Dietary Fatty Acid Increases Body Weight Gain without a Change in Rumen Fermentation in Fattening Cattle

K. Kita*, M. Oka and H. Yokota

Laboratory of Grassland Science, University Farm, Graduate School of Bioagricultural Sciences, Nagoya University Togo, Aichi 470-0151, Japan

ABSTRACT : Dietary fatty acid including mainly palmitic acid and stearic acid was fed to fattening cattle and its effect on body weight gain, plasma lipid contents and rumen liquid fermentation *in vitro* was examined. In expt. 1, the effect of dietary fatty acid on body weight gain and plasma lipid concentrations was examined. In the control diet group, cattle were fed 1 kg/day of rice straw and concentrate which satisfied the requirement. In the fatty acid group, cattle were given 250 g/d of fatty acid with the same diet of the control diet group. In the excess concentrate group, cattle were given the same diet of the control diet group plus 735 g/d of concentrate corresponding to the same TDN of 250 g/d of fatty acid. Diets were given for 7 days. Body weight gain of cattle given dietary fatty acid was significantly greater than that of cattle fed only rice straw and concentrate. When dietary fatty acid was added to cattle feed, plasma NEFA and HDL-cholesterol concentrations increased. In expt. 2, the influence of dietary fatty acid on gas production and VFA profile in the rumen liquid was investigated *in vitro*. In the control group, 10 mg of rice straw and 90 mg of concentrate were incubated in the rumen fluid. In the excess concentrate group, 10 mg of rice straw and 97.5 mg of concentrate were incubated. In the fatty acid group, 10 mg of rice straw, 90 mg of concentrate and 2.5 mg of fatty acids were incubated. The rumen liquid mixed with feed materials was incubated for 24 h and the cumulative gas volume was measured. The VFA profile was also measured. Cumulative gas volume in the rumen liquid with fatty acid was equal to the control. Excess concentrate increased cumulative gas volume compared to the fatty acid group. There was no significant difference in total VFA concentration between experimental diet groups. It is suggested that dietary fatty acid has the potency to improve growth performance in fattening cattle without failure in rumen fermentation. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 1 : 39-43)***

Key Words : Fattening Cattle, Dietary Fatty Acid, Body Weight Gain, Plasma Lipids, Rumen Fermentation

INTRODUCTION

It has been well known that lipids added to animal diets can affect productive efficiency through caloric effect, attributing to greater energy content and energetic efficiency for lipid than for carbohydrate or protein (Jenkins, 1994). Recently, rape seed oil (Strzetelski et al., 2001) and canola oil (Wettstein et al., 2000) were given to fattening bulls and their effects on animal performance and meat quality were investigated. Although rape seed oil did not affect body weight gain, it increased fat content in the body (Strzetelski et al., 2001). Canola oil also did not affect live weight gain, but increased polyenoic fatty acids in the kidney and intermuscular fat (Wettstein et al., 2000). On the other hand, Naruse et al. (1999) reported that dietary beef tallow tended to increase daily gain of steer compared to the control. However, it has not been well investigated the effect of dietary fatty acids on growth performance and plasma lipid metabolism in fattening cattle. In the present study, therefore, we gave dietary fatty acid composing mainly palmitic acid and stearic acid to fattening cattle and examined its effect on body weight gain, plasma lipid contents and rumen liquid fermentation *in vitro*.

* Address reprint request to K. Kita. Tel: +81-561-37-0203, Fax: +81-561-37-0203, E-mail : kitak@agr.nagoya-u.ac.jp

Received July 24, 2002; Accepted October 7, 2002

MATERIALS AND METHODS

Two experiments were conducted. In expt.1, the effect of dietary fatty acid on body weight gain and plasma lipid concentrations was examined. In expt. 2, the influence of dietary fatty acid on gas production and VFA profile in the rumen liquid was investigated *in vitro*.

Animals and diets

In expt. 1, six (3 males and 3 females) F1 back-cross cattle {F1 (Holstein×Japanese Black)×Japanese Black} bred in University Farm of Nagoya University, Japan, were used. These cattle were 16 to 21-months old and male cattle were castrated in 2 to 3-months old. In the control diet group, cattle were fed 1 kg/day of rice straw and concentrate (Kuroushi72, Marubeni Shiryo Co. Ltd., Tokyo, Japan) which satisfied TDN recommended by Japanese Feeding Standard for Beef Cattle (Central Association of Livestock Industry, 1995). Chemical compositions of feed materials are shown in Table 1. In the fatty acid group, cattle were given 250 g/d of fatty acid (GOLDEN FLAKE, Nutrition Trading (International) Ltd., Warwickshire, UK) with 1 kg of rice straw and concentrate which satisfied TDN recommended by the standard. 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

Table 1. Chemical compositions of concentrate and rice straw

Chemical compositions	Concentrate	Rice straw
DM (%)	87.3	96.3
CP (%DM)	14.07	4.12
Crude fat (%DM)	3.03	1.50
Crude ash (%DM)	4.21	7.14
NDF (%DM)	23.03	80.08
ADF (%DM)	7.87	49.04

linolenic acids. In the excess concentrate group, cattle were given the same diet of the control diet group plus 735 g/d of concentrate corresponding to the same TDN of 250 g/d of fatty acid.

In expt. 2, one F1 back-cross steer like expt.1 was used. Cattle were fed the same diet of control diet group in expt. 1.

Experiments

In expt. 1, two cattle were allotted to one of three treatment groups. A cow and a steer were kept in the same pens, and three pens were prepared. Cattle were assigned in 3×3 Latin square design and the same experiment was repeated. Experimental diets were divided equally and given twice a day at 9:00 and 17:00. Diets were given for 7 days. Cattle were allowed free access to drinking water and trace-mineralized salt blocks (Cow candy, Mercian Co. Ltd., Tokyo, Japan). Blood samples were taken by jugular venipuncture before and after experiment. Plasma was separated and stored at -80°C until analyzed.

In expt. 2, a cannula was inserted into rumen of steer, and approximately 300 mL of rumen liquid was collected. The rumen liquid was filtrated by passing through gauze and diluted with a medium described by Menke et al. (1979) at the ratio of 1:2 (rumen liquid : medium). The CO_2 gas was passed through diluted rumen liquid, and the liquid was warmed at 39°C until used. The 15 mL of diluted rumen liquid was put in a 20 mL flask. A plastic syringe with plastic extension tube was attached on the lid of flask to measure the cumulative gas volume. Four treatment groups corresponding to expt. 1 were set. In the control group, 10 mg of rice straw and 90 mg of concentrate were incubated in the rumen fluid. In the excess concentrate group, 10 mg of rice straw and 97.5 mg of concentrate were incubated. In the fatty acid group, 10 mg of rice straw, 90 mg of concentrate and 2.5 mg of fatty acids were incubated. In the blank, no feed materials were incubated. The rumen liquid mixed with dietary materials was incubated for 24 h and the cumulative gas volume was measured at 3, 6, 9, 12, 18 and 24 h of incubation. After 24 h of incubation, rumen liquid was stored at -30°C until analyzed VFA profile.

Analyses

The contents of moisture, CP, crude fat and crude ash in feed materials were measured by standard procedure (AOAC, 1990). Crude protein in the ingredients of experimental diets was determined by using Kjeldahl distilling unit "Kjeltec System 1026" (Tecator, Hoganas, Sweden). Crude fat was analyzed by Soxhlet's extractor "FATEX Speedy Fat Extractor Auto Program System" (Mitamura Riken Kogyo Inc., Tokyo, Japan). The total VFA, NDF and ADF were analyzed by the methods described by Ohshima et al. (1991). The profile of various VFA in the rumen liquid was analyzed by gas-chromatograph Shimadzu GC-12A (Kyoto, Japan).

Plasma concentrations of glucose, non-esterified fatty asid (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 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

Body weight gain of cattle in the fatty acid group was significantly greater than that in the control group (Figure 1). There was no significant difference in body weigh gain between fatty acid and excess concentrate groups.

The concentrations of plasma glucose, NEFA, triglyceride, total-cholesterol and HDL-cholesterol in cattle given various experimental diets are shown in Table 2. When dietary fatty acid was added to cattle feed, plasma NEFA concentration was significantly higher than those in other groups. Neither dietary fatty acid supplementation nor excess concentrate intake affected plasma glucose, triglyceride and total cholesterol concentrations. Plasma HDL-cholesterol concentration of cattle given dietary fatty acid was significantly higher than that of cattle given excess energy intake by feeding excess amount of concentrate.

The cumulative change in gas production from the rumen liquid incubated with various experimental diets *in vitro* was represented in Figure 2. Cumulative gas volume was increased until almost 12 h of incubation, and then keep remained the steady volume. Little gas production was observed in the rumen liquid without feed materials (blank). When fatty acid was supplemented into the rumen liquid, cumulative gas volume was similar to that of rumen liquid

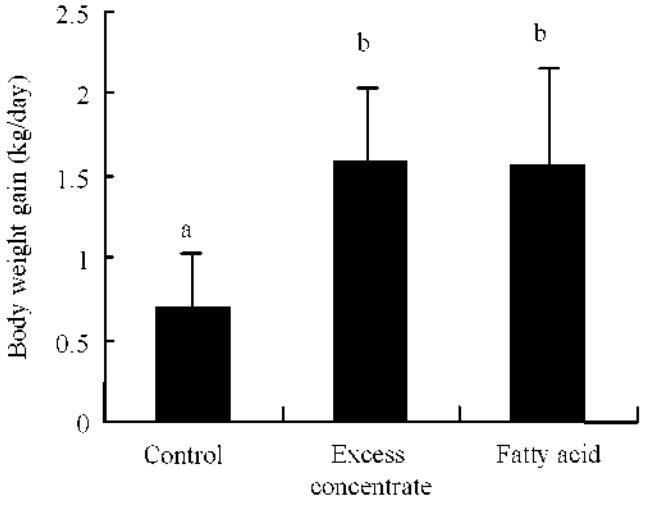

Figure 1. Body weight gain in the cattle given various experimental diets (Experiment 1). Cattle in the control group were given 1 kg/day of rice straw and concentrate which satisfied TDN recommended by Japanese Feeding Standard for Beef Cattle (Central Association of Livestock Industry, 1995). Cattle in the excess concentrate group were given 1 kg/day of rice straw and concentrate which was 735 g excess compared to that given cattle in the control group. TDN of 735 g of concentrate was corresponding to that of fatty acid given cattle in the fatty acid group. Cattle in the fatty acid group were given 1 kg/day of rice straw, 250 g/day of fatty acids, and concentrate which satisfied TDN recommended by the standard.

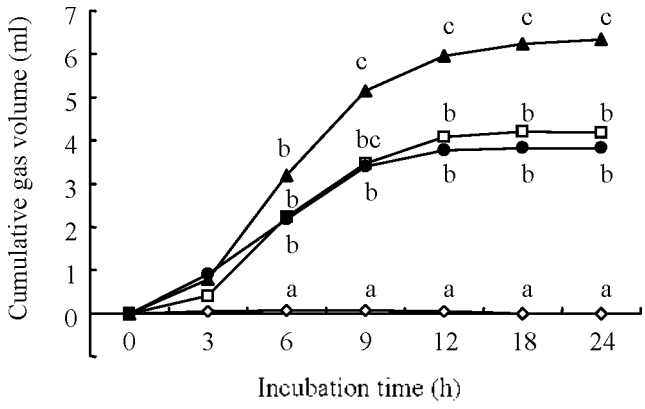

Figure 2. Cumulative change in gas production from the rumen liquid incubated with various experimental diets *in vitro* (Experiment 2). In the blank (ˊ) group, rumen fluid was incubated without diets for 24 h. In the control (二) group, 10 mg of rice straw and 90 mg of concentrate were incubated in the rumen fluid for 24 h. In the excess concentrate (▲)group, 10 mg of rice straw and 97.5 mg of concentrate were incubated in the rumen fluid for 24 h. In the fatty acid (●) group, 10 mg of rice straw, 90 mg of concentrate and 2.5 mg of fatty acids were incubated in the rumen fluid for 24 h.

incubated with ordinary cattle feed (control group). Excess concentrate increased cumulative gas volume compared to those in the fatty acid and control groups.

Table 2. Concentrations of glucose, NEFA, triglyceride, total cholesterol, high-density lipoprotein (HDL)-cholesterol in the plasma of goats given dietary fatty acids (Experiment 1)

	Control[1]	Excess concentrate[2]	Fatty acids[3]
Glucose (mg/dl)	90.7±1.55	91.0±2.69	94.9±1.63
NEFA (mEq/l)	0.140±0.015[a]	0.138±0.024[a]	0.170±0.021[b]
Triglyceride (mg/dl)	43.9±4.23	40.3±2.83	42.9±2.37
Total-cholesterol (mg/dl)	120±6.8	125±6.1	143±7.9
HDL-cholesterol (mg/dl)	60.3±4.13[ab]	55.4±3.49[a]	68.9±2.91[b]

Values are means±SEM. Means in the same row with different superscript letters are significantly different at $p<0.05$.

[1] Cattle in the control group were given 1 kg/day of rice straw and concentrate which satisfied TDN recommended by Japanese Feeding Standard for Beef Cattle (Central Association of Livestock Industry, 1995).

[2] Cattle in the excess concentrate group were given 1 kg/day of rice straw and concentrate which was 735 g excess compared to that given cattle in the control group. TDN of 735 g of concentrate was corresponding to that of fatty acid given cattle in the fatty acid group.

[3] Cattle in the fatty acid group were given 1 kg/day of rice straw, 250 g/day of fatty acids, and concentrate which satisfied TDN recommended by the standard.

VFA concentrations in the rumen liquid incubated with various experimental diets *in vitro* were shown in Table 3. Total VFA concentrations in the rumen liquid incubated with experimental diets were significantly higher than that in the blank group. There was no significant difference in total VFA concentration between experimental diet groups. Although the incubation of rumen liquid mixed with experimental diets increased the percentage of propionic acid to total VFA and decreased the percentage of iso-butyric and iso-valeric acids to total VFA, no significant differences between experimental diet groups were observed.

DISCUSSION

In the present study, we gave dietary fatty acid composing mainly palmitic acid and stearic acid to fattening cattle and examined its effect on body weight gain. As shown in Figure 1, body weight gain of cattle given dietary saturated fatty acids was significantly greater than that of cattle fed only rice straw and concentrate. It has been reported that fat supplementation increasing from 0 to 8% to diets resulted in a linear increase in empty body weight gain, empty body fat and marbling score (Zinn, 1989; Zinn and Plascencia, 1996). Wu et al. (1991) also reported fatty acids in calcium soap were more digestible than those in animal-vegetable blended fat due to greater unsaturation in the small intestine. Therefore, as some attempts have been done to improve productive efficiency of ruminants by modifying the amount or composition of lipids added to the diet, dietary fatty acids supplementation would be available to improve animal growth and performance.

As shown in Table 3, there was no significant influence

Table 3. VFA concentrations in the rumen liquid incubated *in vitro* (Experiment 2)

	Blank	Control[1]	Excess concentrate[2]	Fatty acids[3]	Pooled SEM
Total VFA (mmol/l)	22.8[a]	46.2[b]	50.2[b]	47.7[b]	1.34
Acetic acid (%)	50.1	50.0	52.1	52.7	0.41
Propionic acid (%)	19.7[a]	24.5[b]	24.7[b]	24.6[b]	0.48
iso-Butyric acid (%)	2.9[b]	1.8[a]	1.7[a]	1.8[a]	0.11
Butyric acid (%)	13.6	14.1	13.7	13.3	0.44
iso-Valeric acid (%)	9.8[b]	5.9[a]	5.5[a]	5.6[a]	0.47
Valeric acid (%)	4.3	3.8	3.6	3.7	0.22

Means in the same row with different superscript letters are significantly different at $p<0.05$.

[1] The 10 mg of rice straw and 90 mg of concentrate were incubated in the rumen fluid for 24 h.

[2] The 10 mg of rice straw and 97.5 mg of concentrate were incubated in the rumen fluid for 24 h.

[3] The 10 mg of rice straw, 90 mg of concentrate and 2.5 mg of fatty acids were incubated in the rumen fluid for 24 h.

of dietary fatty acid on total VFA concentration and VFA profile. As Jenkins (1990) found that hydrogenated fat fed to steers had no effect on ruminal VFA, the fatty acid used in the present study might have no influence of ruminal VFA production *in vivo* because it composes mainly saturated fatty acids. Weisbjerg et al. (1992) reported that fiber digestibility was not significantly affected by tallow addition up to 6% of dry matter. As represented in Figures 2 and 3, the addition of fatty acid in animal diets did not affect cumulative gas volume *in vitro* and total VFA concentration, which also suggests that dietary fatty acid (approximately 3% of dry matter) would have no influence of fiber digestibility in the rumen.

When dietary fatty acids were added to cattle feed, plasma NEFA concentration was significantly higher than those in other groups but no change was observed in plasma triglyceride concentration (Table 2). When calcium soaps of fatty acids were added to diets for dairy cows, plasma triglycerides were increased but not free fatty acids (Sklan and Tinsky, 1993; Espinoza et al., 1995). This inconsistency might be due to the difference in calcium intake from calcium soap. Plasma HDL-cholesterol concentration of cattle given dietary fatty acids was significantly higher than that of cattle given excess concentrate (Table 2). Serum concentration of HDL-cholesterol was greater in cows fed calcium soap fatty acid (Espinoza et al., 1995). Similarly, greater concentrations of total and HDL-cholesterol were also observed by Morgan and Williams (1989) in cows fed diets with elevated lipids. Therefore, the addition of fat in the diet would have the potency to increase plasma HDL-cholesterol level in the cattle.

In conclusion, we suggest that dietary fatty acid has the potency to improve growth performance in fattening cattle without changes in rumen fermentation.

ACKNOWLEDGEMENTS

The authors would like to thank T. Inagaki, K. Uesaka, K. Nagao, Y. Hirano, M. Kondo, K. Harada and H. Hasegawa for their technical assistance and J. Okumura for his scientific advice.

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