African Journal of Dairy Farming and Milk Production ISSN 2375-1258 Vol. 4 (4), pp. 001-007, April, 2017. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

A field study on negative energy balance in periparturient dairy cows kept in small-holder farms: Effect on milk production and reproduction

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Accepted 21 November, 2016

Impact of negative energy balance (NEB) and its consequences on milk production and reproduction were studied in 51 dairy cows. All cows were randomly selected from 11 small-holder farms according to their calving date during December 2006 to May 2007. Body condition score and milk yield were recorded. Blood samples were collected from all cows at 2 weeks before expected calving date and at 2 and 4 weeks after calving to determine glucose, nonesterifed fatty acids, triacylglycerol, cholesterol and urea nitrogen concentrations. Postpartum reproductive activities were also recorded. Results showed that dairy cows in this study had significantly lower serum glucose and triacylglycerol, and significantly higher serum of non-esterified fatty acids concentrations after parturition. Cows also lost their weights during postpartum period as compared with prepartum period. Results indicated that these cows suffered from NEB. The average milk yields during 16 weeks of lactation did not show the peak of yield. Pregnancy rates of these cows were 28.6, 11.1, and 12.0% for first, second, and third artificial insemination. In conclusion, these dairy cows went into a periparturient NEB period, and its consequences on suboptimal milk yields and lower conception rates were observed. Prevention of the adverse effects of NEB and its consequences would result in an increase of performance of dairy cows raised in small-holder farms.

Key words: Dairy cow, milk yield, negative energy balance, reproduction.

INTRODUCTION

It is well-known that dairy cows usually suffer from a negative energy balance (NEB) in periparturient period due to increased energy requirements and physical-endocrinological changes during that period (Harrison et al., 1990). Cows with NEB increase mobilization of body energy reserves, mainly glycogen, fat and protein to compensate for their energy needs (Rukkwamsuk et al., 1999). Increased lipolysis causes an elevation of blood non-esterified fatty acids (NEFA) concentrations (Rukkwamsuk et al., 1998), which may result in fatty liver and ketosis (Bruss, 1993). Combination of NEB, increased lipolysis and fatty liver is associated with suboptimal milk production, poor health condition and reproductive disorders in postparturient dairy cows (Gerloff et al., 1986; Wentink et al., 1997; Jorritsma et al., 2005).

In Thailand, most dairy cows are raised in small-holder farms, which are not well-managed in terms of nutrition and herd health management. Therefore, Thai dairy cows kept in small-holder farms have confronted several health problems including clinical and subclinical mastitis, blood parasites, reproductive disorders, respiratory problems, lameness and hoof problems (Poolket et al., 2000). However, suboptimal reproductive performances of post-parturient dairy cows were reported in Thai cross-bred Holstein-Friesian cows, particularly raised in small-holder farms (Yawongsa et al., 2003). These problems are likely related to periparturient NEB and its consequences. Evidence exists that dairy cows raised in small-holder farms had lowered blood glucose concentrations after calving and lost their body condition scores during the first month of lactation (Rukkwamsuk et al., 2006). This

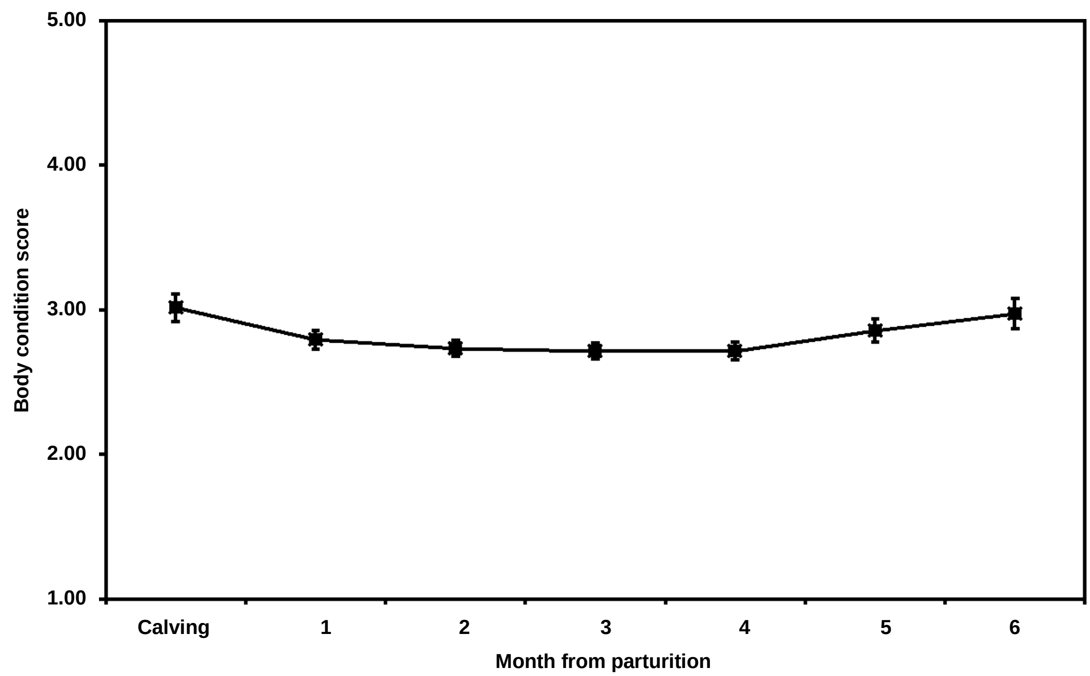

Figure 1. Average body condition scores of 51 dairy cows during 6 months postpartum. Data represent means and SD as error bars.

result suggested that NEB was also inevitable in Thai dairy cows during the periparturient period. Another study in Thailand showed that 68% of periparturient dairy cows in a commercial dairy farm suffered from fatty liver (Rukkwamsuk et al., 2004). The objective of the study is to investigate the impact of NEB and its consequences on production and reproduction of periparturient dairy cows.

MATERIALS AND METHODS

Animals and farm management

Fifty-one dry cross-bred Holstein-Friesian cows from 11 small-holder farms in Kamphaengsaen, Nakhonpathom were randomly selected according to their calving date during December 2006 to May 2007. They were kept in a tie-stall housing, and were offered commercial concentrated feed at a rate of 1 kg feed per 2 kg milk produced. Corn-cob, corn-stem, and rice straw were used as roughage sources.

All cows had free access to clean water. They were milked twice daily and milk yield were recorded once a week. Body condition scores and postpartum reproductive activities were recorded by the veterinarian. Body condition score was recorded monthly from calving to 6 months postpartum according to the method described by Edmonson et al. (1989).

Sampling and sample analyses

Blood samples were collected from all cows at 2 weeks before expected calving date and at 2 and 4 weeks after calving to determine glucose, NEFA, triacylglycerol, cholesterol and urea nitrogen concentrations. Serum glucose (Biotech Reagent, Biotechnical Co., Ltd., Bangkok, Thailand), NEFA (NEFA FA 115, Randox Laboratories Ltd., Crumlin, UK), triacylglycerol (Biotech Reagent, Biotechnical Co., Ltd.), cholesterol (Biotech Reagent, Biotechnical Co., Ltd.) and urea nitrogen (Biotech Reagent, Biotechnical Co., Ltd.) concentrations were determined using spectrophotometric method with the use of commercially available test kits as indicated. Milk samples were collected once a week for 8 weeks to determine milk composition. Milk composition was determined using automatic milk analyzer.

Statistical analyses

Data were explored for normality using the Shapiro-Wilk W test (Patrie and Watson, 1999). Comparison of data between prepartum and postpartum sampling days were performed using the paired Student t test. The two-sided level of statistical significance was preset at $P \leq 0.05$.

RESULTS AND DISCUSSION

Body condition score and milk production

Average body condition score (BCS) at calving was 3.02 ± 0.64, which was lower than an expected score of 3.50, indicating that, on average, dairy cows in small-holder farms entered the calving period with lower BCS. During 4 weeks postpartum, average BCS of all cows was lower than BCS at calving (Figure 1), suggesting that cows in this study lost body weight, most likely due to NEB postpartum. This result confirmed the notion that

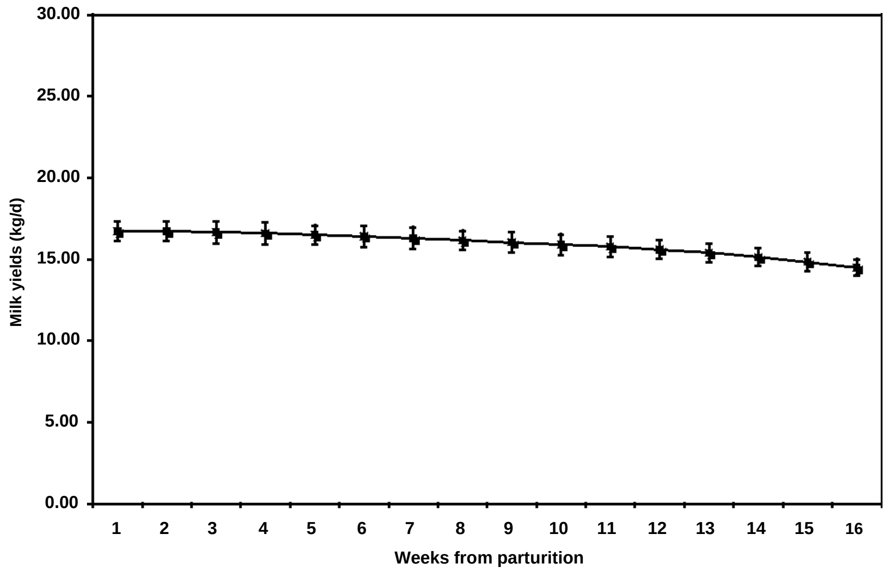

Figure 2. Average milk yield of 51 dairy cows during 16 weeks postpartum. Data represent means and SD as error bars.

Table 1. Milk composition of cows (n = 51) during the first 8 weeks from parturition. Data represented mean (s.d.).

Milk parameter	Week from parturition							
	1	2	3	4	5	6	7	8
Lactose (%)	4.72 (0.90)	4.41 (0.85)	4.09 (1.14)	4.53 (1.28)	4.26 (0.82)	4.65 (1.28)	4.27 (1.02)	4.30 (0.87)
Protein (%)	3.26 (0.51)	3.07 (0.54)	2.93 (0.60)	3.14 (0.89)	3.09 (1.04)	3.21 (1.64)	3.00 (0.59)	3.01 (0.57)
Fat (%)	3.42 (1.64)	3.98 (1.54)	3.85 (1.12)	3.77 (2.32)	4.23 (1.50)	3.84 (1.27)	4.23 (1.85)	4.14 (1.53)

postparturient dairy cows usually go into a NEB period (Harrison et al., 1990; Castañeda-Gutiérrez et al., 2009). In a previous report (Rukkwamsuk et al., 2009), average BCS before calving of dairy cows raised in small-holder farms was 3.20 ± 0.10, and all cows lost their BCS during the 4 weeks of lactation, even in a group that were drenched with propylene glycol between 7 days before expected calving and 7 days after calving. Therefore, changes of BCS during periparturient period could be an indirect parameter for determination the severity of NEB in dairy cows.

Average milk production during the first 16 weeks of lactation in these cows was 15.80 ± 4.10 kg/d. However, average milk yields showed that cows did not produce optimum yields because the milk curve did not have its peak of yield between 7 to 9 weeks of lactation (Figure 2). Although it could not be conclusive, the lack of the peak of milk yield might possibly be due to mismanage-ment of feeds and feeding or physiological changes related to NEB in dairy cows (Harrison et al., 1990). Milk composition of cows during the first 8 weeks of lactation is presented in Table 1. Average percentages of milk lactose, protein, and fat did not significantly changes and still remained in a normal range throughout the experimental period. Although NEB might affect milk production, milk composition during the NEB period was unaffected (Rukkwamsuk et al., 2005).

Blood biochemistry

Serum glucose, NEFA, triacylglycerol, cholesterol, and urea nitrogen concentrations are shown in Figures 3, 4, 5, 6 and 7, respectively. Serum glucose concentration at 2 weeks after calving was significantly lower than the concentration at 2 weeks before expected calving (Figure 3), and the concentrations increased to the prepartum level at 4 weeks after calving. This result confirmed that dairy cows entered a period of NEB postpartum, particularly during the first 2 weeks of lactation, which caused a reduction in blood glucose concentrations (Rukkwamsuk et al., 2003; Rukkwamsuk et al., 2006). Decreased blood glucose concentrations as a result of NEB, postparturient dairy cows increased mobilization of energy reserves by increasing lipolysis of adipose tissue (McNamara and Hillers, 1986; Rukkwamsuk et al.,

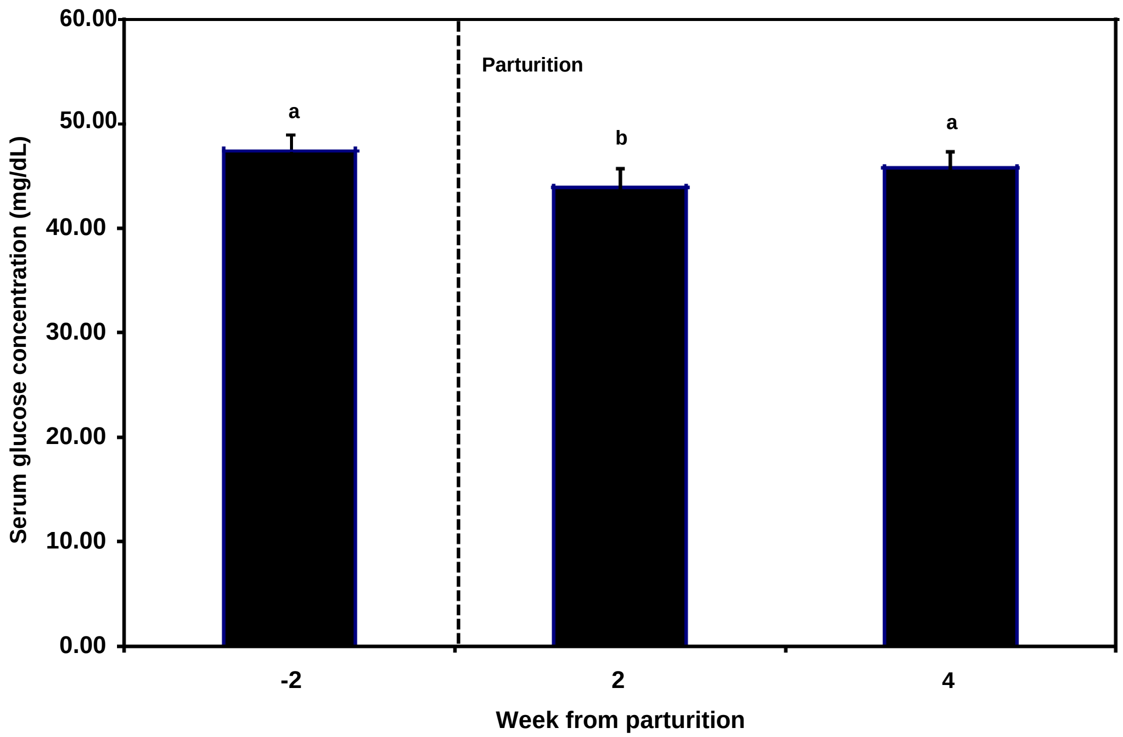

Figure 3. Serum glucose concentrations in dairy cows (n = 51) at -2, 2, and 4 weeks from parturition. Different letters indicated that mean concentrations differed among each sampling periods at P < 0.05.

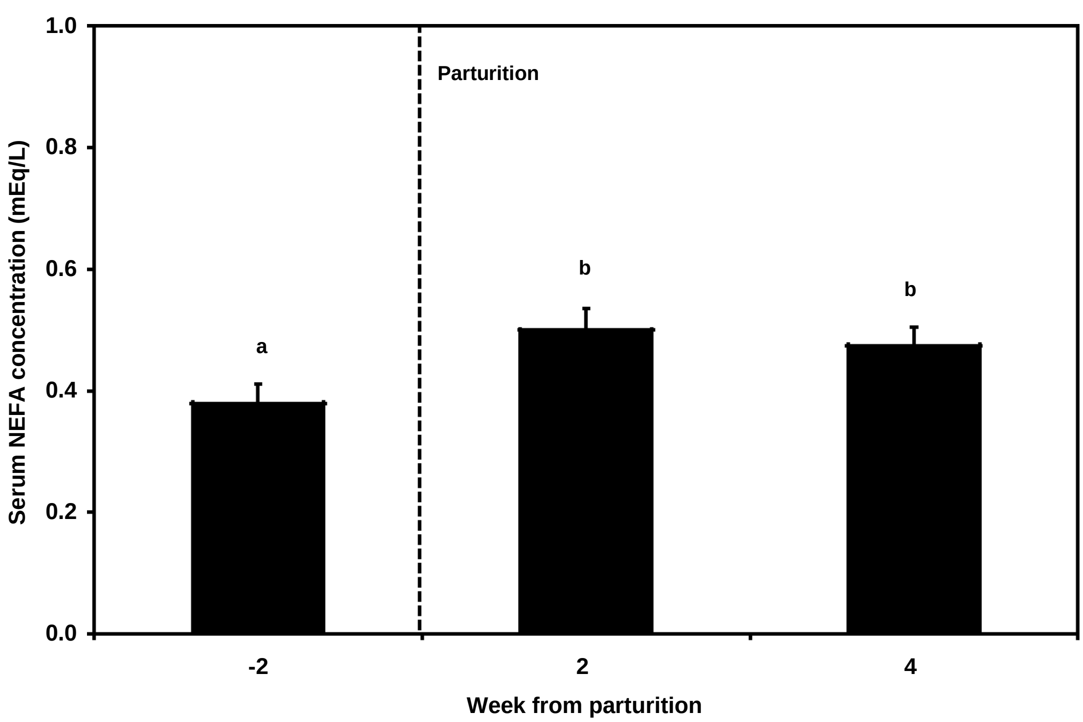

Figure 4. Serum non-esterified fatty acids (NEFA) concentrations in dairy cows (n = 51) at -2, 2, and 4 weeks from parturition. Different letters indicated that mean concentrations differed among each sampling periods at P < 0.05.

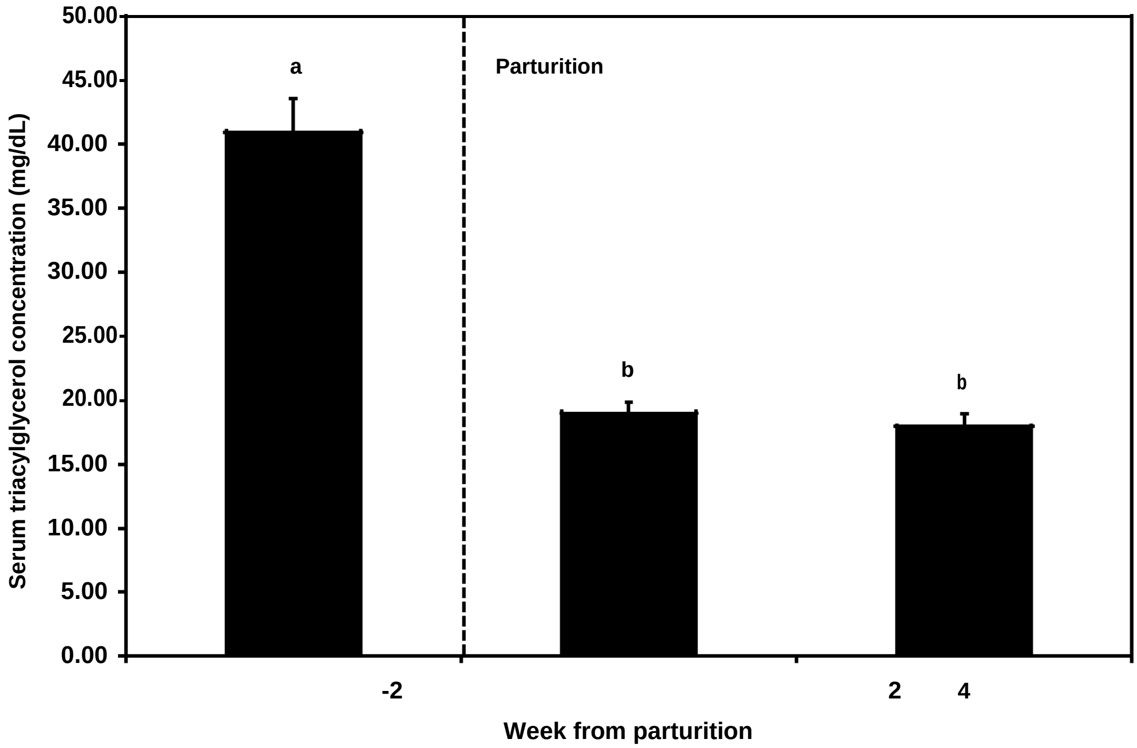

Figure 5. Serum triacylglycerol concentrations in dairy cows (n = 51) at -2, 2, and 4 weeks from parturition. Different letters indicated that mean concentrations differed among each sampling periods at $P < 0.05$.

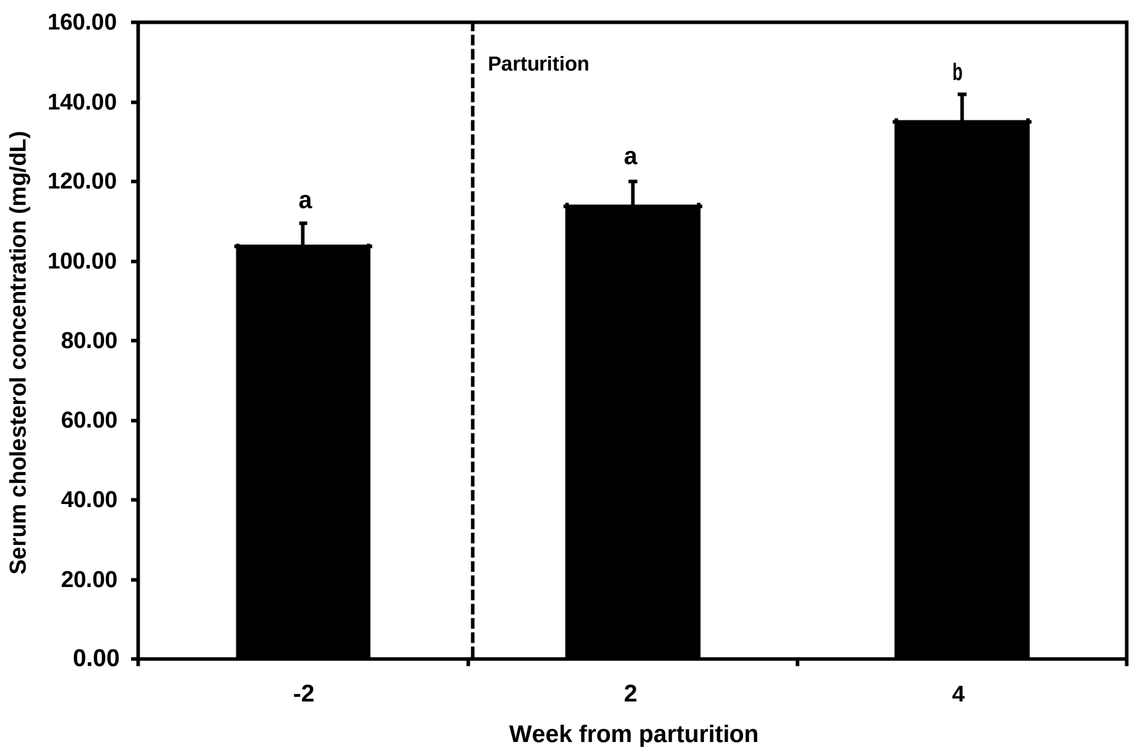

Figure 6. Serum cholesterol concentrations in dairy cows (n = 51) at -2, 2, and 4 weeks from parturition. Different letters indicated that mean concentrations differed among each sampling periods at $P < 0.05$.

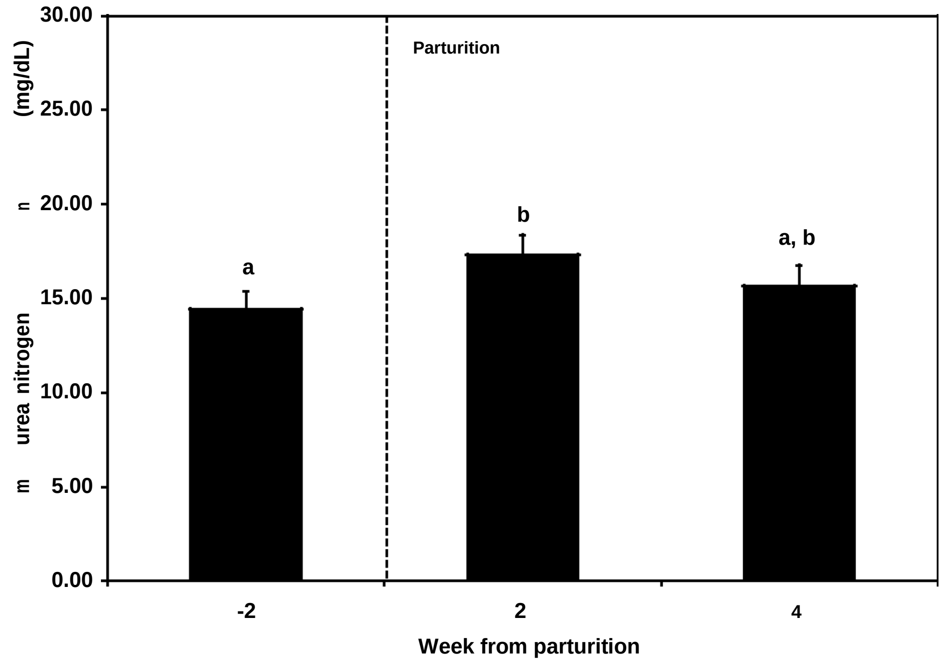

Figure 7. Serum urea nitrogen concentrations in dairy cows (n = 51) at -2, 2, and 4 weeks from parturition. Different letters indicated that mean concentrations differed among each sampling periods at $P < 0.05$.

1999). Increased adipose tissue lipolysis resulted in an increase of blood NEFA concentrations. In this study, serum NEFA concentrations at 2 weeks postpartum were significantly higher than the concentrations at 2 weeks prepartum (Figure 4), which was in agreement with previous studies (Rukkwamsuk et al., 2004). Increased circulating NEFA concentrations were closely related to accumulation of triacylglycerol in the liver, resulting in fatty liver (Bruss, 1993). Although the present study did not determine triacylglycerol concentrations in the liver, a report in Thailand has been confirmed a problem of fatty liver in dairy cows during postparturient period (Rukkwamsuk et al., 2004), in which dairy cows in that study increased their blood NEFA concentrations during the postparturient period.

Serum triacylglycerol concentrations at 2 weeks before calving were significantly higher than the postpartum concentrations (Figure 5), which was related to the milk fat synthesis. Circulating triacylglycerols are used to synthesize milk fat (Glascock et al., 1966); therefore, cows in lactating period drain their blood triacylglycerols through the udder, resulting in lower triacylglycerol concentrations in the blood as compared with the concentrations during the dry period. Serum cholesterol concentrations at 2 week before calving were significantly lower than the concentrations at 4 week of lactation (Figure 6). Ruegg et al. (1992) also reported that serum cholesterol concentrations increased when dairy cows start their milk production right after calving and were negatively related to their loss of body condition score. Dairy cows in this study lose their body condition score after calving; thus increasing serum cholesterol concentrations, which was in agreement with Kim and Suh (2003).

Serum urea nitrogen concentrations at 2 week were significantly higher than the concentration at 2 wk before calving and did not differ from the concentration at 4 wk of lactation (Figure 7). In general, elevation of serum urea nitrogen concentrations is associated with consumption of high protein, especially quickly degradable protein in the rumen (Godden et al., 2001). In addition, dairy cows during the last 3 wk of the dry period are fed limited amount of concentrates whereas, during early lactation, they were fed on high concentrates. Therefore, serum concentrations of urea nitrogen were significantly higher in early postpartum cows than in dry cows. This present result was also corresponded with previous report (Kim and Suh, 2003).

Postpartum reproductive performance

Average day from calving to first estrus was 72 ± 65 days, which was longer than a normal range of 30 - 50 days. However, some cows showed their estrus during expected period. A large variation of the first estrus postpartum is needed further studied. Pregnancy rates of these cows were 28.6, 11.1, and 12.0% for first, second, and third artificial inseminations, which was relatively low.

Grimard et al. (2006) reported that first service conception ranged from 38 to 50% depending on lactation number. Suboptimal milk yields, longer days from calving to first estrus and lower first service conception rate in this study could be due to some consequences of NEB during periparturient period.

Conclusions

Negative energy balance is an inevitable phenomenon in periparturient dairy cows, including those cows that were raised in small-holder farms, where the problem is likely to be caused by improper feed and feeding management. This study demonstrated an evidence of NEB occurring in dairy cows raised in small-holder farms. These NEB cows showed suboptimal milk yield and had a delayed first estrus after calving. Research on the prevention of NEB in periparturient dairy cows, particularly raised in small-holder farms is required to improve production and reproduction efficiency of the cows.

ACKNOWLEDGMENTS

The author is grateful for the financial support from the Thailand Research Fund (TRF), The Commission of Higher Education, Ministry of Education, and Kasetsart University Research and Development Institute (KURDI). The author also thanked Dr. Apisit Seubsai and Dr. Teerachad Setkit for their technical assistance.

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