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Effect of Oral Administration of Propylene Glycol on Serum Glucose Concentrations in Periparturient Dairy Cows

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ABSTRACT

The effect of oral administration of propylene glycol on serum glucose concentrations was studied in 10 dairy cows. At -1, 1, 3, 5, and 7 days from parturition, 6 cows were orally received 300 ml of propylene glycol/cow per day (treated group), and 4 cows were received 300 ml of water/cow per day (control group). At each interval, blood samples were collected from all cows at 0, 1, 2, 3, 4, and 5 hours following propylene glycol or water drenching. Serum was harvested and stored until determination of glucose concentrations. Compared with the concentration at 0 hour, serum glucose concentrations after drenching were increased for treated cows, but not for the control cows. For treated cows, serum glucose concentrations at 1, 2, 4, and 5 hours were higher than the concentration at 0 hour. Serum glucose concentrations of treated cows at 1, 2, 3, 4 and 5 hours were higher than those concentrations in control cows. These results indicated that cows drenched with propylene glycol had increased serum glucose concentrations, which would help these cows to improve their energy demands during a period of negative energy balance. In addition, propylene glycol administration could alleviate the mobilization of fat store, which would prevent cows from any consequences of intensive lipolysis.

Key words : dairy cow, glucose, propylene glycol

INTRODUCTION

During the final days prior to calving and immediately postpartum, dry matter intake (DMI) of dairy cows are usually decreased, and energy requirements for initiation of lactation are greatly increased (Garnsworthy and Topps, 1982; Harrison *et al*., 1990; Kunz *et al*., 1985). This phenomenon, so called negative energy balance, induces the cows to increase mobilization of body tissues, particularly fat. The resulting negative energy balance overwhelms the cow's liver with non-esterified fatty acids (NEFA) which are originated from lipolysis in adipose tissue (McNamara, 1994). When intrahepatic uptake of NEFA is increased, the liver is likely to synthesize a greater amount of triacylglycerols (Van den Topp *et al*., 1995), which finally accumulate in the liver leading to fatty liver (Van den Topp *et al*., 1995; Rukkwamsuk *et al*., 1999). Cows with fatty liver are more susceptible to other postparturient problems (Andrews *et al*., 1991; Gerloff *et al*., 1986). Therefore, severity of fatty liver can be alleviated by preventing cows from periparturient decrease in DMI or from severe negative energy balance. Administration of gluconeogenic precursors such as propylene glycol effectively reduces plasma NEFA and, subsequently decreases triacylglycerol accumulation in the liver (Studer *et al*., 1993). The majority of propylene glycol escapes the rumen

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intact and a portion is metabolized to propionate (Emery *et al*., 1964). Propylene glycol escaping rumen fermentation is converted to glucose in the liver, primarily via the lactaldehyde pathway, which is subsequently oxidized to lactate.

Propylene glycol administered as an oral drench or mixed with concentrates or fed separately from forages is approved to be more effective than feeding propylene glycol as part of a total mixed ration (Christensen *et al*., 1997). An oral drench of 296 ml of propylene glycol once a day is effective in increasing blood glucose and insulin and in reducing plasma NEFA and 3-hydroxybutyrate of periparturient heifers that were fed restricted amounts of feed (Grummer *et al*., 1994).

The objective of this study was to determine the effect of propylene glycol orally administered on serum glucose concentration in dairy cows during periparturient period.

MATERIALS AND METHODS

Animals and diets

Ten healthy, dry Holstein Friesian cross-bred cows in their first or second lactation were used. Cows were randomly allocated into 2 groups; 4 cows in the control group and 6 cows in the treated groups. Cows were fed 15 kg of corn silage and 8 kg of commercial concentrate per day. The concentrates contains 19% cassava chip, 18% soybean meal, 13% palm meal, 20% coconut extract, 2% fish meal, 9% molass, 0.5% NaCl, 0.5% premixed, 1.5% urea, 0.1% sulfur, 0.1% MgO, 0.3% $NaHCO_3$, 0.6% $CaCO_3$, 1.1% Monocalcium and 1% Dicalcium. All cows were fed twice daily at 6.00 a.m. and at 4.00 p.m. The treated cows were orally drenched with 300 ml of propylene glycol /cow per day, and the control cows were received 300 ml of drinking water /cow per day. The oral drench was performed by using drenching gun at 6.00 p.m. on day 1 prior to anticipated calving date and on day 1, 3, 5, and 7 after calving.

Blood samples and analysis

Blood samples from all cows were collected from jugular vein before giving either propylene glycol or drinking water (at 0 hour) and at 1, 2, 3, 4, and 5 hours after drenching, respectively. Blood samples were allowed to clot at room temperature for 30 minutes and were centrifuged at 1500 rpm for 5 minutes. Serum was harvested and stored at -20°C until analysis. Serum glucose concentrations were determined using spectrophotometry with a commercial available kit (Rephoton-glucose 30 STR, Diethelm Trading Co. Ltd., Bangkok).

Statistical analyses

Data were statistically analyzed using an SPSS computer program (SPSS, 1994). Data were explored for normal distribution using Shapiro-Wilk test. When data had a normal distribution, homogeneity of variances was verified using Levene's test. Normally distributed data were subjected to ANOVA using propylene glycol treatment as a fixed main effect and sampling hour as a repeated measure. Comparison of data from different sampling times was performed using the paired Student *t* test. Comparison of data between the two groups of cows was performed using the Student *t* test. The two sided level of statistical significance was preset at $P \leq 0.05$.

RESULTS AND DISCUSSION

All cows calved normally. During the first week of lactation, milk production was not affected by either propylene glycol or water administration in this study. Results from repeated measure analysis demonstrated that there was no time effect on the sampling day; therefore, serum glucose concentrations at the same hours of each sampling date were included in the analysis. In the control group, serum glucose concentrations at 0 hour did not significantly differ ($P > 0.05$) from the concentrations at 1, 2, 3, 4, and 5 hours (Figure 1). This is simply because water did not provide any

gluconeogenic precursors to the liver of the control cows. In contrast, serum glucose concentrations in the treated group at 1, 2, 4, and 5 hours were significantly higher ($P < 0.05$) than the concentrations at 0 hour (Figure 2), indicating that cows drenched with propylene glycol had an increase of glucose concentrations in their blood circulation. However, the difference between the concentrations at 3 hours and at 0 hour did not show any statistical significance but the tendency of the difference could be expected ($P = 0.11$). Our results were in agreement with the results observed by Grummer *et al.* (1997). At 0 hour, serum glucose concentrations did not differ between the two groups. It was also obvious that the concentrations at 1, 2, 3, 4, and 5 hours were higher

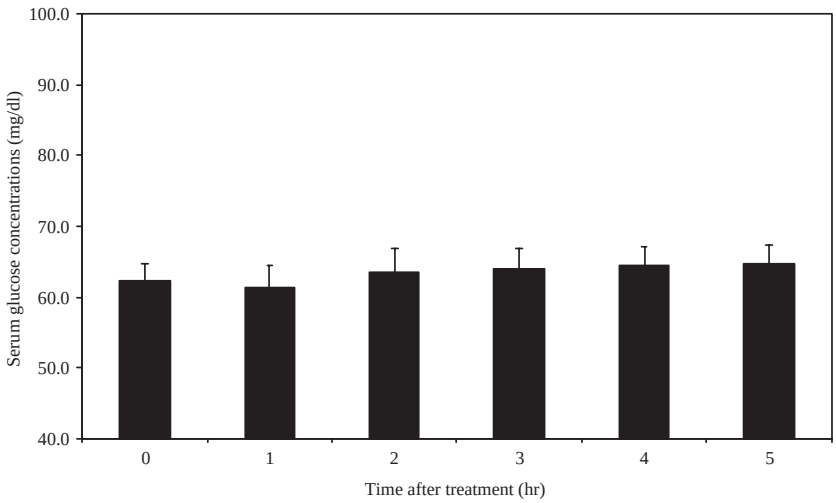

Figure 1 Serum concentration of glucose in the control group (n = 4) that was received 300 ml of water /cow per day. Data represent means and S.E.M.

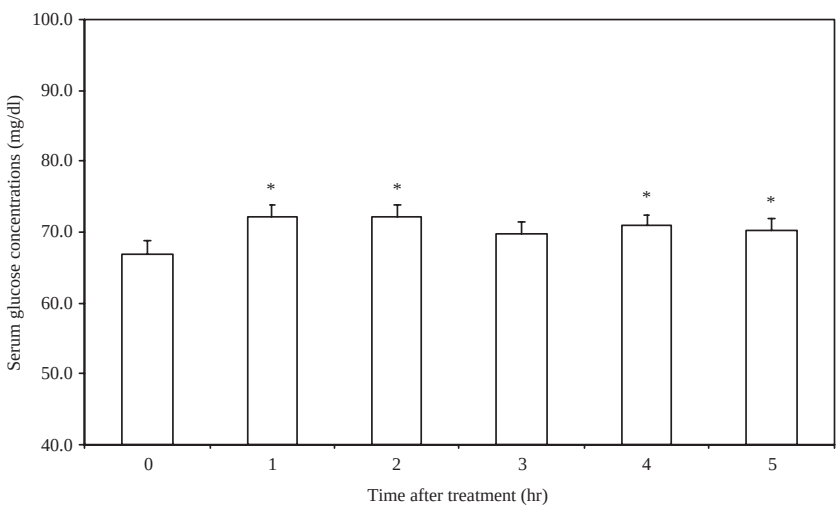

Figure 2 Serum concentrations of glucose in the treated group (n = 6) that was received 300 ml of propylene glycol /cow per day. Data represent means and S.E.M. Asterisks indicate that serum glucose concentrations significantly differed ($P \leq 0.05$) from the concentration at 0 hour.

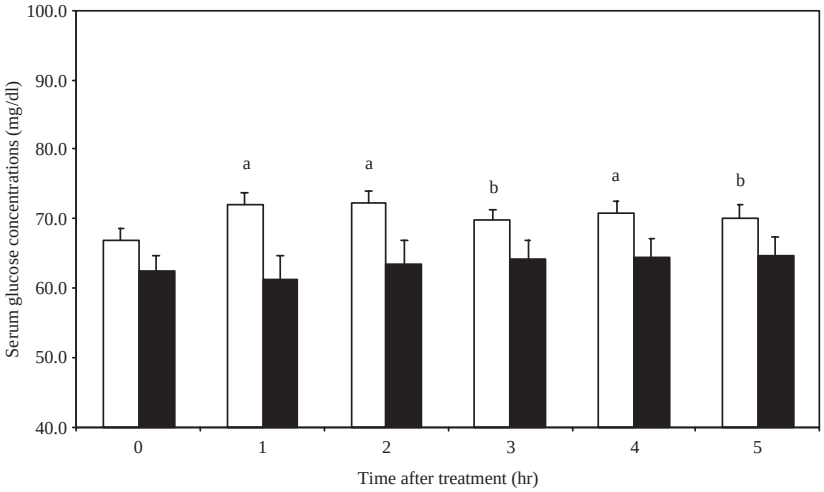

Figure 3 Comparison of serum concentrations of glucose at each hour intervals between the treated (❑; n = 6) and the control (■; n = 4). Data represent means and S.E.M. Letters indicate that serum glucose concentrations significantly differed (a: $P \leq 0.05$; b: $P \leq 0.1$) between the two groups.

for the treated group than for the control group (Figure 3). Propylene glycol was gluconeogenic precursor in the ruminants. It could be fermented by rumen microorganisms to propionate which is known as major gluconeogenic precursor. Propylene glycol could be administered to the cows in several methods (Christensen *et al*., 1997; Sauer *et al*., 1973), but drenching propylene glycol is the most appropriate way to increase glucose concentration in the circulation as observed by Christensen *et al*. (1997).

In conclusion, propylene glycol is a useful substance that can be drenched into cows suffering from energy deprivation, because propylene glycol can raise blood glucose concentrations immediately after drenching. In addition, the blood glucose concentrations can be elevated for at least 5 hours after drenching as indicated in this study. Therefore, propylene glycol is suggested to use to prevent cows from negative energy balance particularly at the period around parturition.

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