 ml of propylene glycol /day/per head,
- group III – cows receiving 500 ml of propylene glycol /day/ per head.

The propylene glycol applied in research (1,2-propandiol), containing 99.9% of monopropylene glycol, in liquid form was administered daily to animals per os, beginning from 2nd week before calving to the 3rd week of lactation, inclusively.

After parturition, the first colostrum was collected from all the cows and analysis of its composition was carried on Milko-Scan 133B apparatus. The level of total lactoglobulines in whey was marked by blotting-paper method. Samples of milk were also collected, for the first time 3 weeks after calving (the end of preparation administration) and in the 6th week of lactation. The analyses of chemical composition of milk were performed on Milko-Scan 133B apparatus (Foss Electronic) and analyses of urea nitrogen were performed on AA autoanalyser (Braun-Luebbe). The content of casein was determined by Wolker method. The count of somatic cells (SCC) was estimated on Soma-count 150 apparatus (Bentley). During the research the weekly milk yield was recorded. Condition of experimental cows was estimated by BCS method in 1, 3, 6 and 10 week of lactation.

The results of experiment were subjected to statistic analyses with use of statistic program Statgraphics 5.0 with inclusion of mean, standard deviation and significance of differences estimated using Duncan interval test.

I: *Composition and nutritive value of TMR doses for cows*

Specification	Drying-off period (3-4 weeks a.p.)	Beginning of lactation
Part of foders in TMR dose (% s.m)		
Maize silage	17.25	41.70
Dried forage of grass	54.95	-
Dried forage of lucerne	10.35	11.66
Silage of surage beet pulp	-	5.18
Barley malt culms	-	4.32
Straw of wheat	16.95	3.71
Soya meal	-	4.51
Maize meal	-	5.63
Suplemente mixture (protein 18.5 %)	-	22.79
Mineral supplement	0.50	0.50
Nutrition value		
Dry matter (%)	44.12	43.85
Crude fiber (%s.m.)	33.23	17.20
NEL (MJ/kg s.m.)	5.98	7.04
BO (g/kg s.m.)	94.83	153.13
nBO (g/kg s.m.)	116.05	153.72
Calcium (g/kg s.m.)	5.48	6.45
Phosphorus (g/kg s.m.)	2.22	4.13
Sodium (g/kg s.m.)	1.22	1.30
Magnesium (g/kg s.m.)	1.70	2.47

NEL – Net energy of lactation

BO – Crude protein

nBO – Crude protein available in small intestine

s.m – Dry matter

II: *Mean milk yield of cows and theirs condition BCS*

Group	Daily yield ¹⁾ (kg)	Daily yield ²⁾ (kg)	Term of estimate			
			2 week a.p.	1 week p.p.	3 week p.p.	6 week p.p.
	\bar{x} SD	\bar{x} SD	\bar{x} SD	\bar{x} SD	\bar{x} SD	\bar{x} SD
I	35.04±6.94	42.52±4.42	3.53±0.35 ^{ab}	3.08±0.57 ^a	2.87±0.46 ^b	3.02±0.32
II	35.79±6.69	40.54±7.30	3.41±0.32	3.20±0.38	3.17±0.46	3.10±0.48
III	38.68±4.80	42.85±3.99	3.48±0.69	3.17±0.58	3.20±0.37	3.18±0.23
Statistic*		II>>I, III				

Explanations:

¹⁾ in period of first 3 weeks of lactation²⁾ in period of 10 first weeks of lactation> – significant differences between groups at $p \leq 0.05$ >> – significant differences between groups at $p \leq 0.01$ a, b – significant differences between terms of estimate making at $p \leq 0.05$ A – significant differences between terms of estimate making at $p \leq 0.01$

* – Statistical characteristic

RESULTS AND DISCUSSION

The cows were fed according to TMR system. The assurance of nutritional requirements on energy and protein of cows during the research may be assessed as correct. Only too high rate of Ca:P in dry period was incorrect. Miyoshi et al. (2001) stated that 500 ml of propylene glycol make 2.35 Mcal of energy (NEL). Thus, in our own research the cows of groups II and III received additional, accordingly larger dose of energy.

The condition of cows, estimated by BCS method, 2 weeks before expected calving was even and it varied from 3.41 at group II to 3.53 at group I. In the 1st and 3rd week after parturition cows from group I showed statistically significant drop ($p \leq 0.05$) of condition. In groups receiving the propylene glycol that decrease was not large. At the last day of preparation administration the drop condition in group II was -0.24 , and in group III -0.28 . Significantly higher loss of condition was stated in group I (-0.66). In the 6th and 10th week of lactation the condition of experimental cows stayed on nearly unchanged level, and at the control group it increased.

The point estimation of body condition (BCS) of cows is simple, and also accepted method of estimation of feeding correctness as regards meeting of nutritional components requirement (Edmonson et al., 1989; Gillund et al., 2001) and assessing the ratio of negative energy balance on beginning of lactation (Edmonson et al., 1989; Heuer et al., 2000). In many research it was demonstrated that condition of cows at calving and its decreasing in period of early lactation were connected with a risk of metabolic and infectious disorders (Markusfeld et al., 1997; Gillung et al., 2001), fertility and milk yield of cows (Domecq et al., 1997; Adamski and Onyszko, 2000; Reksen et al., 2002).

There are few works including the impact of propylene glycol on the condition cows. In research concerning the short-term administration of propylene glycol to cows any significant effect of it onto body mass and BCS was stated (Studder et al., 1993; Pickett et al., 2003). Pickett et al. (2003) demonstrated that cows lost on average 0.22 point in period of 3 weeks of lactation (from 3.53 to 3.31 points). In our research the loss of body condition in experimental groups was similar. Also Ballard et al. (2001), using the energy supplement in transition period, did not stated any differences among the groups. However they obtained higher condition of experimental cows between 5th and 8th week of lactation. Bodarski et al. (2003), gave the propylene glycol in a powdery form to cows, noted much smaller drop of cows body mass from calving to the 4th week of lactation comparing with the control cows. Basing on own research, for the sake of

the small loss of body condition of cows receiving the glycol, it can be supposed that it caused the limitation of energy deficiency that, according to Heuer et al. (2000) takes place at the beginning of lactation.

The content of chosen components in cows' colostrum is showed in Tab. III. There were no statistically significant differences between the groups. The highest content of dry matter (263.2 g/l) and lactose (19.13 g/l) was noted in colostrum of cows from group III, however, the content of fat (51.28 g/l) was the highest in group II. The increased fat content in colostrum in this group could possibly be explained by the formation of so-called chylomicrons. They are synthesised from precursors of glucose and after their release into milk they increase the amount of detectable milk fat (Jelinek and Koudela, 2003). The smallest content of α -lactoglobulines and β -lactoglobulines was stated in cows' colostrum from group II. The largest content of β -lactoglobulines was found in group III (109.59 g/l). The content of colostrum components for all the cows was similar to the results obtained by others authors (Zachwieja, 1991 and 1995; Blum and Hammon, 2000). Taking of colostrum by the calves directly after the birth in the right amount is very important with respect to gaining the immunity and because of the content of hydroxycarbons, lipids, proteins, mineral elements and vitamins (Zachwieja, 1991; Blum and Hammon, 2000). Despite of the lack of statistic differences, the more profitable composition of colostrum was stated in group III receiving the highest dose of propylene glycol. There are no works concerning the influence of propylene glycol used in cows' feeding before parturition onto colostrum composition, thus it is difficult to compare the results.

The mean daily milk yield during the first three weeks of lactation was the lowest at control group (35.04), and the largest at group III (38.68). The higher daily yield in this period was at group III, of about 3.64 kg in comparison to control group. It undoubtedly enlarges the profitability of propylene glycol using. In group III the cessation of propylene glycol administration caused not large drop of milk yield (4 week of lactation).

In 3 week of lactation, that in day of the end of propylene glycol administration, the relatively small somatic cells counts (SCC) was noted in milk from cows from II and III groups (Tab. IV). At control group, the quantity of cells was significantly larger ($p \leq 0.05$), exceeding the accepted values for cows with health mammary gland (Malinowski, 2001). During subsequent collections the systematic growth of somatic cells number was found. The large values of SCC in milk of cows from group II (6th week) have unquestionable impact onto decreased milk yield (Fig. 1).

III: The components content in colostrum of cows (g/l)

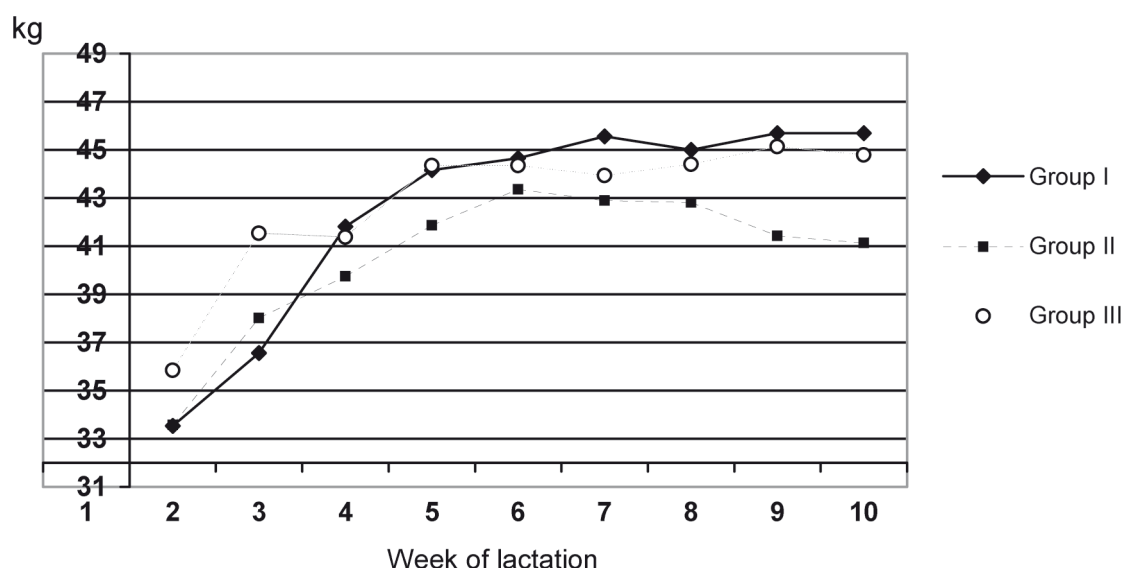
Group	Dry matter	Dry matter not-fat	Protein	Fat	Lactose	Albumins	α -lactoglobulins	β -lactoglobulins
	\bar{x} SD	\bar{x} SD	\bar{x} SD	\bar{x} SD	\bar{x} SD	\bar{x} SD	\bar{x} SD	\bar{x} SD
I	249.20 \pm 30.00	214.48 \pm 25.95	117.73 \pm 19.34	34.83 \pm 20.68	18.90 \pm 11.62	1.09 \pm 0.54	10.14 \pm 3.16	106.34 \pm 21.23
II	219.60 \pm 97.50	168.41 \pm 72.97	95.16 \pm 45.34	51.28 \pm 38.97	13.19 \pm 8.46	1.06 \pm 0.61	8.83 \pm 5.63	85.14 \pm 42.35
III	263.20 \pm 32.79	217.90 \pm 20.82	117.78 \pm 14.70	45.38 \pm 23.29	19.13 \pm 5.20	1.11 \pm 0.79	10.03 \pm 4.17	109.59 \pm 12.68
Statistic*								

Explanations: like in the Tab. II

IV: The general number of somatic cells and content of individual components in milk

Group	Casein (%)	SCC (ths./ml)	Fat (%)	Protein (%)	Lactose (%)	Dry matter (%)	Dry matter not-fat (%)	Urea nitrogen mg/100 ml
	\bar{x} SD	\bar{x} SD	\bar{x} SD	\bar{x} SD	\bar{x} SD	\bar{x} SD	\bar{x} SD	\bar{x} SD
Sampling in 3 rd week of lactation								
I	2.17 \pm 0.25	351.38 \pm 290.85	4.86 \pm 0.68 ^{aA}	2.78 \pm 0.28	4.82 \pm 0.16	13.06 \pm 0.84 ^a	8.20 \pm 0.29	16.00 \pm 3.26 ^A
II	2.12 \pm 0.11	35.50 \pm 33.23	4.16 \pm 0.14	2.70 \pm 0.18	4.87 \pm 0.14	12.33 \pm 0.88	8.17 \pm 0.75	18.39 \pm 2.14 ^B
III	2.43 \pm 0.11	59.00 \pm 62.26	4.50 \pm 0.45	2.87 \pm 0.15	4.93 \pm 0.11	12.89 \pm 0.67	8.39 \pm 0.76	13.97 \pm 3.49 ^C
Statistic*		I>II, III						III>>I, II
Sampling in 6 th week of lactation								
I	2.05 \pm 0.23	324.50 \pm 60.36	4.31 \pm 0.63 ^a	2.81 \pm 0.17	4.76 \pm 0.13	11.79 \pm 1.64	8.17 \pm 0.46	15.56 \pm 4.78 ^D
II	2.13 \pm 0.16	345.67 \pm 337.47	4.38 \pm 0.45	2.96 \pm 0.16	4.94 \pm 0.12 ^a	12.89 \pm 1.5	8.50 \pm 0.26	17.41 \pm 3.25 ^E
III	2.18 \pm 0.15	193.00 \pm 295.17	4.48 \pm 0.74	3.00 \pm 0.26	4.93 \pm 0.15	13.03 \pm 1.88 ^b	8.55 \pm 0.27 ^a	15.37 \pm 5.45 ^F
Statistic*								

Explanations: like in the Tab. II



1: Yield of cows in the first weeks of lactation

In the 3rd week of lactation the statistical differences ($p \leq 0.05$) were stated in urea nitrogen content in milk. The lowest content was noted in group III (13.97 mg/100 ml). Also Ballard et al. (2001) obtained similar values after the use of energetic formulas at the beginning of lactation. In our own investigations, in subsequent sampling in all the groups of cows the growth of urea content ($p \leq 0.05$) was stated. Juszcak et al. (1997) showed that the increase of urea level in milk indicated the deterioration of nutritional components utilisation of fodder, especially the protein and thus, the lower productive effectiveness of feeding. In own research this relationship was affirmed at group II. The other milk components did not differ in significant manner between groups in individual samplings (Tab. IV). In the 3rd week of lactation a little larger content of non fat dry matter, protein and casein, in comparison to the other groups was noted in group III. During the research period in the milk of control group the content of protein dropped, from 4.86 to 3.29% ($p \leq 0.01$). The fluctuations of others parameters were not large. The decrease of dry matter and fat content in milk probably results from deterioration of health condition of cows' mammary gland.

During the subsequent analyses of milk content some differentiation in the protein and fat ratio were stated. The proportion of fat and protein in milk has been accepted as the potential marker of energy deficiency in nutrition dose as well as the expression of energy balance of the organism (Heuer et al., 2000). In day of the end of preparation administration it slightly exceeded 1.5 (1.54 in group II and 1.76 in group I). However, at subsequent samplings, it was

lower at all the groups. Cows, which have the fat to protein rate higher than 1.5 are particularly subject to any metabolic disorders (Heuer et al., 1999).

The milk yield and its content depend on genetic and environment factors as well as on interactions between these factors. Among the extra-genetic factors the fundamental effect of nutrition is emphasized (Heuer et al., 2000; Pieszka and Brzóska, 2001). There are a lot of papers about the influence of different supplements e.g. protected fat and proteins (Szulc et al., 1995; Pieszka and Brzóska, 2001), mineral-fat supplements (Szulc, 2000) and profilactic formulas (Kupczyński and Chudoba-Drozdowska, 2000) on the milk yield and content. However, according to Goff and Horst (1997), the high energy uptake and its optimal transformations in the early lactation have the critical impact on the health and productivity of high yield dairy cows.

Adding the energy supplements with propylene glycol to the feeding dose of high yield dairy cows in transition period, caused the growth of milk, fat and protein yield, without any significant effect onto the content of these components in milk (Ballard et al., 2001). In the literature available, the results concerning the immediate influence of propylene glycol onto milk yield and composition are divergent. The short-term feeding of preparation to cows in periparturient period did not affect the milk yield and composition (Studer et al., 1993). Pickett et al., (2003) only stated the higher content of milk fat for cows that were given the protected fat together with the glycol. Propylene glycol administered alone caused the decrease of fat content without any effect onto daily yield. Simi-

lar results were obtained by Formigoni et al. (1996) who demonstrated that it had no effect on the milk yield and content, but caused the low count of somatic cells and the urea in milk ($p \leq 0.01$ and $p \leq 0.05$, respectively). It was confirmed in own research and by Cozzi et al. (1996). Miyoshi et al. (2001) showed, that per os administration of propylene glycol in dose of 500 ml/day/per head beginning from 7th to 42nd day of lactation did not effect the milk yield, however Fisher et al. (1973) noted the increase of daily yield and the lactose content in milk and the decrease of fat content in milk during the long-term administration. The propylene glycol administered to cows in the transition period caused the higher milk yield and the fat produced, and also the increase of protein yield (Bodarski et al., 2003).

The propylene glycol is the effective profilactic mean lowering the risk of cows' ketosis in early lactation that always negatively affects the productivity. Rajala-Schultz et al. (1999) stated that in case of cows with ketosis there is the decrease in milk production from 3.0 to 5.3 kg/day, and the milk yield in lacta-

tion period is lower meanly about 353.4 kg of milk, in comparison to the healthy animals.

CONCLUSIONS

1. The propylene glycol administered to cows had a profitable effect onto the change of their condition as it moderated its decrease during entering the peak of lactation.
2. In colostrum of cows from group III (500 ml of glycol per head), the higher contents of dry matter, lactose and β -lactoglobulins were noted.
3. The highest daily milk yield were stated for cows receiving higher dose of preparation (daily yield 38.68 kg) during the first 3 weeks of lactation, higher of 3.64 kg comparing to control group.
4. In the 3rd week of lactation the low level of somatic cells in milk of cows receiving the preparation was observed. In milk of cows receiving 500 ml of preparation the lower ($p \leq 0.01$) urea nitrogen content was obtained. There were no significant effects of preparation administration on the participation of other components.

SOUHRN

Vliv přidavku propylenglykolu na tělesnou kondici krav, jejich mléčnou užitkovost a kvalitu mleziva

Analýzy byly provedeny na skupině 24 vysokoprodukčních dojnic. Skupina zvířat byla rozdělena na tři podskupiny ($n = 8$). Podskupina I. – kontrolní, zvířata bez přidavku propylenglykolu; podskupina II. – aplikace propylenglykolu v denní dávce 250 ml na kus; podskupina III. – aplikace propylenglykolu v denní dávce 500 ml na kus. Přípravek byl zvířatům podáván formou per os od dvou týdnů před plánovaným porodem do třetího týdne laktace. V průběhu pokusu byla sledována a hodnocena tělesná kondice zvířat metodou BCS, měřena denní produkce mléka a stanoven obsah složek v mléce. Přídavek propylenglykolu zmírnil pokles kondice u dojnic na počátku laktačního vrcholu. Z pohledu obsahu složek se jevila jako zajímavější vyšší dávka propylenglykolu, u které byl prokázán nižší obsah močovinného dusíku v mléce a zároveň vyšší produkce o 3,64 kg v porovnání s kontrolní skupinou. Ve třetím týdnu laktace byl potvrzen nižší obsah somatických buněk v mléce dojnic s přidavkem preparátu propylenglykol. Na základě výsledků námi provedené studie je možné očekávat výrazný pozitivní účinek přidavku propylenglykolu podávaného dojnicím před a po porodu na jejich tělesnou kondici, poněkud méně výrazný pozitivní účinek je možné očekávat u kvality kolostra a mléčné užitkovosti.

krávy, propylenglykol, mlezivo, produkce mléka, složení mléka, kondice krav, BCS

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