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AMMONIA CONCENTRATION IN URINE OF DAIRY COWS IN DIFFERENT PHASES OF CALVING INTERVAL

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Abstract

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The ammonia concentration in the urine of 3,237 cows was followed over the years 1980-1984. The whole population of cows was divided into four groups: I - the first lactation phase, II - in the 2nd lactation phase, III - in the 8th month of pregnancy, IV - in the 9th - 9.5 month of pregnancy. A regular increase in the ammonia concentration in urine of late pregnant cows (III 57.74 mmol.l^{-1} and 59.4 mmol.l^{-1} in winter and summer season, resp.; IV 67.33 and 72.24 mmol.l^{-1} in winter and summer season, resp.) was found in both types of feed rations. This increase was observed to be significant when compared with the values of lactating cows (I 44.6 and 51.4 mmol.l^{-1} in winter and summer season, resp.; II 46,4 and 51.4 mmol.l^{-1} in winter and summer season, resp.). This increase progressed significantly with the approaching calving. The increase of ammonia and the simultaneous decrease of urine urea and of proteinemia demonstrated the lowered ureosynthesis and proteosynthesis. Thus the necessity to change the standard defining the energy nutrient requirements of late pregnant cows has become obvious.

Dairy cows, 1st and 2nd lactation stage, 8th and 9th-9.5th month of pregnancy, summer and winter feed rations.

When evaluating the feed ration adequacy using the metabolic profile of cattle the biochemical values of urine appear to signal the metabolic disturbances earlier and more distinctly than the values found in blood. This is due to the regulatory function of kidneys which, under normal conditions, eliminate the metabolic end products, excrete and/or reabsorb them in an extent necessary for a relatively constant internal milieu of the organism. Blood, lymph and tissue liquor represent this internal milieu in which the cells of an organism live, their function being predomi-

nantly a transporting one. Any disturbance of the internal milieu affects the cell function or it may itself be a manifestation of the anomalous cell function.

When carrying out the screening examinations of dairy cows it is therefore necessary to perform the examination of urine, or also of milk (Kirchgessner et al. 1985). Both these fluids are easily obtainable. According to many years experience with dairy cattle metabolism studies the following urine parameters were found to be the best indicators of nutrition adequacy and of balanced metabolism: acid-base status, urea, ammonia, and ketone bodies concentration with regard to the urine specific density.

Knowing the nutrient availability in the feed ration indicators represent a sound image of the metabolization level of protein (pH), of protein ratio (urea, ketone bodies, pH), of energy deficit (ammonia) or possibly of a damage of liver function (urea and ammonia).

The importance of the acid-base status, urea, ketone bodies and of specific density and their values for a diagnosis is generally well recognized and used in veterinary medicine. The diagnostical significance of ammonia concentration in urine as a reflection of the saturation of nutrient requirements or of the damage of liver function has not been so far fully appreciated. It is thus the purpose of the present work to demonstrate its importance.

Material and Methods

Over the years 1980-1984 the ammonia concentration in the urine of 3.237 dairy cows was determined. Altogether 1.441 and 1.796 samples were examined during the period of summer and winter feed rations, resp. The sets of dairy cows usually comprised of groups in various phases of calving interval: I - 1st lactation stage, from 14 days to 2, or 3 at the most, months post partum; II - 2nd lactation stage, 4 - 6 months post partum; III - 8th month of pregnancy; IV - 9th - 9.5th month of pregnancy. Urine samples were taken using a plastic catheter usually between 9 and 11 a.m. On this occasion a complex metabolic profile examination of dairy cattle was performed.

Urine samples for the ammonia concentration determination were preserved immediately after sampling by N/1 HCl (4 parts of urine per 1 part of acid). The NH_3 concentration in urine was determined by the photocolorimetric method according to Wooton (1964) using the 480 nm wavelength.

Results

The results confirm our previous finding (Lebeda 1984) that the ammonia concentration in the urine of dairy cows in their last 2 to 2.5 months of pregnancy and under both types of feed rations, was significantly higher than during the lactation period. This fact has now been specified in that the increase of ammonia concentration is significantly intensified in the last six weeks of pregnancy (group IV). This increase in ammonia con-

centration in urine can thus be regarded as regular under feeding conditions in our agricultural establishments.

The distribution curves of ammonia concentration in urine of the whole cow population examined were found to exhibit the Gaussian behaviour with a tendency to positive assymetry, both in summer and winter feeding periods. The mean winter values (53.81±±28.85 mmol.l^{-1}) were found to be significantly lower than the average of summer values (62.28±32.69 mmol.l^{-1}), the scatter of the former being significantly smaller than the latter. The coefficient of variation differed, however, only slightly (53.51 and 53.60 % in summer and winter, resp.).

The values exceeding 170 mmol.l^{-1} represented only 0.33 and 0.83 % in winter and summer feeding, resp. 88.92 % of values in winter and 86.19 % of values in summer were found to range within 17.6 and 88.1 mmol.l^{-1}.

Figure 3 shows the effect of quantitative and qualitative changes in feeds in individual years upon the ammonia concentration in urine. Although the general tendency of these changes was found to be similar in all groups of cows, it appears at the same time that the increase of ammonia concentration in late pregnancy occurs also in individual winter and summer seasons. A greater variability of values was also observed in late pregnant cows. Examinations carried out in individual feeding seasons confirm the significant increase in ammonia concentration in the group III when compared with the group I in one of the four summer feed rations and in three from four winter feed rations. If compared with the group II, the increase was found to be significant in the group III in two from four summer seasons and in three from four winter seasons. The ammonia concentration in the case of cows in 9th - 9.5th month of pregnancy (IV) was found to be higher than that of cows in the 1st and 2nd lactation stage (group I and II) and in all seasons. On the other hand, the differences between both groups of lactating cows in any of the feeding season were not statistically significant (Table 1).

The differences of ammonia concentrations noted in summer seasons were found to be significant in two cases belonging to the group I, twice in the group II, once in the group III, in no case in the group IV, and once in the whole population (Table 2).

Discussion

The results of the present work differ from those obtained earlier (L e b e d a 1984) by the frequency of significant differences between summer and winter ammonia concentrations only. The average winter values were found to be lower by only 6.41 mmol.l^{-1} and summer values by 3.12 mmol.l^{-1} higher if compared with the preceding four years. The coefficient of variation decreased by 4.43 and 4.84 % in summer and winter, resp.

The main contribution of the present study is seen in the confirmation of regularity of the urine ammonia concentration increase in late pregnant cows and of its further progress with pregnancy in both feeding seasons. The increase of urine ammonia could indicate starvation or damage of liver parenchyma (V a r á d y et al. 1970). In summer, when starvation of late

Table 1

Significance of ammonia values differences in the urine between individual groups of cows (I, II, III, IV) in single periods of summer feeding (S) and winter feeding (W) . P =, NS = nonsignificant; t-test in the left column, F-test in the right column

Groups	1980_S		1981_S		1982_S		1983_S		$1980/81_W$		$1981/82_W$		$1982/83_W$		$1983/84_W$	
I/II	NS	NS	NS	NS	NS	0,05	NS	NS	NS	NS	NS	0,01	NS	0,01	NS	NS
I/III	0,01	0,01	NS	NS	NS	NS	0,05	0,01	0,05	0,01	0,001	0,01	0,01	NS	NS	0,05
I/IV	0,001	0,01	0,001	0,05	0,001	0,01	0,001	0,05	0,001	0,05	0,001	0,01	0,001	0,01	0,001	0,01
II/III	NS	0,05	0,01	0,01	0,05	0,01	0,001	0,05	0,01	0,05	0,001	0,01	0,001	0,01	NS	NS
II/IV	0,01	0,05	0,001	0,01	0,001	0,01	0,001	NS	0,001	NS	0,001	0,01	0,001	0,01	0,001	0,01
III/IV	0,02	NS	0,001	NS	0,01	0,01	NS	NS	NS	NS	0,01	0,01	NS	NS	0,001	0,01

pregnant cows can be eliminated, the damage of liver parenchyma can be thus regarded as a more probable cause of the ammonia concentration increase in urine. This hypothesis is supported by the fact that the urea concentration in urine of late pregnant cows is lower than in cows in the 2nd lactation stage (in 20 % of cases significantly) (L e b e d a 1987). It indicates a lowered ureosynthesis and an increase of urine nitrogen excretion in the form of ammonia in late pregnant cows. In winter, the late pregnant cows are not usually overfed but their ammonia concentration in urine again increases. The ammonia concentration was found to be higher in late pregnant cows fed feed rations according to the Czechoslovak Standard 46 7070 than in cows whose feed ration differed form the norm by more than 10 %. On the other hand, in lactating cows fed according to the standard the ammonia concentration was lower than in cows with feed rations differed from the standard. The difference in ammonia concentration between lactating and late pregnant cows increased therefore 3.25 times (L e b e d a 1984). This shows that the Standard ČSN 46 7070 specifying the nutrient requirements of late pregnant cows does not correspond to their physiological needs.

It can be concluded from these findings that the standard should set a lower content of digestible nitrogen substances or higher energy content, i.e. a broader ratio of nutrients, rendering possible a higher ureosynthesis in the liver of high pregnant cows.

The values of metabolites, including ammonia and urea, could be influenced also by the increase of nutrient requirements and metabolic changes during the last weeks of pregnancy due to the effect of hormones. This is supported also by a marked rise of creati-

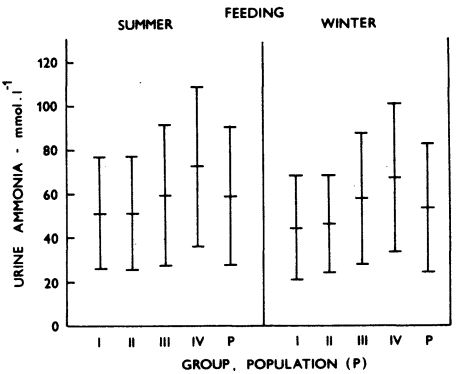

Fig. 1. Arithmetical mean and standard deviation of urine ammonia concentrations in groups and populations of dairy cows in four summarized green (S) and winter (W) feeding seasons.

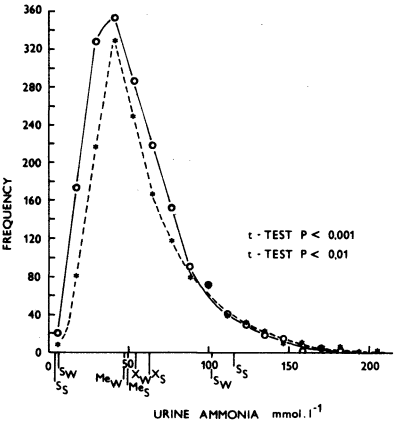

Fig. 2. Distribution of urine ammonia values in cows populations for the whole four year period. Winter feed rations (solid line, rings, subscript W) and summer feed rations (dashed line, crosses, subscript S). Average values ($\bar{X}$), standard deviations (S), medians (Me).

Table 2

Significance of differences between the summer (S) and successive winter (W) ammonia values in the urine of the same nominal groups of cows in years 1980-1984. P =< ; NS = non significant, t-test in the left column, F-test in the right column, P = population

Groups	1980/(80/81)		1981/(81/82)		1982/(82/83)		1983/(83/84)	
I_S/I_W	NS	0.05	0.001	0.01	NS	0.01	0.02	NS
II_S/II_W	NS	0.05	0.05	0.05	0.001	0.05	NS	NS
III_S/III_W	NS	NS	NS	NS	0.05	0.05	NS	0.05
IV_S/IV_W	NS	0.01	NS	NS	NS	NS	NS	0.01
P_S/P_W	NS	0.01	0.001	NS	NS	0.05	NS	NS

nine level in the blood of cows in the last two months of pregnancy (Bo ď a 1969).

Further evidence of the changed proteosynthesis and of the changed nitrogen metabolism in late pregnant cows can be seen in

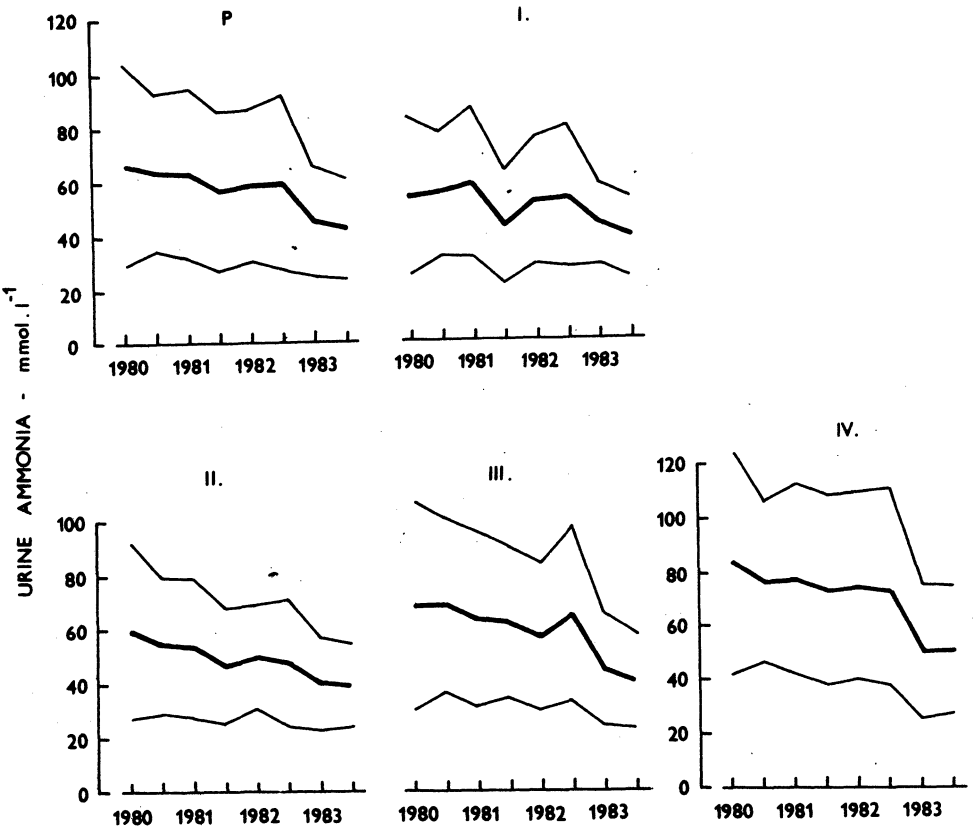

Fig. 3. Arithmetical mean (solid middle line) and standard deviation range (thin line) of urine ammonia concentrations in the population (P) and in the group (I, II, III, IV) of dairy cows in single summer (over year number) and winter (between year numbers) seasons.

the decrease of total protein level in their plasma (L e b e d a 1985).

It follows from the presented data that current feed rations fed to late pregnant cows produce an undesirable metabolic deviations that should be prevented. To realize this, it will further be necessary to solve the question of normal range of ammonia concentration in the urine of cows. Preliminary, the limits ranging from 11.7 to 58.7 mmol.l^{-1} of ammonia contained in urine are regarded as acceptable. This range could however still be changed depending on the analytical determination of ammonia at other wavelength. It has been shown that the measurement at 415 nm gives higher extinctions and is thus substantially more

sensitive than the measurement carried out at 480 nm. When ammonia concentrations exceed 142 mmol.l^{-1} significantly higher values are obtained when measuring at 480 nm when compared with those obtained at 415 nm. On the other hand, when using the wavelength 480 nm the ammonia levels below 24.98 mmol.l^{-1} are often unmeasurable (zero or negative) (L e b e d a and U r b á n k o v á 1986).

Koncentrace amoniaku v moči dojnic v různých fázích mezidobí

V letech 1980 - 1984 byla vyšetřena koncentrace amoniaku v moči 3 237 krav rozdělených do 4 skupin: I - v 1. fázi laktace, II - v 2. fázi laktace, III. - v 8. měsíci březosti, IV. - v 9.- - 9,5. měsíci březosti. U krav vysokobřezích byl zjištěn jak při krmných dávkách se zelenými krmivy, tak při zimních krmných dávkách, pravidelný vzestup koncentrace amoniaku v moči (III. 57,74 mmol.l^{-1} v zimním období a 59,4 mmol.l^{-1} v letním období, IV. 67,33 mmol.l^{-1} v zimním období a 72,24 mmol.l^{-1} v letním období), který byl signifikantní vzhledem k hodnotám krav laktujících (I. 44,6 mmol.l^{-1} v zimním období a 51,4 mmol.l^{-1} v letním období, II. 46,4 mmol.l^{-1} a 51,4 mmol.l^{-1} analogicky). Tento vzestup se signifikantně zintenzivňuje s blížícím se porodem. Vzestup amoniaku a současný pokles močoviny v moči a proteinémie svědčí o snížené ureosyntéze a proteosyntéze a o nutnosti korigovat normu potřeby energetických živin u vysokobřezích krav.

Концентрация аммиака в моче дойных коров на разных фазах промежуточного периода

В 1980 - 1984 гг. проводили исследования концентрации аммиака в моче 3237 коров, разделенных на 4 группы: 1 - на первой фазе лактации, II - на второй фазе лактации, III - на 8 месяце беременности, IV - на 9 - 9,5 месяце беременности. У коров на высокой стадии беременности было установлено не только в рационе зеленым кормом, но и в зимних рационах регулярное увеличение концентрации аммиака в моче (III 57,74 ммоль.л$^{-1}$ в зимний период и 59,4 ммоль.л$^{-1}$ в летний период, IV - 67,33 ммоль.л$^{-1}$ в зимний период и 72,24 ммоль.л$^{-1}$ в летний период), ставшее значительным по сравнению с величинами коров в лактации (1 - 44,6 ммоль.л$^{-1}$ в зимний период и 51,4 ммоль.л$^{-1}$в летний период, II - 46,4 ммоль.л$^{-1}$ и 51,4 ммоль.л$^{-1}$ аналогично). Данное увеличение значительно возрастает с приближающимся отелом. Увеличение аммиака и одновременное мочевины в моче и протеинемия свидетельствуют о пониженном уреосинтезе и протеосинтезе и о необходимости коррекции нормы потребления питательных веществ энергетического характера у коров на высокой стадии беременности.

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