Non-structural carbohydrates in the nutrition of high-yielding dairy cows during a transition period

K. Poláková[1,2], V. Kudrna[1], A. Kodeš[2], B. Hučko[2], Z. Mudřík[2]

[1]Institute of Animal Science, Prague-Uhříněves, Czech Republic
[2]Department of Microbiology, Nutrition and Dietetics, Czech University of Life Science, Prague, Czech Republic

ABSTRACT: The main aim of this study was to investigate experimentally the effect of different composition of non-structural carbohydrates (NFC) in prepartum feed rations administered to high-yielding dairy cows at a high concentration of NFC in the diet on dry matter intake both before and after parturition and on subsequent milk performance, body condition and physiological traits of rumen fluid and blood. Thirty-six high-yielding dairy cows were allocated into one of the three well-balanced groups (K, O, and C), and each group received a different feeding rations. Feeding rations differed in non-structural carbohydrate (NFC) structure. The "K" (control) group received a feeding ration with NFC in the form of maize starch in particular, while the feeding rations of the other two (experimental) groups contained either (besides maize starch) saccharose from dried sugar beet (the "O" group) or a dominant amount of NFC was in the form of saccharose (the "C" group). After calving, all dairy cows were given the same feeding ration from the first day after parturition. The experiment was conducted for 21 days before and 50 days after calving. FR in the form of total mixed ration was offered *ad libitum*. Dry matter intake, milk performance, body condition, live weight, and blood and rumen parameters were recorded for the duration of the experiment. Average daily dry matter intake before calving was highest in the "K" group (14.32 kg per head). Differences among groups were statistically significant ($P < 0.05$). Prepartum dry matter consumption dropped as the rate of saccharose in the diet of cows increased. Dry matter consumption levelled off after calving. Milk yield was also highest in the "K" group (43.71 kg/head/day), but fatness of milk and thus the production of fat corrected milk were lowest in this group. The highest milk fat content (4.10%) and fat corrected milk production (44.03 kg/head/day) were recorded in the "C" group, whereas the highest milk protein concentration was found in the milk of the "O" group. The composition of NFC affected dry matter intake before parturition, but these concentrations did not significantly affect dry matter intake, milk yield, milk composition, live weight, body condition or blood serum and rumen fluid parameters after calving.

Keywords: dairy cows; NFC; dry matter intake; milk performance; transition period

Considerable attention has been paid in recent years to the metabolic processes of cows in their transition period which is an interval including two or three weeks before parturition (*pre partum*) and three weeks after parturition (*post partum*). This is the most critical time period of parturition for a number of reasons. Nutrition and management during this period fundamentally determine profitability of dairy cows for the duration of their lactation (Gulay et al., 2004; De Frain et al., 2005;

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Odensten et al., 2005). During the progress of gravidity, the concentration of progesterone declines, unlike the level of oestrogen in blood, which is very high or even rises. It is thought that this high level of oestrogen in blood is a crucial factor in the decrease of dry matter intake (DMI; Grummer, 1995; Butler et al., 2002; Van Saun, 2003).

DMI decreases during the last 7 to 14 days prepartum approximately by 10 to 30% in comparison with the period of early lactation, although during prepartum period the nutritional requirements of a foetus are the highest (Hayirli et al., 2002; Smith et al., 2005). This decrease in DMI can be influenced by increasing values of non-esterified fatty acid (NEFA) concentrations which increase approximately 10 days before calving. The concentration of glucose in blood plasma drops considerably during the transition period (Dorshorst and Grummer, 2002; Roche et al., 2003b).

The nutrition of dairy cows during the dry-up period can affect their performance at the beginning of lactation, their health both before and after parturition, and their reproduction parameter qualities. Calving and the beginning of lactation have an important impact on the metabolism of many tissues (Bauman, 2000). Many problems manifest after calving. These problems may be established as early as at the end of previous lactation or late at the end of the dry-up period (Robinson et al., 2003). Ingvarsten et al. (1999) found that the decisive factor for achieving high performance was the meeting of nutritional requirements of dairy cows, which ensures their good health, body condition, and reproduction parameters. Other authors reported the same or similar results as well (Dann et al., 1999; Park et al., 2002; Veauthier, 2002; Agenas et al., 2003; Roche et al., 2003a). It is possible to consider slow eating, metabolic disorders, and considerable declines in body condition as symbols of poor and inadequate care of dairy cows during the transition period. Feeding errors during the prepartum period may cause problems and decreases in milk yield after calving (Duffield et al., 2003).

It is thus recommended to minimise the decline of DMI or to increase concentrations of nutrients in a feeding ration (FR) given during the transition period to levels that maintain body reserves, enhance the availability of nutrients for rapid foetus growth, facilitate the metabolic shift from gestation to lactation, and ensure quick and easy adaptation of rumen microorganisms to the new FR.

For successful changeover from dry-up period to lactation period, it is necessary to prepare all rumen microorganisms for the high energy concentration in the cow's diet at the beginning of lactation. In addition to a higher amount of maize feed, concentrates of disposal carbohydrates should also be included in the FR. The inclusion of easily fermentable carbohydrates guarantees the acclimation of microbial population to the upcoming lactation FR (Reynolds et al., 2004). If the fermentable carbohydrate content in the FR is increased, production of rumen propionate and liver glucose also increases, exploitation of liver glycogen is minimised, and insulin secretion is stimulated, which means that adipose tissue mobilisation declines and the occurrence of ketosis is restricted.

The transitional FR, which dairy cows receive two to three weeks before calving, should consist of high-quality structured components for ensuring daily DMI on the level of 10 to 12 kg. This FR should also contain 6.4 to 6.6 MJ NE_L/kg dry matter (DM), 15% crude proteins, and 18% crude fibre or 300 g structural crude fibre per 100 kg of live weight. To maximise DMI, the *pre-* and *post partum* balance of structural (crude fibre) and non-structural (sugar, starch) carbohydrates in FR is very important.

Non-structural carbohydrates (NFC) comprise a diverse group of substances in terms of their composition and nutrient contents, excluding carbohydrates inherent to neutral detergent fibre (NDF). The NFC group of substances includes organic acids, monosaccharides, oligosaccharides, fructans, starch, pectin substances, and β-glucans. Their content in feed is often described as an independent value according to the formula:

$$(\%)\text{NFC} = 100 - ((\%)\text{crude protein} + (\%)\text{NDF} + (\%)\text{fat (ether extract)} + (\%)\text{ash})$$

This value is used due to problems with analyses of single elements of NFC. However, these problems are not caused by their distinctness as nutrients. Analyses that are able to distinguish single elements of NFC can identify starch, soluble fibre (non-NDF, non-starch carbohydrates) and low-molecular-weight carbohydrates. Microorganisms inside the rumens of ruminants can ferment the fibre carbohydrates of the feed to obtain microbial products which have a high nutritive value for these animals (Hall, 2003).

Due to their focus on increasing the energy content of diets that are used for such a close specific period, most surveys result only from changes in

Table 1. Components of *pre partum* diet (kg/head/day)

Feeds	Group		
	K	O	C
Ensiled maize cobs	1.5	1.5	1.5
Maize silage	6.0	6.0	6.0
Meadow hay	2.5	2.5	2.5
Lucerne silage	13.0	13.0	13.0
Barley meal	0.5	0.5	0.5
Wheat meal	0.5	0.5	0.5
Extracted soybean meal	1.0	1.0	1.0
Maize meal	**2.5**	**1.25**	–
Dried sugar beet	–	**1.8**	**3.65**
Ifravit 100	0.25	0.22	0.19

Table 2. Nutrients of *pre partum* diet (per head/day)

Nutrients	Group		
	K	O	C
Dry matter (kg)	13.4	13.8	14.2
Crude protein (g)	2 188.0	2 120.0	2 130.0
PDI-E (g)	1 310.3	1 300.5	1 294.3
NEL (MJ)	91.3	91.1	91.2
Crude fibre (g)	2 531.0	2 582.0	2 631.0
NDF (g)	4 479.0	4 711.0	4 953.0
ADF (g)	2 695.0	2 796.0	2 894.0
Ca (g)	100.57	103.9	107.4
P (g)	63.4	61.9	60.5
Starch (g)	2 601.4	1 846.3	1 091.7
Sugar (g)	348.3	1 447.6	2 577.8
NFC* (g/kg DM)	**413.0**	**415.0**	**412.0**

NFC* – amount of NFC calculated according to the formula: (%)NFC = 100 – ((%)CP + (%)NDF + (%)fat + (%)ash)

the non-fibre carbohydrate content of FR. A commonly held opinion is that feeding rations with higher amounts of NFC than conventional FRs for dairy cows in the dry-up period usually contain have to be fed prepartum to enlarge the surface area of rumen papillae for adequate absorption of volatile fatty acids (VFA) that are produced by rumen fermentation (Overton and Waldron, 2004).

Body condition scores (BCS) are evaluated in dairy cows to assess their body reserves and the overall nutritional state of a herd (Vacek, 1994). This evaluation enables to maintain the herd's nutrition at the optimal level (Garnsworthy and Huggett, 1992). During the dry-up period, every farmer should care to keep BCS constant (Contreras et al., 2004).

MATERIAL AND METHODS

Experimental design, animals

A group experiment was carried out using two breeds of high-yielding dairy cows (Holstein and Czech Fleckvieh) that were in the transition period. The experiment began 3 weeks before calving and ended 50 days after parturition. The main aim of this project was to examine experimentally the effect of different composition of NFC in the prepartum FR with a high level of NFC given to high-yielding dairy cows during the final three prepartum weeks on DMI, milk performance, body condition, and physiologic parameters of rumen fluid and blood serum.

Thirty-six high-yielding dairy cows were used (33 Holstein and 3 Czech Fleckvieh). The animals were transferred to an experimental barn approximately 23 days before their expected calving day. These animals were divided into three well-balanced groups using analogue triplets (e.g. according to breed, number of lactations, previous performance, body weight). Average milk performance in the previous standard lactation was in the particular groups as follows: "K" – 10 131 kg, "O" – 9 829 and "C" – 9 942 kg of milk. Average number of lactation periods was 1.85, 1.82 and 2.0 for groups "K", "O" and "C", respectively. Average body condition score varied from 3.23 ("K") to 3.29 ("O"). Average live weight was lowest in the "K" group (659 kg), whereas in the "O" group it was 685 kg and the highest live weight was in the "C" group (708 kg). Each group was given a FR with different NFC composition (Tables 1 and 2). *Post partum*, all cows received the same produce FR. Animals were housed in a free-stall barn.

Data and sample collection

Cows were milked twice a day, and milking was always associated with automatic weighing. Milk yield was measured after each milking, and samples of milk were taken for analyses of basic milk components and urea content once a week (always from both evening and morning milkings). Dairy cows that did not calve yet were weighed once a week and the body condition scores of all cows were also evaluated weekly.

Consumption of FRs was registered automatically by software controlling the equipment of the experimental barn. The main parts of this equipment were troughs on tensometric scales, ear chips on the cows, chip reading facilities, and a PC with supporting software. Similarly, dosing of single feeds for preparing FR was controlled by software in a mixing wagon.

In each of the three weeks before expected calving, samples of blood (from the *vena caudalis mediana*) and rumen fluid were taken from all cows of each group using a probang. In total, two or three measurements were taken from each dairy cow. Sampling of blood and rumen fluid was also carried out in the first, second, and third *post partum* weeks. The experiment was terminated on the 50th day of lactation period.

Table 3. Components of *post partum* diet (kg/head/day)

Feeds	*Post partum*
Ensiled maize cobs	5
Maize silage	8.5
Lucerne hay	0.5
Lucerne silage	8.5
Brewery grain	4
Barley meal	2
Wheat meal	2.3
Extracted soybean meal	2.5
Maize meal	2.4
Extracted rapeseed meal	0.5
Dried sugar beet	1
Dried whey	0.3
Soda	0.16
Aminoplus	0.85
Energie 100	0.68
Premin ex 6	0.42

aminoplus – thermally processed soybean extracted meal, 390.6 g/kg PDIE; 7.85 MJ NE_L
energie 100 – fatty supplement containing 99.5% of fat, 39.4 MJ ME
premin ex 6 – mineral supplement with chemically bound macroelements (25% Ca, 6% P, 6% Na, 4% Mg, 1 200 mg Cu, 8 700 mg inorganic Mn, 350 mg organic Mn, 7 250 mg inorganic Zn, 750 mg organic Zn, 35 mg Se, 100 mg I, 40 mg Co, 750 000 IU vitamin A, 100 000 IU vitamin D_3, 2 000 IU vitamin E
ifravit 100 – mineral supplement (5.4% Ca, 8.0% P, 6.0% Mg, 4% Na, 1 500 mg/kg Cu, 7 500 mg/kg Zn, 5 000 mg/kg Se, 1 000 000 IU vitamin A, 150 000 IU/kg vitamin D_3, 4 000 mg/kg vitamin E

Diets

During prepartum, three different feeding rations were offered to the three groups of dairy cows. Each FR (in the form of total mixed ration, TMR) differed in NFC composition. The control group (“K”) was given NFC mainly in the form of maize starch, whereas the diet of the second group (experimen-tal 1, “O”) contained (besides maize starch) saccharose from dried sugar beet, and the last group (experimental 2, “C”) received the FR with a dominant amount of NFC in the form of saccharose. Despite their different NFC contents, all FRs were almost isonitrogenous and isoenergetic. Calved dairy cows were placed in a separate part of the barn, creating a group that was given the same shared lactation FR beginning from the first day after parturition (Table 3). The nutrient composition of this FR is listed in Table 4.

Feed was offered *ad libitum* in regular intervals five times per day. According to several studies, the form of TMR used is the most optimal, especially for Holstein cows (Hutjens, 1996; Bargo et al., 2002 and others). Drinking water was available from automatic dispensers throughout the experiment.

Variables measured

Average daily DMI *pre-* and *post partum*
Daily milk performance
Milk composition (fat, protein, lactose, and urea)
Production of fat, FCM, lactose, and proteins
BSC and live weight
Average parameters of blood serum (glucose, total protein, urea, cholesterol, NEFA, Ca, Mg, P)
Average parameters of rumen fluid (pH, total VFA, NH_3, and acetic, propionic, and butyric acid)

Table 4. Nutrients of *post partum* diet (per head per day)

Nutrients	Amount
Dry matter (kg)	21.4
Crude protein (g)	3 770.0
PDI-E (g)	2 538.9
NEL (MJ)	172.7
Crude fibre (kg)	4.2
ADF (g)	3 213.0
NDF (g)	7 150.0
Ca (g)	188.1
P (g)	91.0
Na (g)	109.6
K (g)	224.9

Analytical methods

AOAC procedures (2005) were used to determine the amounts of crude protein (954.01), ether extract (920.39) and starch (920.40) in the feeds for cows. Neutral detergent fibre was measured following the protocol described by Mertens (2002), and acid detergent fibre (ADF) was determined according to procedure 973.18 of the AOAC (2000). Dry matter was determined in duplicate samples by drying at 105°C to constant weight. Samples of blood were taken using a HEMOS kit. After precipitation, blood serum was separated and analysed by standard procedures using a HITACHI automatic analyser and ROCHE and RANDOX sets. Analyses of milk components were performed using a MILCOSCAN FT 6000 (Foss Electric) infrared absorptive analyser.

Calculations

All data collected were recorded, calculated and analysed using Excel (Microsoft Office) or Quattro (Corel WordPerfect Office) software. Statistical analyses were performed using the GLM procedure within the SAS software package.

RESULTS AND DISCUSSION

Dry matter intake

The highest average daily DMI (14.32 kg/head) was found in the "K" group (the group with maize meal in its FR), followed by the "O" group (12.82 kg/head) and the "C" group (11.18 kg/head), in which the FR contained dried sugar beet (Table 5). As shown in many studies (Bertics et al., 1992; Grummer, 2008), it is important to ensure the maximum DMI during the transition period in high-yielding dairy cows, which did not occur for all groups in our experiment. Differences in DMI were statistically significant among all groups ($P > 0.05$) *pre partum*. The difference between groups "K" and "C" was 3.14 kg/head. The reason for such a difference in DM observed in our experiment could be due to the rising amount of NFC in the form of quickly fermentable saccharose contained in dried sugar beet which was given to cows *pre partum*. A similar composition of NFC was examined by Mashek and Beede (2000), Keady et al. (2001) and Smith et al. (2005) but they did not find any conclusive differences in DMI.

Table 5. Average dry matter intake *pre-* and *post partum* (kg/head/day)

Group	*Pre partum*	*Post partum*
K	$14.32^{b,c}$	19.22
O	$12.82^{a,c}$	18.58
C	$11.18^{a,b}$	18.71
SEM	1.001	2.327

^{a,b,c}values in column with the same superscript differ statistically significantly ($P < 0.05$)

Series of experiments were previously conducted in which rations with either high or low levels of NFC were fed at the beginning of the dry-up period (Douglas et al., 2004) or three to four weeks before parturition (Doepel et al., 2002; Shah et al., 2004). These investigations did not report any statistically significant differences between FRs with low and high levels of NFC in DMI before calving. For example, Smith et al. (2005) observed the daily DMI of 13.7 kg/head when feeding the ration with a low level of NFC (34%) and 13.8 kg per head when using the FR with a high level of NFC (40%). However, other authors (Grum et al., 1996; Holcomb et al., 2001; Keady et al., 2001; Rabelo et al., 2003; Chung et al., 2008) found differences in DMI in their experiments. In these studies, higher DMI was always associated with the FR containing higher levels of NFC. Minor et al. (1998) recorded DMI of 10.2 kg/head/day with low rations of NFC, whereas high rations of NFC resulted in DMI of

13 kg/head. Analogous results were obtained in other experiments, e.g. Keady et al. (2001) reported DMI of 9.28 kg/head for the FR with 13% NFC and DMI of 11.03 kg/head for the FR with 28% NFC.

In our experiment, DMI levelled off after parturition. The difference between the group that took in the largest amount of DM ("K") and the group with the lowest DMI ("O") was only 0.5 kg. Increased consumption of the FR was reported (18.71 kg per head/day), and it exceeded that of "O" group, which had DMI of 18.58 kg/head/day. The highest daily DMI was recorded in the "K" group (19.22 kg/head). Differences in DMI *post partum* were not statistically significant ($P > 0.05$). Statistically insignificant differences in DMI *post partum* were also recorded in the studies mentioned above. The resulting daily averages of DMI from our experiment are shown in Table 5.

Milk performance

As for the average daily milk performance, milk yield was highest in the "K" group (43.71 kg), followed by the "C" group, which had an average milk yield of 43.41 kg, and the lowest milk yield was found in the "O" group (Table 6). However, milk fat content was highest in the "C" group (4.1%) and lowest in the "K" group (3.76%). The highest levels of protein content and protein production were found in the "O" group (3.28%), although this group had the total milk yield 1.7 and 1.3 kg lower than groups "K" and "C", respectively. Urea concentration in milk was quite balanced, similarly like the average content of lactose. A statistically significant difference ($P < 0.05$) in urea content in milk was found between groups "C" and "O" only. Similar results were reported in a recently published review (Grummer at al., 2007), in which none of the reviewed studies recorded statistically significant differences in milk yield between cows fed FRs with low or high concentration of NFC.

After recalculation of milk yield to fat corrected milk (4%; FCM), differences in milk performance were statistically insignificant ($P > 0.05$). FCM was markedly higher in the "C" group than in the other two groups, namely by 2 and 4 kg, respectively. A similar result was found for daily average fat production, which was highest in the "C" group due to the high fatness of its milk. The "O" group had higher average fat production than the control group "K", in which the milk fat content was lower by almost 0.1 kg of fat/head/day relative to "C" group. Daily average protein production reflected the results of protein concentrations in milk: the highest protein production (0.78 kg/head/day) was found in the "O" group, which received maize meal and dried sugar beet in its FR. Daily average lactose production was similar in the "C" and "K" group (1.11 kg/head), this value was higher by 0.03 kg in the "O" group. Similar results were reported by Liu et al. (2008), who fed various energy-rich oilseeds to dairy cows but they found no significant difference either in milk performance or in milk

Table 6. Average milk performance

Traits	Group			SEM
	K	O	C	
Yield (kg)	43.71	42.04	43.38	6.64
Fat (%)	3.76	3.83	4.1	1.33
Protein (%)	3.11	3.28	3.19	0.59
Lactose (%)	4.83	4.78	4.81	0.34
Urea (mg/l)	226	201^a	262^a	96.34
FCM (4%) (kg)	42.14	40.97	44.03	6.53
Fat production (kg)	1.36	1.61	1.78	–*
Protein production (kg)	1.36	1.38	1.38	–*
Lactose production (kg)	2.11	2.00	2.09	–*

*fat, protein, and lactose production were calculated from the total average of all values – SEM was not calculated

^{a,b,c}values in line with the same superscript differ statistically significantly ($P < 0.05$)

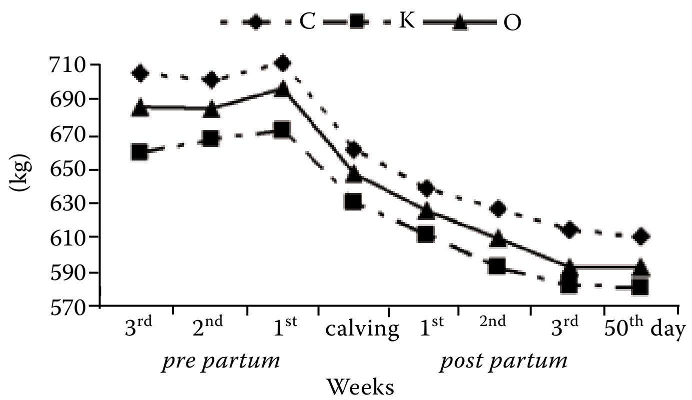

Figure 1. Changes of body weight for the duration of the experiment (kg)

components. Zhai et al. (2006) found no statistically significant differences in milk performance *post partum* except for urea concentration, which is similar to our experiment.

BCS and body weight

The values of BCS were rather balanced among all groups. They oscillated between 3.25 and 3.5 and they did not exceed the limits for BCS reported previously in scientific papers (Hanuš et al., 2004; Jílek et al., 2008). Body weights (BW) of dairy cows were recorded for the first time when they were transferred into the experimental barn (three weeks before calving). As shown in Figure 1, the highest average weight at the beginning of the experiment was recorded in the "C" group, followed by the "O" group and the "K" group. DMI was highest in the leanest group, the "K" group, and lowest in the "C" group, which had the highest body weight and BCS. BW in all the groups increased until parturition.

In the period between calving and the end of the experiment (50th day of lactation), decreases in BW of approximately 50 kg occurred in all groups. This value is in line with the normal physiological decline of BW in dairy cows after calving, which should not exceed 1 kg per day (Gallo et al., 1996). Similarly, a decline in BCS of up to 0.3 was observed, which can be explained again by the normal physiological decrease in BW, and stress after parturition (Jílek et al., 2008). Dairy cows from the "C" group maintained the highest BW, followed by the "O" group and then the "K" group. Figure 2 shows changes in BCS. Thus, the attempt to create fully equivalent groups only according to BW and BCS at the beginning of the experiment was not successful because of the necessity of taking into account more parameters which appeared to be more important. This should be taken into consideration when evaluating the following results.

Average values of rumen fluid and blood serum parameters

We measured rumen fluid pH and concentrations of acetic, propionic, butyric, and valeric acid, the

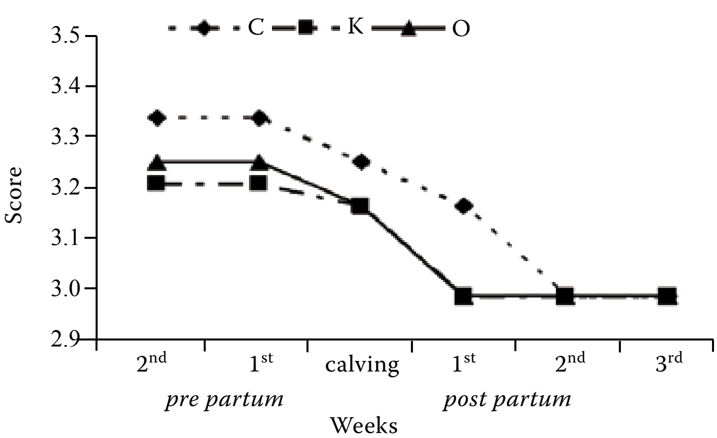

Figure 2. Changes of body condition score

Table 7. Average values of rumen fluid parameters *pre partum* and *post partum* (mmol/l)

Group	pH	Acetic	Propionic	Butyric	Valeric	Σ VFA	NH_3
Pre partum							
K	6.74	63.84	24.31	16.77	0.92	105.84	15.85
O	6.78	61.22	23.22	16.50	0.93	101.87	15.53
C	6.78	61.42	22.66	16.61	0.74	101.43	15.73
SEM	0.29	10.93	4.32	3.12	0.32	17.23	2.19
Post partum							
K	6.54	70.1	26.29	17.56	0.79	114.74	16.1
O	6.55	70.3	26.46	18.27	0.91	115.94	16.34
C	6.55	71.74	26.16	18.74	0.87	117.51	15.96
SEM	0.36	13.32	4.76	3.25	0.38	20.56	1.99

sum of VFA and NH_3 concentrations. All these values were determined both *pre partum* (three-week average) and *post partum* (three-week average). No statistically significant differences were found for any traits or groups either before or after parturition. Rabelo et al. (2005) reported a decline of pH values in a group with higher energy content in the FR, but no significant differences in the sums of VFA were found. All values of rumen fluid measured in our experiment are shown in Table 7.

All pH values were within normal physiological limits for the duration of the experiment. *Pre partum* pH values were higher than *post partum* values in all groups by virtue of the concentrates in the prepartum diets. The concentrations of VFA (acetic, propionic, butyric, and valeric acid) were quite balanced prepartum, whereas the *post partum* concentrations of acetic, propionic, and butyric acid were increased. Only the concentrations of valeric acid maintained approximately the same level. The sum of VFA showed an increase after calving, as did the concentration of NH_3.

In blood serum, glucose, total protein concentration, cholesterol, calcium, phosphorus, magnesium and NEFA were measured and considered as an average for three weeks *pre partum* and *post partum* (Table 8). Statistically significant differences ($P < 0.05$) were found only in total protein contents between groups "C" and "O" and between "K" and "O" both before and after parturition, and in urea

Table 8. Average values of blood serum parameters *pre partum* and *post partum* (mmol/l)

Group	Glucose	Total protein (g/l)	Urea	Cholesterol	Ca	Mg	P	NEFA
Pre partum								
K	3.64	70.07^{a}	4.49	2.48	2.58	0.72	1.69	0.24
O	3.53	69.95^{b}	4.69^{a}	2.44	2.76	0.74	1.75	0.26
C	3.56	72.03^{a,b}	3.9^{a}	2.15	2.71	0.70	1.72	0.28
SEM	0.38	6.93	1.28	0.73	0.44	0.08	0.26	0.70
Post partum								
K	3.11	72.44^{a}	5.73^{a,b}	2.89	2.48	1.69	1.70	0.58
O	3.11	72.96^{b}	4.99^{b}	2.55	2.39	1.91	1.75	0.56
C	3.14	76.94^{a,b}	4.58^{a}	2.76	2.42	2.46	1.84	0.53
SEM	0.63	8.15	1.41	0.93	0.39	1.84	0.35	0.11

^{a,b,c}values in line with the same superscript differ statistically significantly ($P < 0.05$)

contents between groups "K" and "O" (*pre partum*) and between "C" and "O" and "C" vs. "K" (*post partum*)

Concentrations of total protein were within normal physiological limits for the duration of the experiment, and these concentrations decreased as parturition approached. After parturition, concentrations of total protein began to increase. Concentrations of urea ramained almost constant *pre partum* and began to rise slightly in all groups *post partum*. The lowest content of urea in the blood of "O" group reflects the good utilisation of nitrogen substances, especially regarding the combination of fast and slow fermentable sources of energy (i.e. starch and saccharose).

Glucose concentrations gradually decreased until the second week after calving, then they increased somewhat. The lowest concentration of glucose was observed in the second week *post partum*.

NEFA concentrations rose slightly from the beginning to the end of the experiment, while cholesterol concentrations first decreased until the day of parturition and then started rising.

Minor et al. (1998) reported increasing levels of glucose and reduced NEFA concentrations in the blood of cows receiving rations with high levels of NFC, whereas Petit et al. (2007) recorded higher NEFA concentrations and lower glucose levels in a group of dairy cows that were given the FR high in energy.

Concentrations of calcium remained almost invariable prepartum, while a slight decrease occurred *post partum*. These concentrations levelled off over the period of three *post partum* weeks. Magnesium concentrations increased considerably *post partum*, exceeding physiological limits (0.78 to 1.07 mmol/l) and indicating enhanced supply of this element (Jagoš et al., 1985). Phosphorus concentrations were well balanced for the duration of the experiment. All values measured in the blood serum (except magnesium concentrations) were within normal physiological limits and indicated the very good health state of the animals.

CONCLUSIONS

The composition of NFC in diets given to dairy cows prepartum significantly affected dry matter intake before parturition, with benefits observed for diets with maize meal, or more precisely with maize starch. However, the NFC concentrations did not influence dry matter intake after calving, nor did they affect milk performance or milk composition (except for urea content in milk between groups "C" and "O"). Furthermore, the monitored parameters of rumen fluid and blood serum were not significantly affected by NCF levels, except for total protein and urea content in blood among some groups both *pre-* and *post partum*.

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Corresponding Author

Ing. Václav Kudrna, CSc., Institute of Animal Science, Přátelství 815, 104 00 Praha-Uhříněves, Czech Republic
Tel. +420 267 009 627, e-mail: kudrna.vaclav@vuzv.cz