Dietary Fatty Acid Supplementation during Transitional Period Increases Milk Production in Dairy Cows

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ABSTRACT : The effect of dietary fatty acid supplementation on milk production, milk composition and plasma constituents in dairy cows was examined. Dietary fatty acids including mainly palmitic acid and stearic acid were given to cows from 2 weeks before and 8 weeks after parturition. Weekly gain of daily milk production was increased gradually during early lactation period and reached a plateau at 4 weeks after parturition. Weekly gain of daily milk production in lactating cows received dietary fatty acids was significantly higher than that of cows given a control diet alone. Although milk lactose concentration was slightly decreased by dietary fatty acid supplementation, milk fat and protein were not significantly influenced by dietary fatty acid supplementation. Dietary fatty acids did not affect plasma concentrations of triglyceride, non-esterified fatty acids, total cholesterol, high-density lipoprotein cholesterol and glucose during postpartum. It is suggested that dietary fatty acid supplementation has the potency to enhance energy balance and improve milk yield without any adverse effects on milk composition. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 8 : 1105-1109)***

Key Words : Dairy Cows, Dietary Fatty Acids, Milk Production, Milk Composition, Plasma Constituents

INTRODUCTION

Dry matter intake is an important criterion when formulating diets, especially for high-yielding dairy cows. Occasionally, however, it is impossible to fulfill energy requirements by dry matter intake limits of high-producing cows, which results in weight loss and, subsequently, lower milk yields (National Research Council, 1988). Moe and Tyrrell (1972) reported that energy requirements for maintenance and pregnancy of dairy cattle increased 23% during last month prepartum, but feed intake typically decreased up to 30% during this period (Grummer, 1993). Milk production usually peaks between 4 and 8 weeks of postpartum, maximum dry matter intake usually occurs between 10 and 14 weeks of postpartum. The lag of maximum dry matter intake behind peak milk yield causes a negative energy balance in early lactation, and then cows consequently mobilize body tissues, particularly fat deposits, to overcome the energy deficit, which results in weight loss (National Research Council, 1988). Furthermore, inadequate energy intake may also cause postpartum metabolic diseases (Gerloff et al., 1986; Grummer, 1995), and several feeding trials were attempted to prevent energy deficit during early lactating period. In order to enhance energy intake and overcome the negative energy balance before calving, a increase in the energy density of diets might be benefit during the last period of gestation. The effects of concentrate feeding in late gestation on feed intake, milk yield and milk composition were evaluated, and additional concentrates increased milk fat concentration but not alter feed intake, milk yield and milk composition other than milk fat (Keady et al., 2001).

It was suggested that after sexual maturation adipose tissues might, in some way, have a feed back role in controlling feed intake, and changes in feed intake seemed to control body composition, especially percentage of body fat (National Research Council, 1988). In fact, it has been reported that in beef cattle serum concentration of leptin, which is known to be synthesized in white adipose tissue and have the potency to decrease feed intake, was positively and significantly correlated with marbling score, back fat depth, kidney fat and heart fat (Geary et al., 2003). Therefore, the available feeding techniques have been expected to achieve high energy intake after maturation. Recently, we reported that supplementary fatty acids including mainly palmitic and stearic acids could successfully prevent the reduction of energy intake and achieve the improvement of body weight gain in fattening beef cattle (Kita et al., 2003). In the present study, therefore, we supplemented dietary fatty acids in conventional diets for cows from pre- to postpartum and examined the effect of dietary fatty acid supplementation on milk production, milk composition, and plasma constituents in dairy cows.

MATERIALS AND METHODS

Animals and diets

Ten Holstein cows (24 to 65-months old) bred in Gifu Prefectural Livestock Research Institute, Japan, were used. Daily feeding amounts of experimental diets for dry cows

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Table 1. Daily feeding of experimental diets for dry and lactating cows (kg/d)

Ingredients	Dry cows		Lactating cows	
	Control	Fatty acids	Control	Fatty acids
Italian ryegrass silage	4.4	4.4	17.0	17.0
Italian ryegrass hay	0.8	0.8	3.0	3.0
Alfalfa	0.8	0.8	3.0	3.0
Beat pulp	2.8	2.8	3.0	3.0
Barley	0.5	0.5	2.0	2.0
Corn	0.5	0.5	2.0	2.0
Cotton seed	0.4	0.4	1.5	1.5
Concentrate [1]	1.8	1.8	7.0	7.0
Oat hay	5.0	5.0	0	0
Fatty acids	0	0.23	0	0.5
TDN[2]	8.7	8.7	16.9	18.0
CP[3]	1.5	1.5	3.4	3.4

[1] Zenraku Rakuto18 (TDN 72.5%, CP 18%). The National Federation of Dairy Co-operative Associations, Tokyo Japan.

[2] Total digestible nutrients. [3] Crude protein.

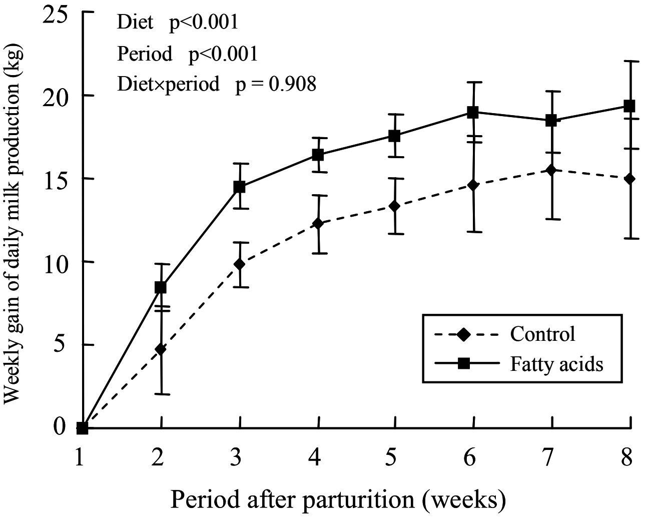

Figure 1. Weekly gain of daily milk production of dairy cows given additive dietary fatty acids. Vertical bars represent SEM (n = 5).

during prepartum is shown in Table 1. In the fatty acid group, 0.23 kg/day of fatty acids (GOLDEN FLAKE, Nutrition Trading (International) Ltd., Warwickshire, UK) was added in the control diet. Daily feeding amounts of experimental diets for lactating cows during postpartum is represented in Table 1. In the fatty acid group, 0.50 kg/day of fatty acids was supplemented in the control diet. The fatty acid composes 1.5% of myristic acid, 49.0% of palmitic acid, 42.0% of stearic acid, 6.0% of oleic acid and 1.5% of linoleic and linolenic acids. Control diets for dry cows and lactating cows were sufficient for the requirement of total digestible nutrients (TDN) and crude protein (CP) (Central Association of Livestock Industry, 1994).

Experiments

Five cows each were allotted to one of two treatment groups and were kept in the individual pens. All ingredients of each experimental diet were mixed as total mixed ration, and dairy cows were allowed free access to the fixed amount of daily feeding of experimental diets. Diets for dry cows were given for 2 weeks before expected parturition. During 8 weeks of postpartum cows were given experimental diets for lactating cows. Cows were allowed free access to drinking water and trace-mineralized salt blocks. Milk yield was determined daily and milk samples were collected during milking weekly. Blood samples were taken from jugular vein every week, and plasma was separated and stored at -20°C until analyzed.

Analyses

TDN was estimated according to Japan Livestock Industry Association (2001). CP content in the ingredients of experimental diets was determined by the method described in AOAC (1990). Milk samples were analyzed for fat, protein and lactose using an infrared spectroscopy (Milco-Scan 133B, FOSS JAPAN LTD. Tokyo, Japan). Plasma concentrations of glucose, non-esterified fatty acid (NEFA), triglyceride, total cholesterol and high-density lipoprotein (HDL)-cholesterol were measured by using commercial kits (glucose:Glucose C II test Wako; NEFA:NEFA test Wako; triglyceride:TG G test Wako; total cholesterol:T-Cho E test Wako; HDL-cholesterol:HDL-test Wako; Wako Pure Chemical Co. Ltd., Osaka, Japan).

Statistical analyses

Data was analyzed by mixed two-factor within subject design (split-plot design). The main factor with independent groups was experimental diet (control vs. fatty acid). Sub factor with repeated measures was experimental period (days). Data was calculated by a commercial statistical package SAS (SAS Institute Inc., Cary, NC, USA). For all analytical procedures, P-value of less than 0.05 was considered statistically significant.

RESULTS AND DISCCUSION

Feed intakes of lactating cows received control and fatty acid diets were 24.2 and 23.7 kg DM/d, respectively. In both dietary groups, there was no significant difference in feed intakes. This result suggested that dietary fatty acid supplementation did not impair feed intake of lactating cows. Weekly gain of daily milk production is represented in Figure 1. There was no significant interaction between supplemented fatty acid and experimental period in weekly gain of daily milk production. Weekly gain of daily milk production increased gradually during early lactation period and reached plateau after 4 weeks after parturition. This alteration in milk yield seems to be common trends in lactating cows as summarized in National Research Council

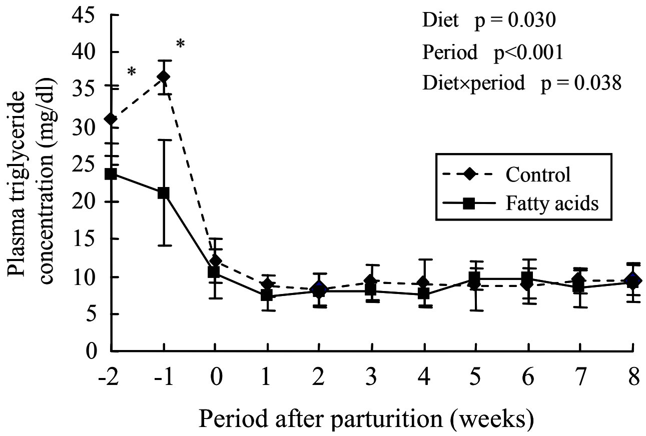

Figure 2. Changes in plasma triglyceride concentration in dairy cows given additive dietary fatty acids. Vertical bars represent SEM (n = 5). Asterisk shows significant difference between control and fatty acid groups on the same week ($p<0.05$).

Table 2. Milk composition of lactating cows in response to supplemental fatty acids (%)

Milk composition	Control	Fatty acid
Fat	3.54	3.40
Protein	3.14	3.08
Lactose	4.55^a	4.46^b

$^{a, b}$ Means not sharing with the same superscript letters within the same raw were significantly different at $p<0.05$.

(1988). Figure 1 also shows that weekly gain of daily milk production in lactating cows received dietary fatty acid was significantly higher than that of cows given conventional diets alone. It was well recognized that the peak of dry matter intake occurring between 10 and 14 weeks postpartum was approximately 4 weeks later than that of milk production. The inadequate energy intake caused by the lag of peaks between milk production and dry matter intake may cause postpartum metabolic diseases (Gerloff et al., 1986; Grummer, 1995). One way to enhance energy intake and overcome the negative energy balance before calving might be to increase the energy density of diets for cows in the last period of gestation. Eastridge et al. (1988) reported that the increase in energy density by elevating the percentage of concentrate in diets could supply adequate energy to maintain high milk production. However, the effects of concentrate feeding on milk production were not consistent. For example, Keady et al. (2001) reported that supplementation with additional concentrates increased milk fat concentration but not alter milk yield. Furthermore, National Research Council (1988) also mentioned that sometimes it is impossible to fulfill energy requirements within dry matter intake limits of high-producing cows. As we reported previously, dietary fatty acid including mainly palmitic and stearic acids could successfully prevent the reduction of energy intake and achieve the improvement of body weight gain in fattening beef cattle (Kita et al., 2003). In the present study, therefore, we gave the same dietary fatty acids to dairy cattle from pre- to postpartum and observed that it was successfully able to improve milk production in lactating cows (Figure 1). Table 2 shows milk composition of lactating cows in response to dietary fatty acids. Although milk lactose concentration was slightly decreased by dietary fatty acid supplementation, milk fat and milk protein were not significantly influenced by addition of dietary fatty acids. It is suggested that dietary fatty acid supplementation has the potency to enhance energy balance and improve milk yield without any failure in milk composition.

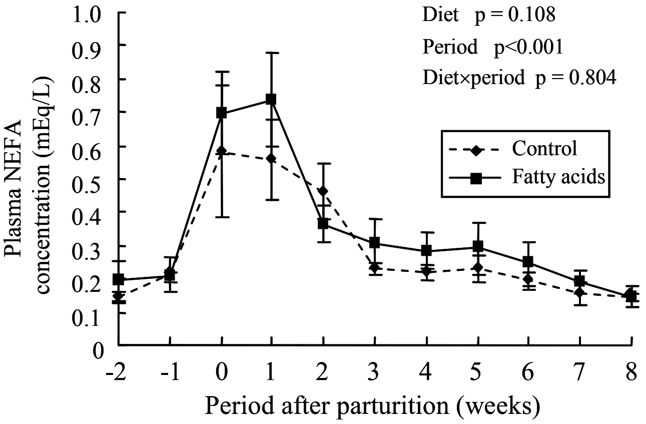

Figure 3. Changes in plasma non-esterified fatty acid (NEFA) concentration in dairy cows given additive dietary fatty acids. Vertical bars represent SEM (n = 5).

The changes in plasma triglyceride and NEFA concentrations in dairy cattle fed dietary fatty acids are represented in Figure 2 and 3, respectively. When dietary fatty acids were given to dairy cows, there was significant interaction between dietary fatty acid and experimental period in plasma triglyceride concentration (Figure 2). During prepartum plasma triglyceride concentration was significantly lower than that of control groups. After parturition, however, there was no significant difference between fatty acid and control groups. No significant interactions were observed in changes in plasma NEFA concentration (Figure 3). Plasma NEFA concentration increased rapidly on parturition and restored to the basal level after 3 weeks of parturition. The increase in plasma NEFA concentration during postpartum was also reported by Vazquez-Anon et al. (1994) and Vandehaar et al. (1999) , which was consisted with our present result. Plasma NEFA concentration of dairy cows receiving dietary fatty acids seemed to be higher, but not significantly ($p = 0.108$), than that in the control group. Recently, we reported that plasma NEFA concentration in fattening beef cattle given additive dietary fatty acids was significantly higher than that in control group (Kita et al., 2003). Therefore, dietary fatty acid supplementation may increase plasma NEFA concentration in both dairy cows and beef cattle.

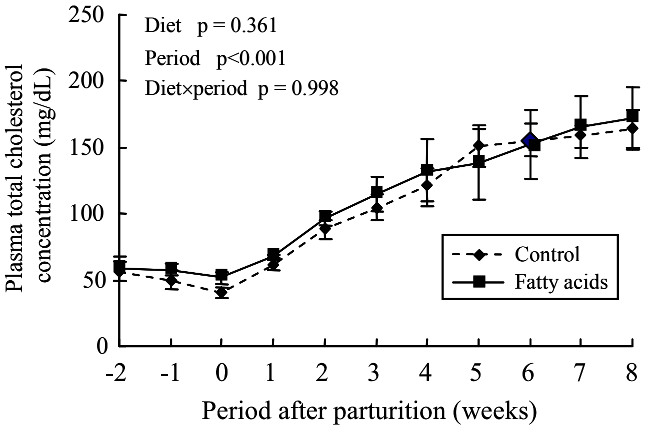

Figure 4. Changes in plasma total cholesterol concentration in dairy cows given additive dietary fatty acids. Vertical bars represent SEM (n = 5).

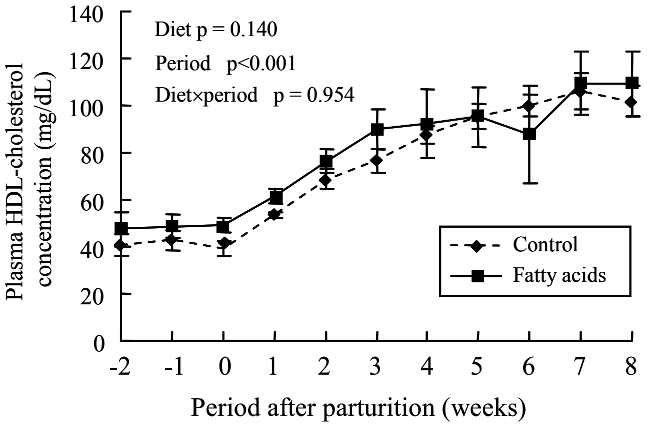

Figure 5. Changes in plasma high-density lipoprotein (HDL) cholesterol concentration in dairy cows given additive dietary fatty acids. Vertical bars represent SEM (n = 5).

The changes in plasma total cholesterol and HDL-cholesterol concentrations in dairy cows given additive dietary fatty acids are represented in Figure 4 and 5, respectively. In both total (Figure 4) and HDL-cholesterol (Figure 5) concentrations, there was no significant interactions between dietary fatty acid and experimental period were observed. Plasma total and HDL-cholesterol concentrations gradually elevated during postpurtam and reached plateau after 5-6 weeks of parturition. Supplementation of additive fatty acids did not significantly affect plasma total and HDL-cholesterol concentrations. In our previous studies, plasma HDL -cholesterol concentration in finishing beef cattle given dietary fatty acids was significantly higher than that given conventional diets. Similar result was derived in beef cows fed calcium soap fatty acid (Espinoza et al., 1995). These results suggested that dietary fatty acid supplementation may have the potency to increase plasma HDL-cholesterol level in the beef cattle but not in dairy cows. This issue should be elucidated in the future.

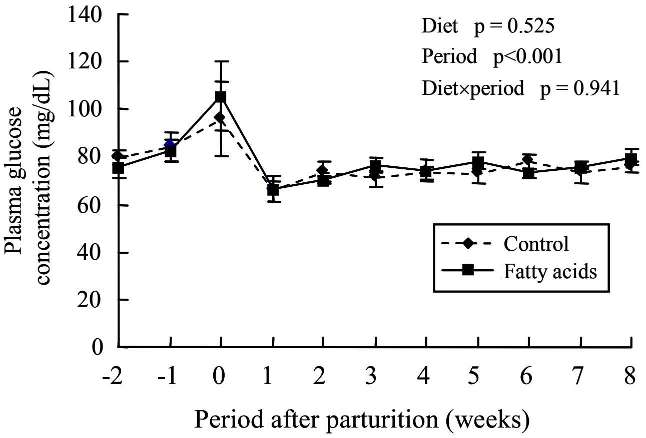

Figure 6. Changes in plasma glucose concentration in dairy cows given additive dietary fatty acids. Vertical bars represent SEM (n = 5).

In conclusion, it was suggested that dietary fatty acid supplementation from pre- to postpartum has the potency to improve milk production in dairy cows.

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