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CRITICAL POINTS IN THE FEEDING OF HIGH YIELDING DAIRY COWS IN ASSOCIATION WITH BCS AND METABOLIC PROFILE TEST

PUNCTE CRITICE ÎN HRĂNIREA VACILOR DE LAPTE ÎN ASOCIERE CU CONDIŢIA CORPORALĂ (BCS) ŞI TESTUL PROFILULUI METABOLIC

GERGÁCZ, Z., SZÜCS, E.

University of West Hungary, Faculty of Agricultural and Food Sciences Mosonmagyaróvár, Hungary

The aim of the study was to analyse the relationship between the body condition and the results of metabolic profile tests done in the milk (DIM) of dairy cows in different days. Moreover, critical points in the early pre- and postpartum period were also analysed. In the experiment, blood and urine samples were taken from 1984 clinically healthy cows (from 49 large scale dairy farms in Hungary), selected randomly from various groups of cows with different physiological stage of lactation and gestation, 3-5 hours after the morning feeding. During the experiment body condition scoring (BCS) was measured on 1-5 scale, as well. It was concluded, that the BCS (body condition score) decreased from the 1st day of lactation (3.48) onwards till the 44th day (2.65) and slightly increased till the day 218 (2.89). The haemoglobin value and the glucose concentration in blood samples were ranging within the physiological range and followed the tendency of BCS and the relationship between them and DIM was ($P<0.001$). There was a close negative correlation between the NEFA (non-esterified-fatty-acid) concentration in blood samples and BCS change and it was found that these values were significantly different ($P<0.01$) compared to the DIM. The aceto-acetic acid concentration exceeded the upper limit of the physiological range indicating hyperketonaemia at DIM 18. The AST (aspartate amino-transferase, liver-enzyme) activity value exceeded the upper limit of physiological range and followed the tendency of BCS change . The urea concentration in the blood exceeded the upper limit of the physiological range in all cows. The NABE (net acid-base empty) value in the urine samples indicated acid load in the first two groups) of samples (pre-, and post calving. During factor analysis I could differentiate three group factors and one individual. The most important factor is the acid-based factor (with urine pH and NEBA). The results of the present study also confirm that the body condition scoring is a reliable tool for revealing the risk of metabolic disorders caused by malnutrition.

Key words: cows, body condition score, days in milk, haemoglobin, glucose, NEFA, aceto-acetic acid, AST, blood and urine urea, NABE, urine pH

Introduction

It has been recognised that evaluation of body condition using Body Condition Score (BCS) is a useful management tool to assess body fat stores especially in Holstein dairy cows. The method is based on a visual and tactile appraisal of body fat reserves in the back and pelvic regions and BCS is usually scored on a scale of 1 to 5. (Edmonson et al., 1989). The BCS has been proposed to measure changes in body reserve as a result of negative energy balance (Berry et al., 2002).

Cows that are fat or over conditioned at calving may be at risk for lower yield and increased reproductive and health problems (e.g. Morrow, 1975).

As a rule, dairy cow has negative nutrient balance in the first weeks of lactation. After delivery the cow needs high amount of energy from body reserves, actually she is not able to cover the required nutrients consumed, the consequence of which is loss of body weight. According to Várhegyi (1999) the energy and protein requirement increases by four to ten times from the calving until the peak of lactation, respectively. In early lactation, the cows have to mobilize the energy and fat reserves to cover the energy needed for milk production. Reynolds and Beever (1995) showed that at average production body tissue mobilization supports about 7 kg of milk per day.

It is also known, that the high yielding dairy cow requires a great amount of glucose mainly to synthesize lactose, and for the synthesis of milk fat and to maintain the nervous system as well. For instance, a dairy cow producing 30-50 kg/day milk requires approximately 2.7-4.0 kg glucose daily (Tóth and Schmidt, 2004). On the other hand, Flachowsky and Lebzien (1997) reported that depending on the diet, no more than 0.5-1.0 kg glucose can be absorbed from the small intestine due to utilization of carbohydrates in the rumen by microbial fermentation. In addition, 520-540 g glucose is stored in the liver and blood plasma. Therefore, approximately 1.2-1.3 kg glucose needs to be synthesized by gluconeogenesis in a cow producing 30-50 kg milk/day (Schmidt et al. 2006).

Morrow (1976) reported that the consequence of rapid loss in condition after calving may account for risk factors for the cow's health status with simultaneous loss of feed intake, decrease of milk production and reproduction indices, especially in fat individuals. According to Gillaund et al. (2001) the healthy cows' body condition have been decreased steeply for 42 days, than it remained unchanged (does not decrease below 3 points). The condition of the cows in the ketogenic group decreased between days 0 and 90. Garnsworthy and Topps (1982) reported that cows starting the lactation with higher condition score loose relatively more points during lactation increasing the risk of ketosis.

High yielding dairy cows express more severe prolonged negative energy balance, which results in greater biological stress (e.g. Berry et al., 2002). This stress may impact upon the reproduction and immune systems leading to fertility and health problems during and beyond the negative energy balance period. Szücs et al. (2005) analysed the average body condition score over 12 measurements during the full lactation period and revealed actual differences among parities and revealed connection between BCS and reproductive performance. The lowest values for BCS were found in first calvers.

The reason is that excessive body condition may provide a risk factor for health problems and may influence feed intake and milk production. In addition, excessive body condition loss has been associated with lowered reproductive performance and dairy production. Thus, BCS has received considerable attention as a tool to aid management in dairy herds (Lowman et al., 1976; Wildman et al., 1982; Veerkamp et al., 1998). Body condition loss, as an indicator of energy balance, was used to study the impact of negative energy balance on stress symptoms, by correlating it to yield (Dechow et al., 2001), days of first insemination, services per conception, conception rate (Gillund et al., 2001) and oocyte development (Snijders et al., 2000)

Feeding errors induce subclinical/clinical metabolic disorders a couple of days/weeks prior to and especially after parturition with an increased rate of mortality, decreased production and reproduction failure (Brydl et al., 2007). Metabolic profiles have been used to predict periparturient problems and fertility, to diagnose metabolic disease, and to assess nutritional status (Carlem, 2005). Recently, a metabolism profile test has been elaborated by Brydl et al. (1987) that is being used in dairy farms.

Materials and Methods

Random samples were taken (N = 1984) in the morning by a veterinary surgeon from clinically healthy cows 3-5 hours after feeding; in the meantime I made the condition scoring in a 1-5 scale system.

Time periods devoted for sample taking and the group of cows:

- Preparatory/pre-fresh group, (1-14 days before expected calving)
- Newly calved cows in calving barn (1-6 days after calving)
- Reception/fresh group (7-30 days after calving)
- Group of cows providing high daily milk yield (31 days after calving).

The samples were analysed by the laboratory of the Department of Animal Hygiene of the Faculty of Veterinary Science of Budapest. The analysed parameters: haemoglobine, plasma aceto-acetic-acid, FFA/NEFA, AST, glucose and urea concentration, and urine pH, urea and NEBA values. The results were classified according to the average days of lactation (DIM): –12 (before calving), 3, 18, 44, 76, 104, 133 and 218 days. Brydl (2003) summarized the normal values (reference values) characterizing the metabolism of dairy cows. (The brown dotted lines are shown in the Figures also.) Blood: haemoglobin 5.0-7.9 mmol/l. Plasma: aceto-acetic acid <0.1 mmol/l; FFA <0.2mmol/l; AST<80U/l, glucose 3.0-3.9 mmol/l; blood urea, 3.3-3.5 mmol/l. Urine: pH 7.8-8.4; urine urea 130-300 mmol/l; NABE normal>+100 mmol/l, acid load 0-100 mmol/l, danger of metabolic acidosis<0 mmol/l. Energy metabolism was analysed by the measurement of blood glucose, aceto-acetic-acid and NEFA concentration. Subclinical fat mobilisation syndrome was monitored by NEFA and AST activity. Subclinical ketosis was diagnosed in blood samples by glucose and aceto-acetic-acid levels. Protein supply was analysed by determination of urea concentration in blood and urine samples. Subclinical acidosis was measured by the urinary pH and by the NABE concentration.

Data analysed were taken from “Riska” the database an ICT supported Dairy Operation Management System and representative data set recorded in the Hungarian National Milk Recording Scheme. Records were analysed by Software of Statistica-Release 7.0 Program Package Basic Statistics, ANOVA, Least Significant Differences.

Results and Discussion

Table 1 shows the main results of blood and urine samples. The results are in agreement with the findings of Gillaund et al. (2001); Szücs et al. (2005), because our curve of nadir of BCS (Figure 1) was in mean of lactation day 44, this BCS was 2,65. The mean of BCS in calving time was optimal, 3.48, but the recruitment passed very slowly, the BCS was only 2.89 in the last examined group. Practically the values of BCS were constant from 44 DIM to 133 DIM (2.65-2.69). This indicated that very difficult lift of the BCS in the top of lactation curve. The relationship between DIM and BCS showed strong correlation (P<0.001).

The parameters of *haemoglobin* (Figure 2) were followed the tendency of BCS. The nadir was group of mean of 44 milking day (5.58 mmol/l) these numbers were in accordance with the reference values. Interestingly, next to calving the value increased (6.54 mmol/l), after this period reduced to mean of 44 DIM, later lifted again. The nadir of haemoglobin and nadir of BCS were in same group (44 DIM). The haemoglobin values were significant associated with DIM (P<0.001). The importance of postpartum haemoglobinuria is low, generally high producing cows in lactations 3-6 are typical, the morbidity is not considerable (GrØneng, 2002).

The *glucose* (Figure 3) values signed negative energy balance in postpartum period. The glucose parameters recorded lower than 3 mmol/l in all groups after calving. The nadir of glucose (2.45 mmol/l) level was in 18 DIM group. In later groups the curve of glucose and BCS showed very similar picture. The glucose is under strict homeostatic control and is levated by many non-nutritional factors.

Table 1

Values of blood and urine samples

Item		**12 days prior calving**	**Days in milk**							**P**
			3	**18**	**44**	**76**	**104**	**133**	**218**	
BCS	**n**	**373**	**270**	**566**	**287**	**185**	**153**	**42**	**108**	
	X	**3.48**	**3.15**	**2.82**	**2.65**	**2.69**	**2.68**	**2.68**	**2.89**	***
	SE	0.025	0.029	0.020	0.029	0.036	0.039	0.075	0.047	
Haemoglobine mmol/l	X	**6.26**	**6.54**	**5.76**	**5.58**	**5.82**	**6.00**	**6.04**	**5.98**	***
	SE	0.044	0.052	0.036	0.050	0.062	0.069	0.131	0.082	
Glucose mmol/l	X	**3.50**	***2.92***	***2.45***	***2.64***	***2.68***	***2.73***	***2.74***	***2.80***	**
	SE	0.044	0.052	0.036	0.051	0.063	0.069	0.132	0.082	
Aceto-acetic acid, mmol/l	X	**0.061**	**0.092**	***0.108***	**0.070**	**0.072**	**0.061**	**0.056**	**0.065**	*
	SE	0.005	0.006	0.004	0.006	0.007	0.008	0.014	0.009	
NEFA/FFA mmol/l	X	**0.142**	***0.256***	***0.200***	**0.109**	**0.100**	**0.079**	**0.070**	**0.062**	**
	SE	0.006	0.007	0.005	0.007	0.009	0.010	0.019	0.012	
AST U/l	X	**68**	***109***	***91***	***80***	***82***	***84***	***101***	***104***	**
	SE	2.081	2.447	1.690	2.373	2.956	3.251	6.204	3.869	
Urea (blood) mmol/l	X	**4.38**	***5.71***	***5.50***	***5.91***	***6.19***	***6.61***	***6.67***	***6.16***	**
	SE	0.081	0.095	0.065	0.092	0.115	0.126	0.240	0.150	
Urea (urine) mmol/l	X	**193.3**	**234.5**	**251.5**	**242.0**	**261.6**	**280.3**	***304.8***	**259.8**	**
	SE	5.387	6.331	4.373	6.141	7.649	8.410	16.052	10.01	
pH (urine)	X	**8.3**	**8.3**	**8.4**	***8.6***	***8.5***	***8.6***	***8.5***	***8.6***	*
	SE	0.030	0.035	0.024	0.034	0.043	0.047	0.090	0.056	
NABE urine mmol/l	X	***80***	***85***	**111**	**141**	**151**	**143**	**134**	**151**	*
	SE	3.614	4.248	2.934	4.120	5.132	5.643	10.771	6.717	

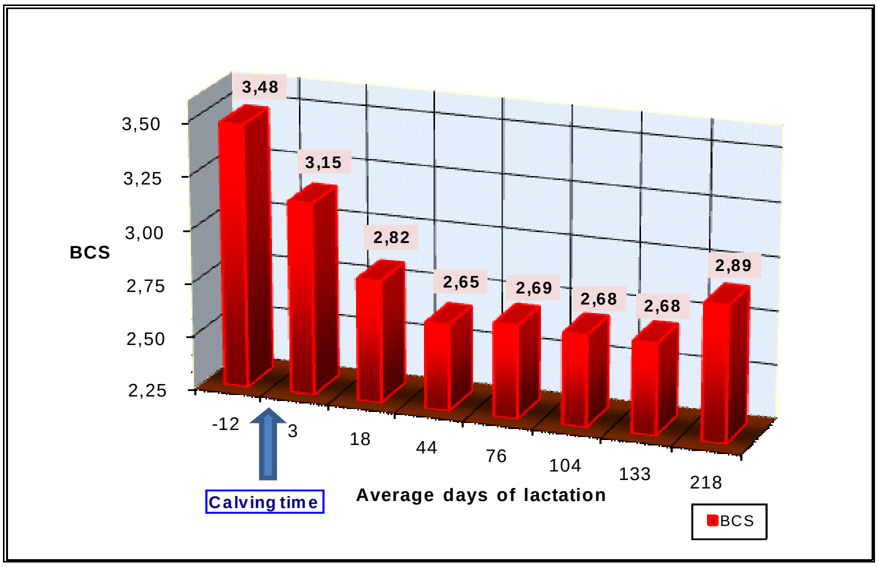

Figure 1. The BCS in plotted against average days of lactation

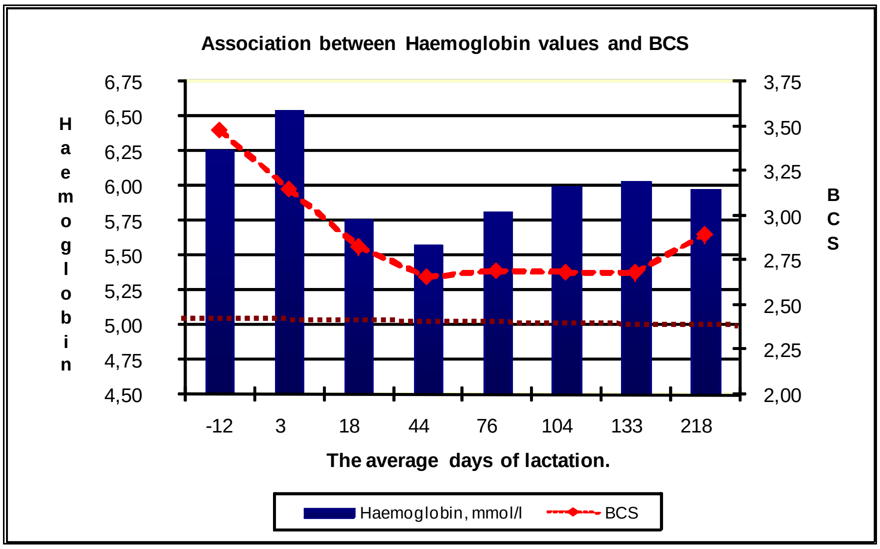

Figure 2. Association between haemoglobine values and BCS

Glucose is an essential metabolite for milk production, for the nervous system and development of the foetus. It can only be considered as an indicator of energy status in lactating or late-pregnant animals (Carlem, 2005). The glucose values were significant associated with DIM ($P<0.01$). When the keton bodies levelled too high into the blood it was marked by *aceto-acetic-acid* (Figure 4). It is in agreement with the used metabolic profile test. The parameters of aceto-acetic-acid registered the risk of ketosis in 18 DIM, the mean of values were higher than 0.1 mmol/l (hyperketonaemia). In accordance with other authors (Gillaund et al., 2001) it was noted that there is a negative correlation between aceto-acetic-acid and BCS. This parameter was interconnected with levels of low glucose, high NEFA and high AST. The problems were clearly caused by malnutrition. Feeding managements were responsible for the fact that cows could avoid the negative energy balance in their first lactation. The aceto-acatic-acid parameters significant connected with DIM (P≤0.05).

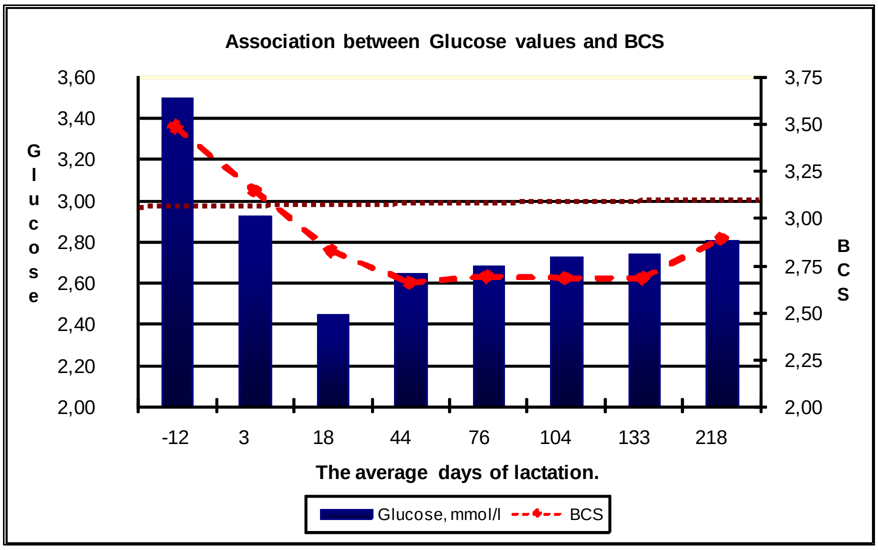

Figure 3. Association between Glucose values and BCS

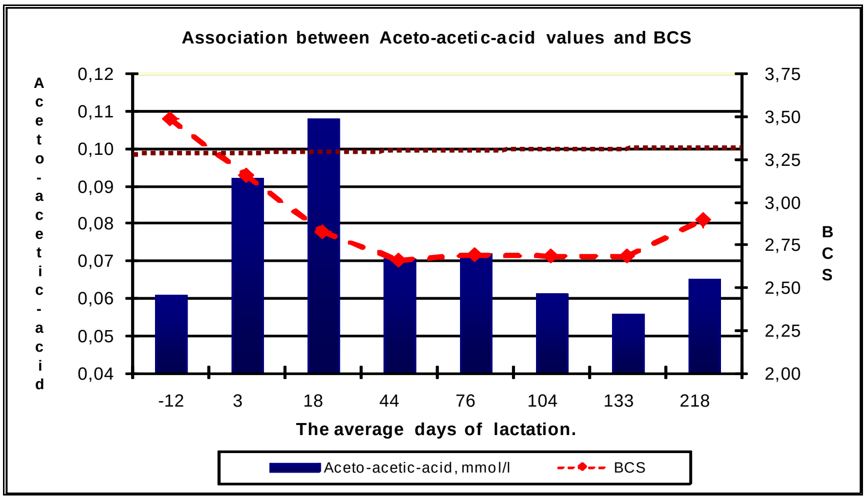

Figure 4. Association between Aceto-acetic-acid values and BCS

A high *NEFA* (Figure 5) concentration in the blood indicates excessive mobilization of body fat due to energy deficit. This can be a response to underfeeding, as the animal mobilises body reserves by hydrolysing the natural fat molecule (Carlem, 2005). In our study dates of NEFA registered too heavy fat mobilization before calving (3 and 18 DIM groups). In these two groups the NEFA values were equal or more than 0.2 mmol/l, that indicated considerable fat mobilisation and a risk of subclinical ketosis (Brydl et al., 2007). The top of NEFA value (0.256 mmol/l) showed fat mobilization disease on the first week postcalving. In the upstage feeding was inadequate in the precalving time caused very low dry matter intake after calving (Schmidt, 2003). The NEFA curve indicated negative correlation with curve of BCS in first lactation, but it was similar to the curve of glucose, aceto-acetic-acetate. The NEFA parameters are also significantly connected to DIM (P≤0.01).

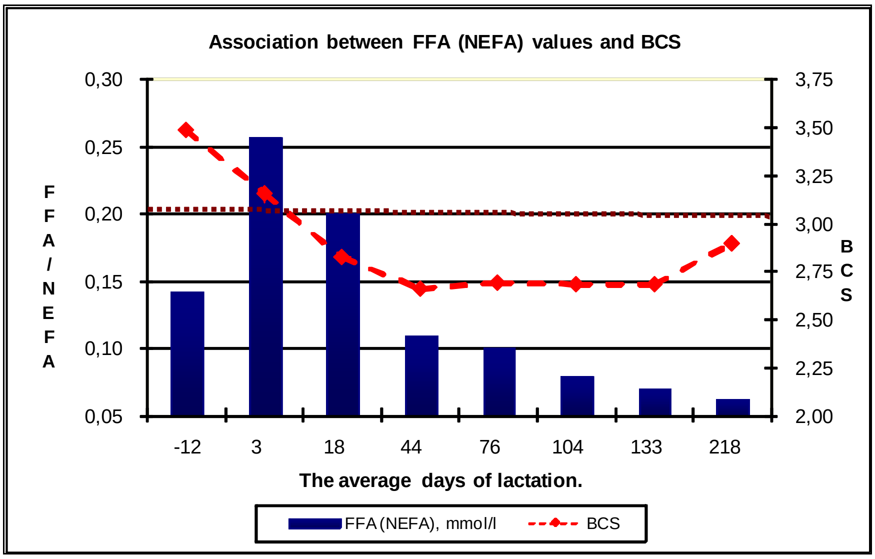

Figure 5. Association between NEFA/ FFA values and BCS

The *AST* activity value (Figure 6) exceeded the upper limit of physiological range in all postcalving groups and followed the tendency of BCS change. Based on the BCS chart we could expect these results. When cows lose heavily from their fat tissue (decrease of the BCS rapidly) we expected the injury of the liver tissue. This assumption was also verified in our experiments. The parameters of AST were above 80 U/l in all groups and these values showed intensive liver cell disintegration. The highest number was in the 3 DIM group (109 U/l). The unfair feeding management gave rise to high AST level in this period. Primarily, the rumen degradable protein (RDP) was overdosed and the blood urea gave extra loading for the liver. The AST values were significantlyDIM (P<0.01). The values of *blood urea* (Figure 7.) – except in pre-fresh group – were higher than 5.0 mmol/l (maximum physiological range) in all postcalving groups. It increased step by step from 44 DIM group (5.91 mmol/l) to 133 DIM group (6.67 mmol/l). The urea levels in the plasma are primarily derived from rumen ammonia, although a certain amount may also arise from the hepatic desamination of amino acids.

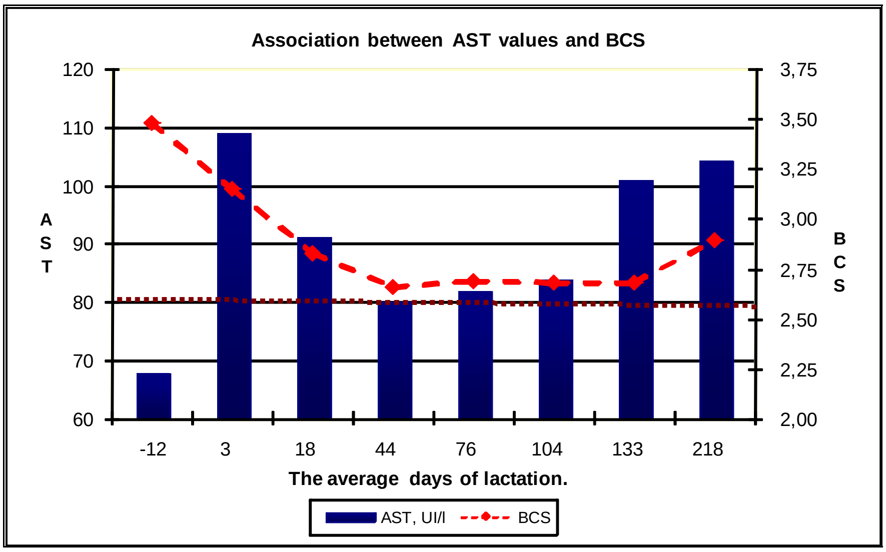

Figure 6. Association between AST values and BCS

There are many factors that can lead to an increased urea level, e.g.:

- increase in protein intake
- increased proportion of RDP in the ration, since this would result in a higher proportion of dietary protein being converted to ammonia
- decrease in energy intake, leading to depressed rumen microbial ammonia assimilation and an increased leakage of ammonia from the rumen.
- increased body tissue catabolism and/or renal failure, this is unlikely to occur on a herd basis.

Feeding high amounts of protein increases the concentration of nitrogenous compounds in blood and vaginal mucus. Urea has proved to be toxic to ova and sperm. It has also been reported that the increase in ammonia concentration can affect the immune system adversely (Targowski, 1983).

According to Sommer (1995) there is great correlation between the protein and energy the urea and cholesterol level in the blood. Our study was reflected on seriously protein overdosage practice in Hungary.

The connection between blood urea and BCS was not considerable, but there was significant correlation ($P<0.01$) between blood urea and DIM. The values of *urine urea* (Table 1) followed the blood urea tendency. The means of urine urea were higher than 300 mmol/litre (maximum of reference parameter) only in 133 DIM group (304.8

mmol/l). We did not find connection between urine urea and BCS, but there was significant difference between urine urea and DIM (P<0.01).

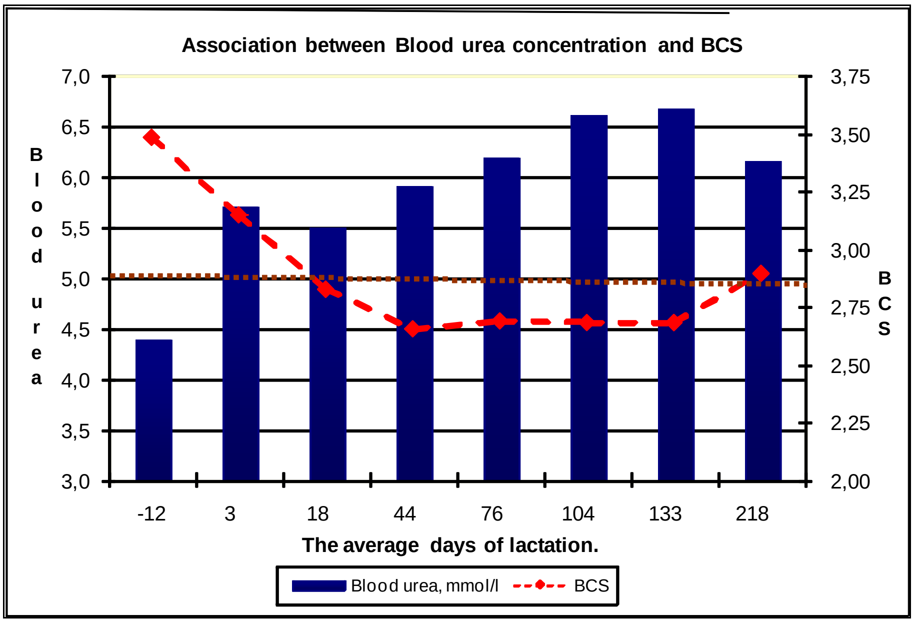

Figure 7. Association between Blood urea concentration and BCS

The values of *pH of urine* (Table 1) were in normal zone (7.8-8.4) in the first three groups, but the numbers indicated weak alcalosis after 44 DIM (pH=8.5 and 8.6). The values of urine pH can indicate two problems. The pH acid shift in the rumen (rumen acidosis) followed from the lack of fibre and the exaggerated concentrates. In practice, it is tried to avoid this by feeding chemical puffers – primarily sodium bicarbonate and magnesium oxide -, but in the case of the overdose the rumen pH does not stop in the optimal field and it can cause alkalosis. The values of pH of urine were mild significant connected with DIM (P≤0.05).

The parameters of *NABE* (Figure 8) showed acid loading in the prepartum period (80 mmol/l) and directly after calving (85 mmol/l). The acid loading in pre-fresh period was caused by inaccurate feeding with too high concentrate dozes. The high grain diets or diets with high ruminally degraded starch decrease rumen pH and modify composition of rumen micro-organisms or reduce dry matter intake of cows.

Moreover, these diets increase rumen propionate concentrations and decrease acetate to propionate ratio and fibre digestion or risk for rumen acidosis, which may lead to loss of appetite and the BSC loss, as well. An increase in the acid load (acidosis) may cause immunosuppression, which makes the cow more susceptible to multifactorial diseases like mastitis and interdigital dermatitis. Laminitis can also be a consequence of acidosis (GrØneng, 2002). The values of NABE showed mild significant connection with DIM (P≤0.05). During factor analysis I could differentiate three group factors and one individual. The demonstrated factors possess the following percentages from the total variance in sequence 1) 19,7 %; 2) 13,3 %; 3) 12,1 %; and 4) 11,6 % and they explain the changes of variance, i.e. 56,7% in the four factors altogether.

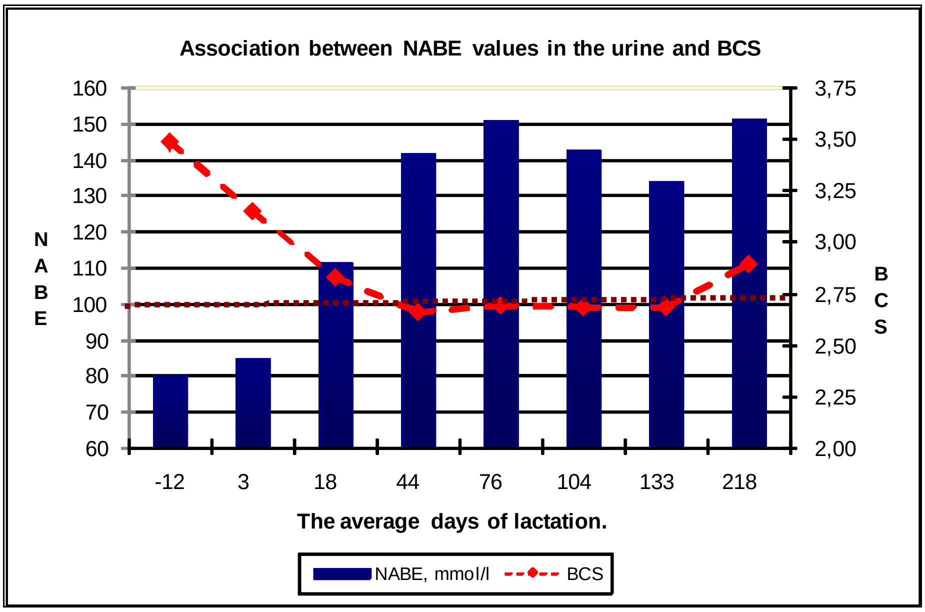

Figure 8. Association between NABE values in the urine and BCS

The four defined factors:

- The factor of acid-base balance (urine pH and NEBA): group factor
- The factor of protein supply (urea plasma and urine): group factor
- The factor of condition (BCS and haemoglobine): group factor
- The factor of liver functioning (AST): individual factor

The results of factor analysis statistically verify my practical observation that the rumen is extremely acidified by feeding even before and directly after calving. The falling pH of rumen liquid facilitates other harmful procedures.

Conclusions

To my mind among Hungarian feeding and breeding conditions, the decreasing BCS, compared to the calving conditions, should not exceed 0,83 score.
The trends of the changing values of hemoglobine, glucose, aceto-acetic-acid, NEFA and AST tightly follow the curve of condition change. According to our results validated may estimate the critical periods of lactation by the BCS and metabolic profile tests in high yielding dairy cows. The largest risks of diseases and economic damage were in first 50-60 DIM after calving. The normal rumen

functions and the harmonious nutriment supply according to the needs of the animals should be reinstated by optimizing the TMR formulas. The results of the study confirm that the body condition scoring is a reliable and cheap tool for revealing the risk of metabolic disorders caused by malnutrition.

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