Changes of the Blood Composition of Periparturient Cows in Relation to Time of Day

T. Toharmat[1], I. Nonaka[2], M. Shimizu[3] and S. Kume*
Hokkaido National Agricultural Experiment Station, Sapporo 062-8555, Japan

ABSTRACT : In order to determine the appropriate sampling time for blood metabolites of periparturient cows, the changes of the blood composition in relation to time of day were evaluated in sixteen multiparous Holstein cows at 1 wk prepartum, 1 and 6 d postpartum. Blood samples were collected at 08:30, 10:00, 15:30 and 17:00 h in each sampling day, and the sampling times at 08:30 and 15:30 h were prior to feeding. The rectal temperature of cows increased gradually from 08:30 to 17:00 h, but blood Hct and Hb decreased constantly. Plasma non-esterified fatty acid (NEFA) concentration at 08:30 h was two-fold higher than those at 10:00, 15:30 and 17:00 h from 1 wk prepartum to 6 d postpartum, and the value was maximum at 1 d postpartum. The highest plasma urea-N was observed at 10:00 h from 1 wk prepartum to 6 d postpartum. Plasma glucose and total protein were not affected by sampling time. The data indicated that blood samples of periparturient cows should be collected before morning feeding for the diagnosis of energy status, because plasma NEFA was the highest before morning feeding. (*Asian-Aus. J. Anim. Sci. 1999. Vol. 12, No. 7 : 1111-1115*)

Key Words : Blood Composition, Sampling Time, Periparturient Cows, Diurnal Variation

INTRODUCTION

Some aspects of the health of cows in dairy herds can be monitored by an assessment of their ability to maintain normal blood metabolites. Variation in blood composition with time of day need to be taken into account in establishing normal ranges, because any variation which might occur would be a potential source of error in metabolic profile testing in beef cattle (Coggins and Field, 1976). Marked diurnal variation was observed in plasma NEFA, glucose and urea-N of lactating cows (Sato et al., 1984).

The transition from nonlactating to lactating status imposes enormous stress on dairy cows and may impair herd health (Grant and Albright, 1995; NRC, 1989). Failure to adequately meet the substantial nutrient requirements during the late pregnancy and early lactation can result in early postpartum health problems, such as ketosis, fat cow syndrome and milk fever (NRC, 1989). Blood NEFA and ketones are elevated, and blood glucose is depressed in ketotic cows (NRC, 1989; Veenhuizen et al., 1991). In our previous experiments, restricted feed intake of periparturient cows decreased blood hematocrit (Hct) and hemoglobin (Hb) of cows and their calves during cool season, and the decreased feed intake depressed plasma glucose and protein of periparturient cows, but plasma NEFA was elevated (Kume et al., 1998; Toharmat and Kume, 1996 and 1997; Toharmat et al., 1998).

Early detection of metabolic disorders is important to maintain the health of dairy herd. The blood constituent value for metabolic profile test is usually based upon the value at the same stage of lactation, in the same herd and sampled at the same time and on the same day (Manston et al., 1981). The assessment of within-day variation in the blood composition of periparturient cows was necessary to determine its contribution as a source of error in metabolic profile testing. However, data on diurnal variation of blood metabolites in periparturient cows have not been well clarified. The objective of this study was to clarify the diurnal changes of the blood metabolites of periparturient cows in order to assess the appropriate sampling time for the blood metabolites of periparturient cows.

MATERIALS AND METHODS

Sixteen multiparous Holstein cows which calved from July to December 1996 at National Institute of Animal Industry were used as previously reported (Toharmat et al., 1998). The cows were kept in individual tie stalls and paddock. Feeding level met the maintenance plus last 2 months of gestation requirement of TDN (MP) or 1.2 times of MP level (HMP) during hot and cool weather (AFFRCS, 1994). The cows were fed at 08:30 and 15:30 h in equal amount for 4 wk before the expected calving date, assuming that the gestation length to be 280 d. Each cow was milked at 08:30 and 15:30 h postpartum.

Blood was sampled via jugular vein puncture into heparinized vacuum tubes at 08:30 and 10:00, 15:30 and 17:00 h at 1 wk before expected calving date, and 1 and 6 d after parturition. The sampling times at

* Address reprint request to S. Kume.
[1] Bogor Agricultural University, Indonesia.
[2] National Institute of Animal Industry, Japan.
[3] Fukui Prefectural Animal Experiment Station, Japan.
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08:30 and 15:30 were prior to feeding or milking. Blood Hct and Hb (Kume and Tanabe, 1993); glucose, NEFA, plasma total protein, and urea-N (Toharmat et al., 1998) were determined as previously described. Rectal temperature was measured before blood sampling.

The general linear models procedure of SAS (1998) was used to analyze the effect of sampling time. Rectal temperature and blood composition were analyzed by least squares ANOVA using the general linear models procedure of SAS (1998). The model was as follows:

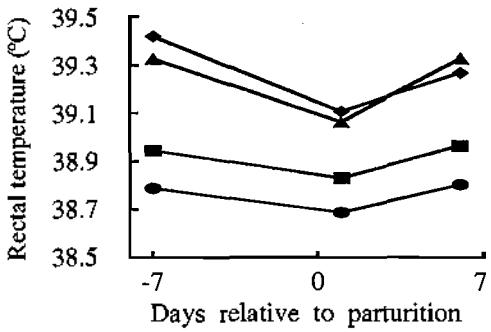
$$Y_{ijklm} = \mu + S_i + T_j + ST_{ij} + C_{(ij)k} + D_l + SD_{il} + TD_{jl} + H_m + SH_{im} + TH_{jm} + DH_{lm} + e_{ijklm}$$

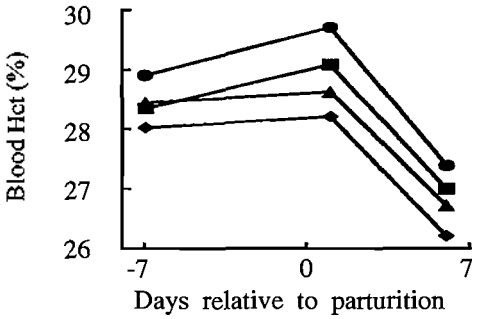
μ = overall mean,
S_i = effect of season,
T_j = effect of TDN level,
$C_{(ij)k}$ = cows, nested in season and TDN level,
D_l = effect of sampling day,
H_m = effect of sampling time,
ST_{ij}, SD_{il}, TD_{jl}, SH_{im}, TH_{jm}, DH_{lm} = interactions, and
e_{ijklm} = residuals.

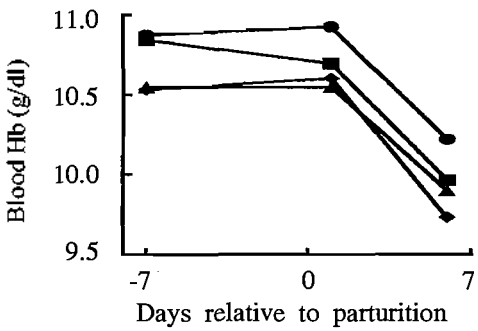
The ANOVA was performed, and the difference was tested by least significant difference. Significance was declared at $p<0.05$ unless otherwise noted.

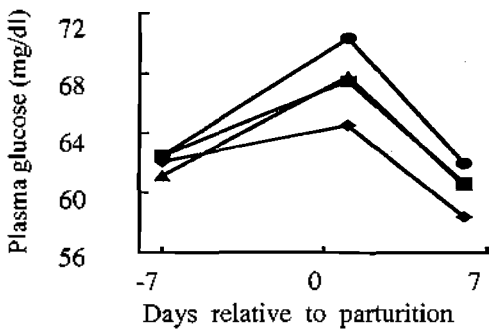
RESULTS AND DISCUSSION

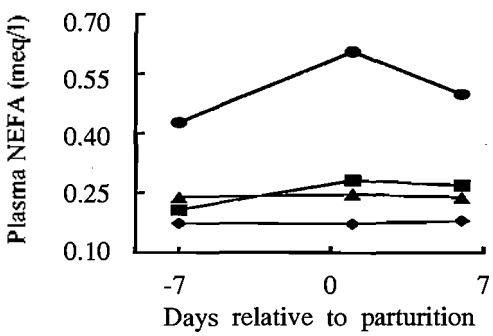
Rectal temperature of periparturient cows increased ($p<0.001$) gradually from 08:30 to 17:00 h during 1 wk prepartum and 6 d postpartum, but blood Hct ($p<0.001$) and Hb ($p<0.01$) decreased constantly (table 1). The rectal temperature was the lowest ($p<0.001$) at 1 d postpartum (figure 1), but the lowest blood Hct ($p<0.001$) and Hb ($p<0.001$) were observed at 6 d postpartum. Although plasma glucose was not affected by sampling time, plasma glucose of cows at 08:30 h was higher ($p<0.05$) than that at 17:00 h at 1 d postpartum. Plasma glucose increased ($p<0.001$) dramatically at 1 d postpartum. Plasma NEFA before morning feeding at 08:30 h from 1 wk prepartum to 6 d postpartum was consistently higher ($p<0.001$) than those after morning feeding and the value was the highest ($p<0.001$) at 1 d postpartum. The values in plasma NEFA at 10:00, 15:30 and 17:00 h were almost constant from 1 wk prepartum to 6 d postpartum. Plasma protein was not affected by sampling time, and plasma protein increased ($p<0.001$) at 6 d postpartum. Plasma urea-N at 10:00 h was consistently higher ($p<0.001$) than those at 08:30, 15:30 and 17:00 h from 1 wk prepartum to 6 d postpartum, and the value decreased ($p<0.001$) at 6 d postpartum.











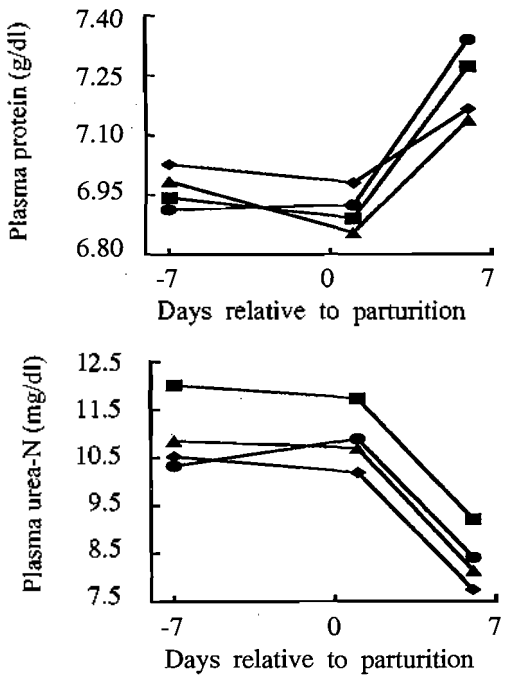


Figure 1. Rectal temperature and blood metabolites of periparturient cows at 08:30 h (●), 10:00 h (■), 15:30 h (▲) and 17:00 h (◆). Blood samples were collected from 16 and 15 cows at prepartum and postpartum periods, respectively, because one cow fed at HMP level had dystocia.

In the diagnosis of metabolic problems in dairy herds, the blood samples are usually collected from cows, but the values in blood constituents often vary with the time of day (Coggins and Field, 1976; Sato et al., 1984). Additionally, it is difficult to take blood samples of cows at same time on the same day during periparturient period in dairy farms, because the sampling time is changed by available technician or local veterinary surgeon. The assessment of within-day variation in the blood metabolites of periparturient cows is necessary to reduce misinterpretation of metabolic disorders by the abnormal blood metabolite concentrations.

The concentrations of plasma NEFA and glucose are good indicators of energy status of cows (Bowden, 1971). Under conditions of nutritional stress, plasma NEFA of lactating cows was influenced by sampling time (Fisher et al., 1975). In the present experiment, the plasma NEFA before morning feeding was two-fold higher than those of other sampling time from 1 wk prepartum to 6 d postpartum. The high plasma NEFA in these cows before the morning feeding agreed with the findings of previous researchers (Coggins and Field, 1976; Sato et al., 1984), which showed that plasma NEFA of lactating cows was higher before morning feeding. Plasma glucose was highest before morning feeding in lactating dairy and beef cows (Coggins and Field, 1976; Sato et al., 1984). In the present study, the high blood glucose before morning feeding was observed only at 1 d postpartum, although the discrepancy of blood glucose was small in relation to the time of day.

The concentrations of plasma NEFA and glucose increased dramatically around parturition, and the reduced feed intake enhanced plasma NEFA in relation to the decreased plasma glucose (Bell, 1995; Grummer, 1995; Toharmat et al., 1998). Morrow (1976) suggested that the normal concentration of blood NEFA of cows is 0.26 mEq/l. However, the mobilization of NEFA from adipose tissue after calving can result in an increased in plasma NEFA to as high as 1 mEq/l (NRC, 1989; Veenhuizen et al., 1991). Because a high increase in plasma NEFA may lead to fat cow syndrome or ketosis, the diurnal maximum values of plasma NEFA are needed for an accurate diagnosis of energy status. Thus, blood samples of periparturient cows should be collected before morning feeding for the diagnosis of energy

Table 1. Diurnal changes[1] of rectal temperature, glucose, NEFA, plasma protein and urea-N of periparturient cows

	Sampling time				SE	Time effect
	08:30 h	10:00 h	15:30 h	17:00 h		
Rectal temperature, ℃	38.76^{c}	38.91^{b}	39.23^{a}	39.26^{a}	0.02	***
Blood						
Hct, %	28.65^{a}	28.13^{b}	27.88^{bc}	27.46^{c}	0.09	***
Hb, g/dl	10.66^{a}	10.50^{ab}	10.31^{bc}	10.28^{c}	0.04	**
Plasma						
Glucose, mg/dl	65.11	63.66	63.14	61.50	0.61	NS
NEFA, mEq/l	0.51^{a}	0.25^{b}	0.24^{b}	0.17^{c}	0.01	***
Protein, g/dl	7.06	7.04	6.99	7.06	0.02	NS
Urea-N, mg/dl	9.87^{b}	10.95^{a}	9.87^{b}	9.47^{b}	0.14	**

[1] Means from 1 wk prepartum to 6 d postpartum. ** $p<0.01$; *** $p<0.001$.
[a,b,c] Means within same row with different superscript letters differ ($p<0.05$).

status.

Plasma urea-N, albumin and blood Hb have been suggested to indicate the protein status of lactating cows (Rowlands et al., 1974). In the present experiment, the highest plasma urea-N concentration was observed after morning feeding at 10:00 h from 1 wk prepartum to 6 d postpartum. The blood Hct and Hb of periparturient cows decreased gradually from 08:30 to 17:00 h, but the plasma protein was not influenced by sampling time. The rise in plasma urea-N after morning feeding agreed with the previous result in lactating cows, which showed that the plasma urea-N increased 2-4 h after morning feeding and it declined gradually to minimum value at midnight (Gustafsson and Palmquist, 1993; Sato et al., 1984). Plasma urea-N varied with time of day, and the time of occurrence of highest plasma urea-N after feeding was influenced by dietary protein level (Coggins and Field, 1976; Thornton, 1970).

Blood urea-N concentrations of lactating and non-lactating dairy cows from 9.5 to 19.5 mg/dl were suggested to be the normal range (Rowlands et al., 1974). The blood urea-N of greater than 8 to 10 mg/dl is required to maximize organic matter digestion, but the values of greater than 19 to 20 mg/dl in early postpartum decrease pregnancy rate (Butler et al., 1996; NRC, 1989). The blood urea-N should be in an optimum range and the reduction of detrimental effect of urea-N in early postpartum is required to optimize milk production and reproduction of the cows. Because the low protein intake decreased blood urea-N of periparturient cows (Carroll et al., 1988), the low plasma urea-N in the present study may be due to the low protein intake.

The changes of plasma NEFA and urea-N of periparturient cows in relation to the time of day as well as days around parturition are important factors for interpretation of the nutritional status. Plasma NEFA concentration of periparturient cows before morning feeding showed an accurate result in diagnosis of energy status of periparturient cows, because plasma NEFA was two-fold higher before morning feeding in the present experiment. However, the highest plasma urea-N concentration was observed after morning feeding and no metabolic disorders were detected in the present experiment. Further study is needed to clarify the changes in blood metabolites of periparturient cows with time of day in relation to the onset of metabolic disorders.

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