The Effect of Feeding Calcium Soap of Fatty Acids and Sodium Acetate on the Physiological Responses of Dairy Cows

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Vegetable and animal oils and acetates are well known as precursors of milk fat in the body of cows.

Recently, some commercial calcium soaps of fatty acids have been prevalent as a supplement feed to dairy cows in Japan in order to elevate the milk fat content. However, they are generally not palatable to dairy cows and therefore an improvement of their taste is required.

On the other hand, vinegar has long been fed to animals by some dairy farmers in Japan for the above purpose. This paper deals with the milk yield, milk fat content, number of rumen protozoa, values of blood metabolites, etc. of the cows given calcium soap of fatty acids and sodium acetate. Sodium acetate was selected as a source of acetic acid for convenience in handling.

Materials and Methods

Calcium soap :

The production of calcium soap was carried out by Taiyo Yushi Co., Ltd. (Yokohama).

In brief, the procedure for the preparation of calcium soap is as follows ; 100 g of commercial soybean oil, whose fatty acids consisted of linoleic (50%), oleic (23%), palmitic (10%), linolenic (7%) and other acids, was added 13.6 g of calcium hydroxide and 150 g of water and stirred. Fifty mg of 0.5% lipase derived from *Pseudomonas Fluorescens* (Amano Pharmaceutical Co., Ltd.) was added to the mixture and stirred to gel. After standing for 3-5 hrs, the gel separated into liquid and solid. The calcium soap obtained from the solids was air-dried at room temperature for 7-8 hrs and crashed.

The energy value and calcium content of calcium soap were 7,750 cal/g and 6.3%, respectively.

Sodium acetate :

Anhydrous sodium acetate of a feed additive was purchased from the Nippon Synthetic

脂肪酸カルシウムと酢酸ナトリウムの給与が乳牛の生理機能に与える影響：相井孝允・栗原光規・久光新一・富田守*・早澤宏紀*（農林水産省九州農業試験場 熊本県西合志町 861-11 * 森永乳業食品総合研究所 座間市 228）

Chemical Industry Co., Ltd. (Osaka).

Animals :

Six Holstein cows with an average of 19.9 kg milk yield, weighing an average of 610 kg, were used in Expts 1-1 ~ 1-3.

Ration :

The cows received corn haylage ad lib., in addition to a formula feed [barley (40%) + maize (11%) + defatted rice bran (10%) + wheat bran (10%) + linseed oil meal (20%) + soybean meal (5%) + salt (1.5%) + calcium carbonate (2.5%)] and beet pulp being equivalent to the nutrient requirements for milk yield according to the Japan Feeding Standard for Dairy Cattle (1978) : The cows were given a formula feed and beet pulp during the morning and evening milking times (8 : 30 and 16 : 30 h) and received corn haylage ad lib. at the paddock except during milking times. However, for the last 5 days of every period in Expts 1-2 and 1-3, the cows were kept in the stanchion barn from 8 : 30 to 20 : 00 h and the feed intake with roughage was determined.

Feeding procedure :

Six lactating Holstein cows were separated into 3 groups with 2 cows each (Expt 1-1, Expt 1-2 and Expt 1-3). These three cow groups were offered the ration only for the first 2 weeks (1st period), and for the next 2 weeks (2nd period) they were given 420 g/head/day of calcium soap of fatty acids in Expt 1-1, 420 g/head/day of sodium acetate in Expt 1-2 and 210 g/head/day of the calcium soap and 210 g/head/day of the sodium acetate in Expt 1-3, respectively, in addition to the same ration during the 1st period. Subsequently, the cows returned to the ration only for the last 2 weeks (3rd period). The individual supplements were completely mixed with a formula feed before feeding. The quantity ratio of the supplement feeding in the morning to that of the evening was 3 : 2.

Sampling of milk, blood and rumen juice :

Milk samples were collected during the last 5 days of every period. Morning and evening

milk were combined, and analyzed for milk fat, protein and total milk solid. A part of the milk samples were frozen at -20°C until the determination of milk fatty acids composition. Milk yield was recorded daily. Blood and rumen juice were taken from the jugular vein and from rumen through a rumen catheter, respectively, at 13 : 00 to 14 : 00 h on the 9th and 11th day every period except in Expt 1-1.

Analytical methods :

Milk fat, protein and total milk solid were determined with a Gerber method, a Kjeldahl method and by a TMS Checker (K 375 A, Anritsu Electric Inc., Ltd.). Milk fatty acid composition was analyzed according to our procedure¹⁾. Fatty acid productions (FAP) were calculated as follows :

$$\text{FAP (g)} = \text{milk fat production (g)} \times \text{each fatty acids group \% in the chromatogram} \times 0.98 \text{ (glyceride \% in butter fat)} \times 0.945 \text{ (a factor obtained from the saponification value of butter fat)}$$

The determination of volatile fatty acids and the count of protozoa number were performed with SUDO's method⁹⁾ and KURIHARA and TAKECHI's method⁵⁾, respectively. The biological analyses for blood serum, total lipids, total cholesterol, triglyceride. HDL-cholesterol and NEFA were performed using an auto-analyzer (ACL 6000, Olympus Optical Co., Ltd.) via the CHEEK and WEASE's method²⁾, the COD-POD-4 AA method³⁾ and the Gly-OD-POD method¹⁰⁾, using a spectrophotometer (UVIDEC-60, Japan Spectroscopic Co., Ltd.) via the phosphotungstic acid- Mg method⁷⁾ using an auto-analyzer (Centri-Phychem 400, Union Carbide Co., Ltd.) via the ATP-POD-4 AA method⁶⁾, respectively. The analyses were carried out at a chemical analysis laboratory (Higo Rinsho Kensa Kenkyusho Co., Ltd.).

Results and Discussion

As shown in Table 1, the C 18 group (stearic, oleic, linoleic and linolenic acids) in the milk fatty acids remarkably increased from 37.10 to

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Table 1. Physiological responses of the dairy cows when taken calcium soap and sodium acetate

	Expt 1-1		Expt 1-2		Expt 1-3	
	Supplement ¹⁾	Cont.	Supplement ²⁾	Cont.	Supplement ³⁾	Cont.
Milk yield (kg/day)	17.6	17.4	22.1	21.1	20.9	20.4
Milk fat yield (g/day)	531	579	838	798	733	669
Milk composition (%)						
Fat	3.19	3.34	3.79	3.78	3.51	3.27
Protein	3.11	3.08	2.96	2.99	2.99	3.01
Total solids	11.78	12.19	12.38	12.33	12.21	11.94
Milk fatty acid composition(%)						
C4~C14 group	23.23	27.18	29.04	30.06	26.56	29.42
C16 group	29.59	35.72	41.73	38.61	38.39	45.67
C18 group	47.19	37.10	29.24	31.34	35.04	24.92
Milk fatty acids production(g/day)						
C4~C14 group	118	138	212	204	172	177
C16 group	155	180	304	268	247	238
C18 group	185	189	213	218	225	173
Rumen pH			7.2	6.9	7.1	7.0
Rumen VFA (%)						
Ac/Total VFA			60.9	58.8	59.3	57.9
Pr/Total VFA			18.5	19.9	19.6	19.8
But/Total VFA			15.8	16.4	15.3	16.0
Ac/Pr			3.3	3.0	3.1	3.0
Rumen protozoa($\times 10^4$ /ml)			41.7	44.0	40.6	38.3
Metabolite concentrations in blood serum (mg/dl)						
Total lipids	343	360	492	469	420	389
Triglyceride	9	8	8	8	11	8
NEFA ⁴⁾	386	402	453	454	415	405
Total cholesterol	115	148	215	204	141	132
HDL-cholesterol	68	72	80	79	67	67
Feed intake (DM kg) ⁵⁾			7.2	8.0	7.8	7.8
Body weight (kg)	514		630	621	691	692

Note : 1; Calcium soap supplement. 2; Sodium acetate supplement. 3; Calcium soap and sodium acetate supplement. 4; Non-esterified fatty acids (Eq/l). 5; Feed intake of roughage for 8:30~20:00 h. Ac; acetic acid, Pr; propionic acid, But; butyric acid.

Cont. indicates an average of the values obtained in Expts 1st and 3rd period.

47.19% when 420 g/head/day of calcium soap was given to the dairy cows, whereas the C 4-C 14 group (the acids from butyric acid to myristic acid, including decenoic and tetradecenoic acids) and the C 16 group (palmitic and palmitoleic acids) decreased from 27.18 to 23.23% and from 35.72 to 29.59%, respectively. Milk fat content and its production decreased by 0.15% and by 48 g/day, respectively. From these results, it is assumed that the feeding of 420 g/head/day of calcium soap, which was performed on the feeding of a formula feed with about 5% calcium soap, inhibits the de

novo synthesis of the C 4-C 14 and C 16 groups in the animal body. STORRY *et al.*⁸⁾ demonstrated the yield reduction in C 4-C 14 and C 16 groups on the feeding of a formula feed with more than 4% tallow to dairy cows. This reduction is probably due to a feedback inhibition on acetyl-CoA carboxylase by the increased concentrations of long chain acyl-CoA in the mammary gland. Therefore, the report indicates that the feeding of a formula feed with less than 4% oil supplement may not inhibit the de novo synthesis of the short- and intermediate-chain fatty acids in the gland.

When 420 g/head/day of sodium acetate was given, the C 16 group increased from 38.61 to 41.73%, but the C 4-C 14 and C 18 groups slightly decreased. According to KNIGHT *et al.*⁴⁾, when [1-¹⁴C] acetate was infused intraruminally into a sheep, the labeled acetate was incorporated mainly into the microbial palmitate in the rumen. In the case of our experiment, it is assumed that most of the sodium acetate ingested was incorporated into the microbial palmitate, and the palmitate was transformed into milk fat in the mammary glands to increase the proportion of palmitic acid in the milk fatty acids. Milk yield and milk fat production tended to increase when sodium acetate was given, but milk fat content scarcely changed. An acetic/propionic acid ratio in the rumen juice tended to broaden because of the ingestion of sodium acetate.

When the supplement composed of 210 g of calcium soap and 210 g of sodium acetate was given, the C 18 group markedly increased from 24.92 to 35.04%, whereas the C 4-C 14 and C 16 groups decreased remarkably. Milk yield, milk fat content and the fat production increased by 0.5 kg, by 0.24% and by 64 g/day, respectively. Although the productions of C 4-C 14 and C 16 groups during the 2nd period was slightly different from those during the 1st and 3rd periods, the C 18 group showed a markedly increased production. These facts indicate that feeding the proper quantities of calcium soap and sodium acetate elevates not only milk fat content but also milk yield and milk fat production, and that a considerable amount of the calcium soap of fatty acids is incorporated into the long chain fatty acids of milk fat.

In the later experiments done by the authors, daily milk yield and milk fat production increased by 0.3-0.4 kg and 62-91 g, respectively, when 220 g of calcium soap and 280 g of sodium

acetate was given to the dairy cows.

The number of protozoa in the rumen juice and the metabolite concentrations in the blood serum were recognized not to be influenced by the feeding of sodium acetate and calcium soap.

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References

- 1) AII, T., S. TAKAHASHI, M. KURIHARA and S. KUME, Fatty acid composition of milk during a hot summer. *Jpn. J. Zootech. Sci.*, **59**: 278-284. 1988.
- 2) CHEEK, S.C. and D.F. WEASE, A summation technic for serum total lipids. Comparison of methods. *Clinical Chemistry*, **15**: 102-107. 1969.
- 3) KANAI, I., *Rinsho Kensaho Teiyo*. 29th ed. 456-457. Kanehara Shuppan. Tokyo. 1983.
- 4) KNIGHT, R., J.D. SUTTON, J.E. STORRY and P.E. BRUMBY, Rumen microbial synthesis of long-chain fatty acids. *Proc. Nutr. Soc.* **38**: 4 A. 1978.
- 5) KURIHARA, K. and T. TAKECHI, in *Usi no Rinsho Kensaho*. 1st ed. (NAKAMURA, T., T. YONEMURA and K. SUDO, eds.) 6.14-6.17. Nosan Gyoson Bunka Kyokai. Tokyo. 1973.
- 6) MAEHATA, A., *Free Fatty Acids*. Medical Technology, **8**: 1029-1042. Ishiyaku Publishers, Inc. Tokyo. 1980.
- 7) NOMA, A., HDL-cholesterol (A precipitation method). *Medical Technology*, **8**: 1092-1096. Ishiyaku Publishers, Inc. Tokyo. 1980.
- 8) STORRY, J.E., A.J. HALL and V.W. JOHNSON, The effects of increasing amounts of dietary tallow on milk-fat secretion in the cow. *J. Dairy Res.*, **40**: 293-299. 1973.
- 9) SUDO, K., in *Usi no Rinsho Kensaho*. 1st ed. (NAKAMURA, R., T. YONEMURA and K. SUDO, eds.) 6.39-6.42. Nosan Gyoson Bunka Kyokai. Tokyo. 1973.
- 10) UEDA, H., Triglycerides (A enzymic method). *Medical Technology*, **8**: 1014-1019. Ishiyaku Publishers, Inc. Tokyo. 1980.