RESEARCH ARTICLE

ARAŞTIRMA MAKALESİ

The Relationship Between Body Condition Scoring and Metabolic Profile in The High Yielding Dairy Cows

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Key Words
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SUMMARY

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 Holstein 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, as well. It was concluded, that the BCS 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 significant ($p<0.001$). There was a close negative correlation between the NEFA 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 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 value in the urine samples indicated acid load in the first two groups of samples (pre-, and post calving). According to the result of cluster analysis, relationship was found among the BCS, DIM, glucose, aceto-acetic acid and NEFA concentration in the blood. The results of the present study also confirm that the BCS is a reliable tool for revealing the risk of metabolic disorders caused by malnutrition.

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Yüksek verimli süt ineklerinde vücut kondüsyon skorlaması ile metabolic profil arasındaki ilişki

ÖZET

Bu çalışmanın amacı süt sığırlarında farklı günlerde sütte yapılan metabolik analiz sonuçları ile vücut kondüsyonu arasındaki ilişkiyi incelemelti. Ayrıca erken pre- ve postpartum periyotlardaki kiritik noktalar değerlendirildi. Araştırmada sabah yemlemeden 3-5 sonra rastgele seçilen farklı gruplarda fizyolojik laktasyon ve gestasyon safhalarında olan klinik bakımdan sağlıklı olan 1984 adet inekten (Macaristan'da 49 büyük Holştayn süt çiftliklerinden) kan ve sidik örnekleri alında. Çalışma süresince vücut kondüsyon skoruda (BCS) ölçüldü. Sonuç olarak, BCS'u laktasyonun 1. gününden (3.48) 44. gününe (2.65) kadar azalma eğilimi ve 218. gününe (2.89) kadar hafif artış gösterdi. Kandaki hemoglobin değeri ve glukoz konsantrasyonu fizyolojik sınırlar içerisinde seyir etti ve BCS ile bunlar ve DIM arasında takib eden ilişki anlamlıydı ($P<0.001$). kan örneklerinde ki NEFA ile BCS değişiminde negatif bir ilişki vardı ve bu değerler DIM'le karşılaştırıldığında anlamlı derecede farklıydı ($p<0.01$). Asetoasetik asit konsantrasyonu üst fizyolojik sınırları aştı buda DIM 18'de hiperketoneminin belirtisidir. AST üst fizyolojik sınırları aştı ve BCS değişimine benzer eğilim gösterdi. Üre konsantrasyonu tüm sığırlarda üst fizyolojik değerleri aştı. Sidikte NABE değeri ilk iki grupta asit yüklenmesini gösterdi (doğum öncesi ve sonrası). Cluster analizine göre, kanda BCS, DIM, glukoz, asetoasetik asit ve NEFA konsantrasyonları arasında ilişki olduğu tespit edildi. Bu çalışmanın bulguları ayrıca malnutrisyondan kaynaklanan metabolik bozukluk risklerinin ortaya çıkarılmasında BCS'nin güvenilir bir araç olduğunu gösterdi.

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.[1] This method has become widespread in Hungary also. The BCS has been proposed to measure changes in body reserve as a result of negative energy balance.[2]

Negative energy balance (NEBAL) is a frequent condition occurring in high producing dairy cows some days after calving. It consists of an imbalance between diet energy supply and production requirements.[3] Most cows enter NEBAL after parturition and this is a normal mammalian adaptation to lactation. Peak milk production may occur when cows are in NEBAL.[4] Increased energy demands to support lactation, coupled with lowered feed intake capacity results in NEBAL and is typically characterized by extensive mobilization of body energy reserves in the early postpartum dairy cow. The catabolism of stored lipid leads to an increase in the systemic concentrations of non-esterified fatty acids (NEFA) also.[5] This metabolite has negative effect on the ovarian and follicles activity.[6]

Metabolic and reproductive disorders in dairy cows in early lactation have been allocated to a negative energy status, resulting from a genetic potential for high milk production accompanied by a delay in feed intake peripartum.[7]

Cows that are fat or over conditioned at calving may be at risk for lower yield and increased reproductive and health problems.[(8,9)]

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[10] 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[11] 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.[12] On the other hand, Flachowsky and Lebzien[13] 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.[14]

A number of authors consider 42-55 kg per condition unit as average bodyweight change in Holstein-Friesian dairy cows.[15,16] Domecq et al.[17] concluded that lowest BCS occurred between week 4 and 8 of the lactation; mean BCS increased after week 8 for multiparous cows. Mean loss of BCS in the 1st month of the lactation was 0.62. The pattern of BCS for primiparous cows was similar, but did not drop as low as the BCS of multiparous cows.

Morrow[9] reported already 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.[18] 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.

High yielding dairy cows express more severe prolonged negative energy balance, which results in greater biological stres.[2] This stress may impact upon the reproduction and immune systems leading to fertility and health problems during and beyond the negative energy balance period. Szűcs et al.[19] 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 primiparouses. Overall condition of cows improved after the second calving and they attained maturity level in the 3rd and 4th parity. Smallest change of condition was found in the first parity, intermediate in the 2nd and 3rd parity and largest in the 4th parity. BCS from delivery until drying off of cows reflects inverse shape of daily milk yield. This study showed that cows with overall low body condition during lactation tend to conceive earlier post partum than their counterparts being over conditioned. Animals with a high body condition score both at parturition and in midlactation phase or even prior to drying off tend to have significant increase in days open and conception rate is higher as compared to animals with an intermediate or low body condition.

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.[20,21] 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[22], days of first insemination, services per conception, conception rate[(18)] and oocyte development.[23]

Feeding errors (low dry matter intake in early lactation, inadequate energy and protein supply or insufficient fibre intake which causes subclinical acidosis) 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.[24] In dairy cows performance, well being and health status are also influenced by various biometeorological factors.[25,26,27]

Metabolic profiles have been used to predict periparturient problems and fertility, to diagnose metabolic disease, and to assess nutritional status.[28] Recently, a metabolism profile test has been elaborated by Brydl et al.[29] that is being used in dairy farms in Hungary as monitoring system of feeding and animal health status. Brydl[30] 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; NEFA <0.2mmol/l; AST<80U/l, glucose 3.0-3.9 (>2.3) mmol/l; blood urea, 3.3-3.5 mmol/l. Urine: pH 7.8-8.4; urine urea 130-300 mmol/l; NABE (Net Acid-Base Empty) normal>+100 mmol/l, acid load 0-100 mmol/l, danger of metabolic acidosis<0 mmol/l.

MATERIALS and METHODS

Blood samples (N = 1984) were taken from clinically healthy, high yielding Holstein cows, randomly selected animals divided into different physiological groups by reproduction stages of lactation (1-14 days before calving, 1-30 after calving, and older than 30 days after calving). Samples were taken by a veterinary surgeon (in tube contained heparin) after the morning feeding in the 3-5 hours. Body condition was evaluated on a 5 point scale developed by Ferguson et al.[31]

The samples were analysed by the laboratory of the Department of Animal Hygiene of the Faculty of Veterinary Science of Szent István University. The analysed parameters: haemoglobine, plasma aceto-acetic acid, NEFA**,** AST, glucose and urea concentration**,** and urine pH, urea and NEBA values. The results were classified according to the average days of lactation (TNSZ): –12 (before calving), 3, 18, 44, 76, 104, 133 and 218 days.

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

Table 1 shows the main results of blood and urine samples.

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, it later lifted again. The haemoglobin values were significant associated with DIM (P<0.001).

The ***glucose*** (Figure 3)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 values were significant associated with DIM (P<0.01).

The parameters of ***aceto-acetic-acid*** (Figure 4) registered the risk of ketosis in 18 DIM, the mean of values were higher than 0.1 mmol/l (hyperketonaemia). It is clear that the more frequently used in the BHBA, but this opportunity provided by the laboratory. The aceto-acatic-acid parameters significant connected with DIM (P≤0.05).

In our study dates of ***NEFA*** (Figure 5) 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. 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).

The parameters of ***AST*** (Figure 6) 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 AST values were significantly related to DIM (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 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).

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 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 values of NABE showed mild significant connection with DIM (P≤0.05).

DISCUSSION

Our results are in agreement with the findings of Domecq et al.[17]; Gillaund et al.[18]; Szűcs et al.[19], because our curve of ***nadir of BCS*** (Figure 1.) was in mean of lactation day 44, this BCS was 2,65.

The nadir of ***haemoglobin*** and nadir of BCS were in same group (44 DIM). The importance of postpartum haemoglobinuria is low, generally high producing cows in lactations 3-6 are typical, the morbidity is not considerable.[32]

The ***glucose*** (Figure 3) values signed negative energy balance in postpartum period. The glucose is under strict homeostatic control and is elevated by many non-nutritional factors. Glucose is an essential metabolite for milk production[(14)], for the nervous system and development of the foetus.[(3)] It can only be considered as an indicator of energy status in lactating or late-pregnant animals.[28]

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.

In accordance with other authors[18] 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.

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.[28] The too high NEFA values indicated considerable fat mobilisation and a risk of subclinical ketosis.[24,8] The top of NEFA value (0.256 mmol/l) showed fat mobilization disease on the first week post calving. In the upstage feeding was inadequate in the precalving time caused very low dry matter intake after calving.[33,34]

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 unfair feeding management gave rise to high AST level in more periods. Primarily, the rumen degradable protein (RDP) was overdosed and the blood urea gave extra loading for the liver.

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. 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. (32)

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.[35]

Our study was reflected on seriously protein overdosage practice in Hungary.

The values of ***urine pH*** (Table 1) 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 ***acid loading (NABE)*** 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.[32]

According to our results ***critical periods of lactation*** *have been established by 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* ■■■

Table 1. Values of blood and urine samples
Çizelge 1. Kan ve sidik örnek değerleri

Items		Days in milk (DIM): 12 days prior to delivery	3	18	44	76	104	133	218	P
N		373	270	566	287	185	153	42	108	
BCS	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	
Haemoglobin 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	2,81	**
	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 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	2,082	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	193,31	234,46	251,49	242,97	261,63	280,33	304,81	259,80	**
	SE	5,387	6,331	4,373	6,141	7,649	8,41	16,052	10,011	
pH (urine)	x	8,26	8,29	8,43	8,59	8,55	8,61	8,48	8,63	*
	SE	0,03	0,035	0,024	0,034	0,043	0,047	0,090	0,056	
NABE (urine) mmol/l	x	80,34	84,95	111,47	141,49	150,70	142,63	133,76	151,27	*
	SE	3,614	4,248	2,934	4,120	5,132	5,643	10,771	6,717	

(***) P<0.001, (**) P<0.01, (*) P<0.05, (+) P<0.10, (NS) P>0.10

Figure 1. The BCS in plotted against average days of lactation
Şekil 1. *BCS ile ortalama laktasyon günleri arasındaki ilişki*

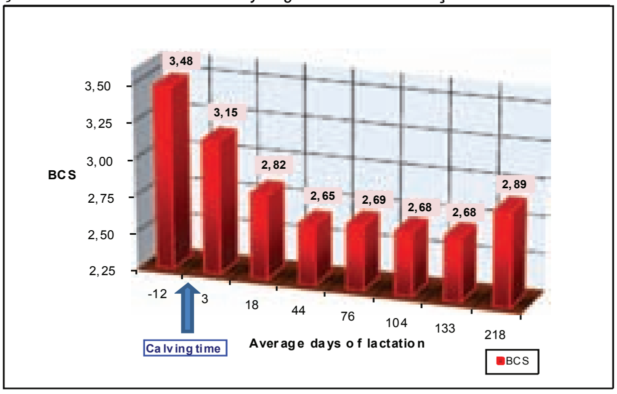


Figure 2. Association between Haemoglobin values and BCS
Şekil 2. *Hemoglobin değerleri ile BCS arasındaki ilişki*

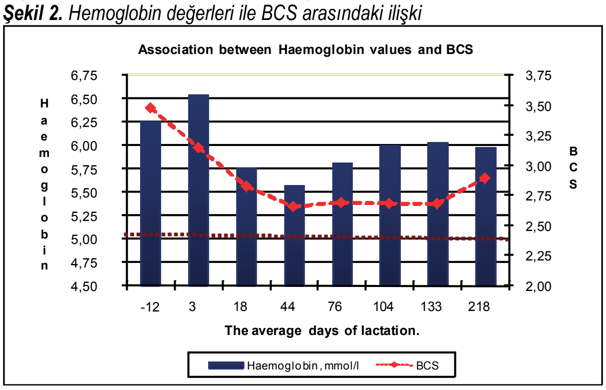


Figure 3. Association between Glucose values and BCS
Şekil 3. *Glukoz değerleri ile BCS arasındaki ilişki*

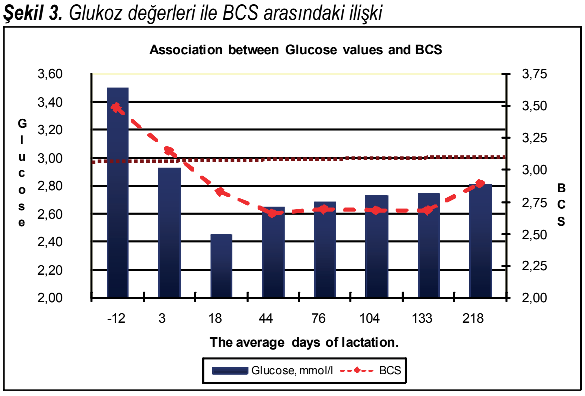


Figure 4. Association between aceto-acetic-acid values and BCS
Şekil 4. *Aseroasetik asit değerleri ile BCS arasındaki ilişki*

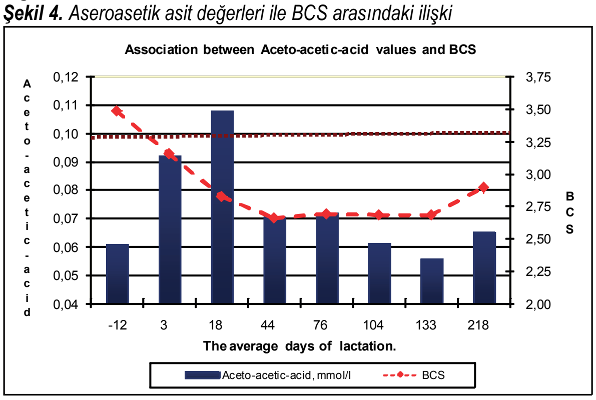


Figure 5. Association between FFA/NEFA values and BCS
Şekil 5. *FFA/NEFA değerleri ile BCS arasındaki ilişki*

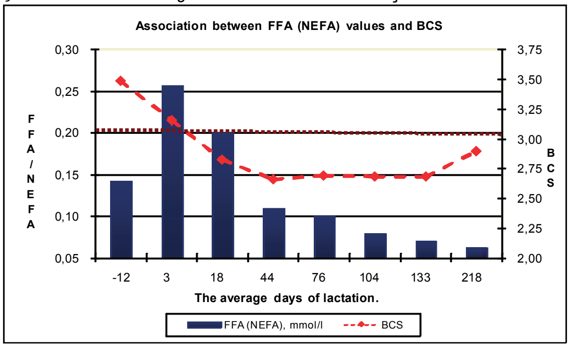


Figure 6. Association between AST values and BCS
Şekil 6. *AST değerleri ile BCS arasındaki ilişki*

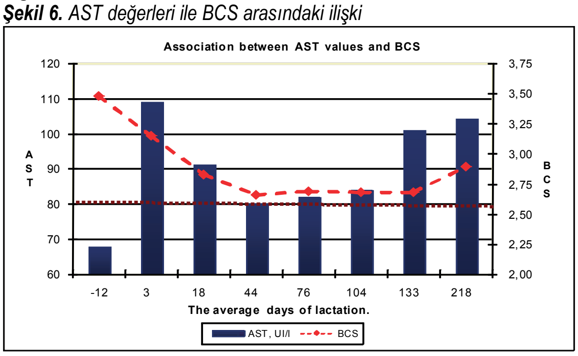


Figure 7. Association between Blood urea concentration and BCS
Şekil 7. *Kan üre konsantrasyonu ile BCS arasındaki ilişki*

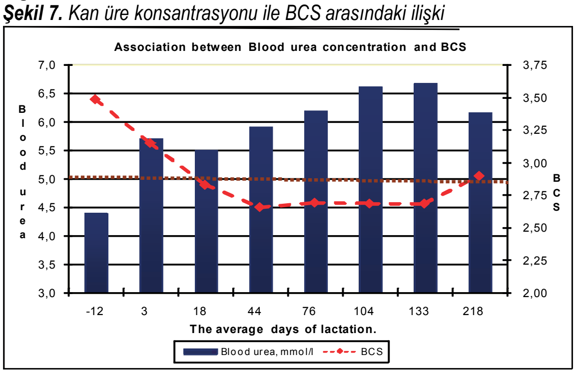
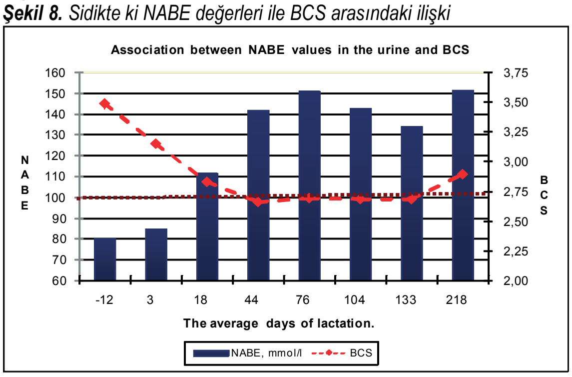


Figure 8. Association between NABE values in the urine and BCS
Şekil 8. *Sidikte ki NABE değerleri ile BCS arasındaki ilişki*



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