RUMINAL ACID CONCENTRATIONS OF GOATS FED HAYS AND SILAGES PREPARED FROM ITALIAN RYEGRASS AND ITS PRESSED CAKE

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Summary

From the same harvest of Italian ryegrass (*Lolium multiflorum*, Lam.), hay (H), wilted silage (WS), pressed cake hay (PCH) and pressed cake silage (PCS) were prepared. These four preserved roughages were restrictedly fed to four goats attached with rumen fistula by 4 × 4 Latin square design to determine the effect of different physical and chemical properties of the roughages on the ruminal acid concentrations. Each goat was given a diet at 2% of the body weight daily in dry matter basis by separating into two equal portions. Half was given at 9 AM and the other half at 5 PM. Ruminal pH was reduced to around 5.5 within 30 minutes after feeding PCS and it was recovered above 6 in 1-2 hours after feeding. By feeding WS, ruminal pH was also reduced but never fell below 6. The two hays rather increased ruminal pH after feeding. The reduction of ruminal pH in the silage feedings was due to the high lactic acid content of the silages, because the highest ruminal lactic acid concentration was observed 30 minutes after feeding when the lowest ruminal pH was attained. While the ruminal VFA concentrations became the highest 1-2 hours after feeding. The ruminal acetic acid concentration fluctuated so much that no significant tendency was observed among the four dietary treatments. The ruminal propionic acid concentration was higher in feeding silages reflecting the initial high lactic acid concentration. As the result, acetic/propionic acid ratio was lower in the silage feedings than in hay feedings. Higher ruminal butyric acid concentration was observed in WS than in others.

(**Key Words**: Ruminal Acid Concentrations, *Lolium multiflorum*, Silage, Hay, Pressed Cake)

Introduction

Many works have been done on the highly utilization of herbage crops by fractionating green vegetations into leaf protein concentrate (LPC), brown juice and fibrous residue (pressed cake). And it has been made clear that LPC contains three times as much protein (Ohshima, 1986) and carotenoid (Hanna and Ogden, 1980) compared with leaf meal and its amino acid compositions match well with the requirement of monogastric animals excepting sulfur amino acids (Ohshima, 1985); the brown juice is a good culture of yeast and the yield of yeast is about a half of LPC recovered in the same process (Reddy and Ohshima, 1990); and the pressed cake is as nutritious for ruminants as the material crop despite of being removed some nutrients (Houseman and Connel, 1976; Ohshima et al., 1988). But in the ruminant nutrition, the value of roughages should be evaluated from ruminal VFA concentrations as well as the digestibility, because high acetic acid concentration is effective in increasing milk fat (Annison et al., 1974; Bickerstaffe et al., 1974) while propionic acid is the most important glucose precursor in ruminants (Herbein et al., 1978) and its higher concentration in rumen fluid promotes growth or increases feed efficiency (Young, 1977).

Pressing out some juice from herbage is effective in controlling moisture content of silage material (Dumont and Boys, 1976; Schoney and McGuckin, 1983) independent from weather (Lu et al., 1980) and in reducing the cost of dehydration (Enochian et al., 1977). The pH of pressed cake silages is usually low even when young grasses and legumes are used as the material crops (Ohshima and Kogure, 1984) because a part of buffering components which prevent the lowering of pH is removed by the pressing (Ohshima and Oouchi, 1979). As the pressed cake is mechanically disintegrated, it may also be a

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Received August 8, 1990
Accepted December 10, 1990

good model of short cut herbage.

In this work, dietary factors affecting the ruminal fermentation were studied using hays and silages prepared from Italian ryegrass and its pressed cake. Pressed cake was prepared by roughly disrupting the herbage with a screw crusher and pressing out some juice with a screw press. Therefore, this study includes the following four factors; different physical states between ryegrass and pressed cake, hay and silage prepared from the same material, different concentrations of water-soluble components between the two hays, and different acid concentrations between the two silages.

Materials and Methods

Herbage

The first growth of Italian ryegrass (*Lolium multiflorum*, Lam.) grown on the Farm of Nagoya University, was harvested on April 10, 1989 at the growing stage by a forage harvester and used for the preparations of hay, wilted silage and pressed cake.

Preparation of pressed cake

Fifteen hundred kilograms of the herbage was disrupted with a screw crusher (Nihon Sharyo Ltd.) and pressed out 850 liters of green juice with a twin roll screw press (Stord Bartz Japan Ltd. JP-24-2). The remaining fibrous residue was referred as pressed cake.

Preparation of hays

A portion of the herbage and a half of the pressed cake were spread in a glass house equipped with funs and cured for four days with occasional turning. The dried products were packed into linen bags and kept in airy shade.

Preparation of silages

The herbage wilted for two days and the remaining pressed cake were packed into 10 and 20 polyethylene bags (625 mm in width, 800 mm in height and 0.06mm in thickness) at the rates of 10 and 16kg per bag, respectively. The upside of each bag was closed by tying with string after removing air with a vacuum pump. All bags were kept in a dark room at ambient temperature for about 7 months. Just before the start of feeding trial, silages for 12 days (one period) feeding were thoroughly mixed and packed again into small polyethylene bags as to feed one bag to one animal at each feeding time. The small bags were kept at 5℃.

Animal trials

Four Shiba strain Japanese pygmy castrated mature goats weighing about 17kg, were fitted with rumen fistulae and individually housed in metabolism cages. They were allotted to 4 dietary treatments in a 4×4 Latin square design. The diets used were; hay(H), wilted silage(WS), pressed cake hay(PCH) and pressed cake silage(PCS). Each goat was given a diet at 2% of the body weight daily in dry matter basis by separating into two equal portions. Half was given at 9 AM and the other half at 5 PM. Sodium chloride was offered with the evening ration at a rate of 66 mg per kg body weight. Water was acceptable at all times. All ration was consumed within 30 minutes. After 7 days of preliminary feeding, feces were collected for 4 days just before the morning ration and dried with a draft oven at 60℃. On the next day, rumen fluids were taken just before, which was called 0 hour, and at 0.5, 1, 2, 4, 6, 8, 8.5, 9, 10 and 12 hours after the morning feeding. Evening ration was given at 8th hour. The samples were taken as follows. A vinyl pipe (13mm in diameter) bored many holes and covered by a nylon stocking was inserted into the rumen through fistula. The fluid filtered into the pipe was taken by suction through a stomach tube. After measuring the pH value, all the fluids were added a few drops of saturated mercury chloride solution and stored at −20℃.

Analyses

The dry matter contents of silage samples were determined by the toluene distillation method (Dewar and McDonald, 1961). Those of the other samples were determined by oven-drying procedure. Determination of crude protein was made by the Kjeldahl method on fresh silages and dried powders of hays.

Twenty grams of each silage was homogenized with 200 ml of water for 1 minute. The homogenate was stored overnight at 5℃ and then filtered through Toyo No.2 filter paper. The silage filtrates and the rumen fluids were subjected to the following analyses.

The pH values were determined with a glass rod electric pH meter (Horiba F-12). Lactic acid was determined photometrically (Barnett, 1951). Volatile fatty acids were analysed on the distillates of acidified samples (Ohshima, 1982) using a gaschromatograph (Shimadzu GC-12A) equipped with flame ionization detector and fitted with a 1.5m × 3mm glass column packed with 25% FAL-M on 80 to 100 mesh Chromosorb W. The oven, injector and detector temperatures were 145, 200 and 200℃, respectively. Nitrogen was used as carrier gas at a pressure of $1.6 kg/cm^2$. Ammonia concentration of the silage filtrates was determined by a distillation method (Ohshima, 1982).

The statistical analysis was made by Duncan's multiple range test.

Results and Discussion

Dry matter and crude protein contents and the in vivo dry matter digestibilities of the diets are shown in table 1. The dry matter contents of both the hays were around 90% suggesting that they were preserved at moderate conditions. That of WS was ideal. That of PCS was a bit too low, but it can easily make high by decreasing the motor speed of the screw press or by re-pressing the pressed cake. The crude protein contents of PCH and PCS were significantly less than those of H and WS reflecting removal of some water soluble components from the pressed cake. But the dry matter digestibilities of WS and PCS were not different. The similar digestibility might be derived from the higher cellulose digestibility of pressed cake compared with the material herbage (Walker et al., 1982). The dry matter digestibilities of H and PCH were significantly lower than those of WS and PCS, and although the difference was not significant, PCH was inferior to H. In our previous study, the difference in the digestibility between the two hays was more great and was significant (Ohshima et al., 1988). The lower digestibility in hays may be due to a formation of indigestible components during the long-term sun curing process which may occur more vigorously on pressed cake because more components are exposed to air. Pressing out juice from macerated herbage is effective in improving the cell wall digestibility when they are artificially dried (Lu et al., 1980).

Chemical quality of silages shown in table 2 are quite similar to those obtained in a previous study (Ohshima et al., 1988). In either studies, PCS was lower in pH, lactic acid and ammonia contents, and higher in acetic acid and propionic acid contents than the material crop silage. The low pH of PCS is derived from partial removal of buffering components before ensiling rather than the high VFA contents (Ohshima and Oouchi, 1979).

Ruminal lactic acid concentration peaked at 1.6-3.4mmole/100ml at 30 minutes after feeding WS and PCS, and rapidly reduced to zero after 2-4 hours. While little rise of it was observed in both the hay feedings (figure 1). A similar result was reported by Waldo and Schultz (1957).

Synchronizing with the lactic acid concentrations, the ruminal pH of goats fed the silages reduced drastically just after feeding and the rate was greater in PCS feeding than in WS feeding (figure 2). The different particle size between the two silages is possible explanation. As PCS was

TABLE 1. DRY MATTER AND CRUDE PROTEIN CONTENTS AND IN VIVO DRY MATTER DIGESTIBILITIES OF HAYS AND SILAGES PREPARED FROM ITALIAN RYEGRASS AND ITS PRESSED CAKE[1]

Item	H[2]	WS[3]	PCH[4]	PCS[5]
Dry matter (%)	89.7[a]	36.1[b]	90.1[a]	26.2[c]
Crude protein (% DM)	14.8[a]	15.4[a]	13.4[b]	12.8[b]
Dry matter digestibility (%)	68.3[b]	73.4[a]	64.5[b]	73.0[a]

[1] Means of 4 replicates. The values with different superscript letters in the same row are significantly different at 5% level.
[2] Hay
[3] Wilted silage
[4] Pressed cake hay
[5] Pressed cake silage

mechanically disintegrated before ensiling, the animals given it might not chew so much as might be done by those fed WS and consequently, saliva excretion might be limitted. This assumption is supported by the fact obtained in the hay feedings in which ruminal pH was increased by feeding and the rate was greater in H than in PCH. As the results, the ruminal pH was always in normal ranges in goats fed WS as well as those fed the hays, while it fell to 5.6 and 5.4, respectively, at 30 minutes after morning and evening feedings of PCS. Such low pH will restrict the activity of cellulolytic bacteria. Because cellulose digestion is completely inhibited at pH less than 6.0 (Mould et al., 1983 4).

Total VFA concentrations of rumen fluids were increased by feeding the diets and the rate was the greater in WS which was followed by PCS (figure 3). The peak values were observed 1-2 hours after feeding. These facts suggest that the pH drop of the rumen fluids of goats fed the silages are attributable to lactic acid because the peaks of both the values were observed 30

TABLE 2. CHEMICAL QUALITY OF THE SILAGES PREPARED FROM ITALIAN RYEGRASS[1]

Item	WS[2]	PCS[3]
pH	4.43[a]	3.98[b]
Total acids (% DM)	10.3[b]	13.4[a]
Lactic acid (% DM)	8.06	7.67
Acetic acid (% DM)	2.08[b]	4.78[a]
Propionic acid (% DM)	0.06[b]	0.31[a]
iso-Butyric acid (% DM)	0.02	0.05
n-Butyric acid (% DM)	0.03	0.30
Ammonia-N (% DM)	11.3[a]	8.31[b]

[1] Means of 4 replicates. The values with different superscript letters in the same row are significantly different at 5% level.
[2] Wilted silage
[3] Pressed cake silage

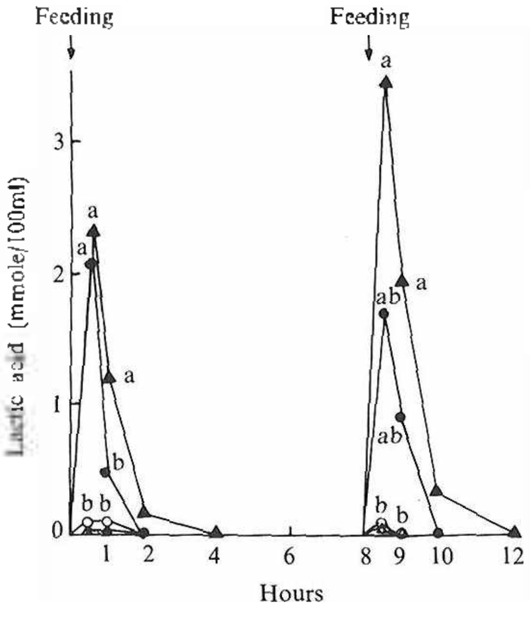

Figure 1. Time course of ruminal lactic acid concentration of goats fed hay (H:○), wilted silage (WS:●), pressed cake hay (PCH:△) and pressed cake silage (PCS:▲) made from Italian ryegrass. The data show means of 4 goats. Those with different letters in the same hour are statistically different at 5% level.

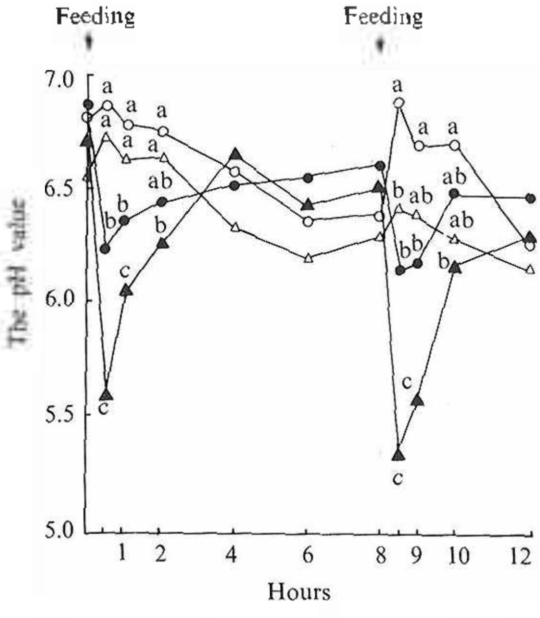

Figure 2. Time course of ruminal pH of goats fed hay (H:○), wilted silage (WS:●), pressed cake hay (PCH:△) and pressed cake silage (PCS:▲) made from Italian ryegrass. The data show means of 4 goats. Those with different letters in the same hour are statistically different at 5% level.

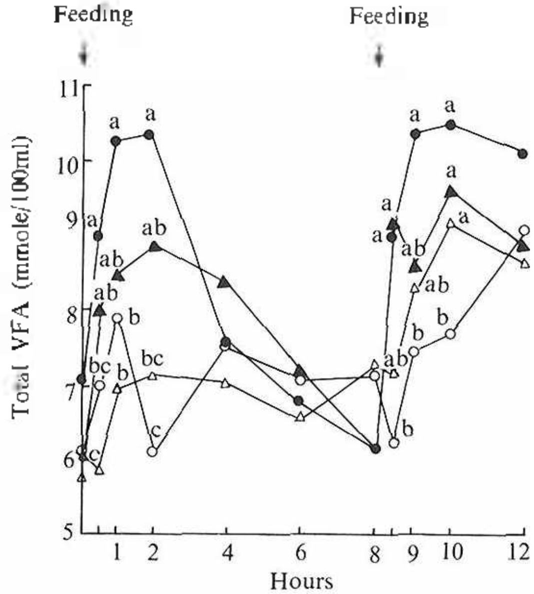

Figure 3. Time course of total ruminal VFA concentrations of goats fed hay (H:○), wilted silage (WS:●), pressed cake hay (PCH:△) and pressed cake silage (PCS:▲) made from Italian ryegrass. The data show means of 4 goats. Those with different letters in the same hour are statistically different at 5% level.

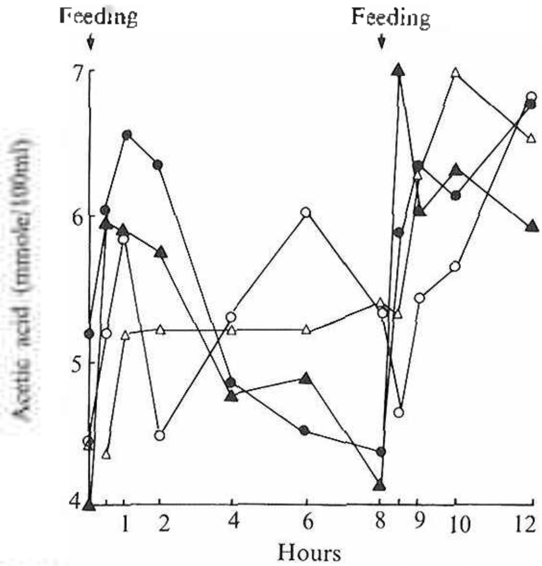

Figure 4. Time course of ruminal acetic acid concentration of goats fed hay (H:○), wilted silage (WS:●), pressed cake hay (PCH:△) and pressed cake silage (PCS:▲) made from Italian ryegrass. The data show means of 4 goats.

minutes after feeding. It is known that lactic acid is 10 times stronger an acid than volatile fatty acids (Russel, 1988). The different total ruminal VFA concentrations between WS and PCS cannot be explained from the present data.

Time course of the ruminal acetic acid concentrations were so fluctuated that no systematic relationship was observed among the four dietary treatments (figure 4). But there was a tendency to be higher after 1-2 hours and to be lower after 4-8 hours of the morning feeding in the silages than in the hays. A part of the initial high value is attributable to acetic acid contained in the silages and the following low values may be due to less ruminal acetic fermentation of the silages. The reason is not clear, but they were more fluctuated after the evening feeding.

The ruminal propionic acid concentration was usually higher in the silage feedings than in the hay feedings (figure 5). Time course of it was almost constant in the hay feedings but sudden rise was observed after feeding the silages showing

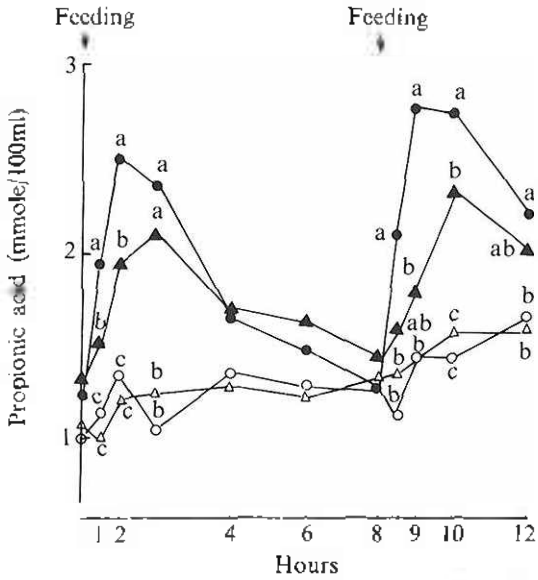

Figure 5. Time course of ruminal propionic acid concentration of goats fed hay (H:○), wilted silage (WS:●), pressed cake hay (PCH:△) and pressed cake silage (PCS:▲) made from Italian ryegrass. The data show means of 4 goats. Those with different letters in the same hour are statistically different at 5% level.

peaks at 1-2 hours. As lactic acid is one of the precursors of propionic acid in the rumen (Russel and Hespell, 1981), this result might be derived from the preceding high lactic aicd concentration.

As the results, the ratio of acetic to propionic acid (A/P ratio) was usually higher in goats fed the hays than those fed the silages except for a extraordinarily high value obtained at 30 minutes after the evening feeding on PCS (figure 6). These facts suggest that a sudden feeding of silage to fasted cows should not be made because low A/P ratio reduces milk fat yield (Woodford et al., 1986).

No significant effects of the physical states of the materials on the ruminal concentration of acetic and pronionic acids and the resultant A/P ratio were observed. It can be explained as follows. Although the pressed cake was lessen the width by disintegrating herbage with the screw crusher and the screw press, it still had more than 0.64cm in length which is enough to keep as high ruminal acetic acid production as yielding milk of high fat content (Woodford et al., 1986).

Ruminal butyric acid concentration was usually higher in WS than in others (figure 7). Similar results between hay and silage have been reported by many workers (Waldo and Schultz, 1957; Izumi, 1975; Takahashi and Itoh, 1988). As PCS contained more butyric acid than WS (table 2), higher ruminal butyric acid concentration in WS than in PCS was not caused by different butyric acid intake. A possible explanation of it is the higher protein content (table 1) in WS, because a part of butyric acid in the rumen is formed by deamination of some amino acids (Wallace, 1988). The different ruminal butyric acid concentrations between WS and H was supposed to be due to different ruminal protein degradabilities, because nearly a half of herbage protein is already degraded during ensilage process (Ohshima and McDonald, 1978).

In conclusion, the pressed cake was as good material of hay and silage as the material Italian ryegrass in respect to the ruminal acid concentrations.

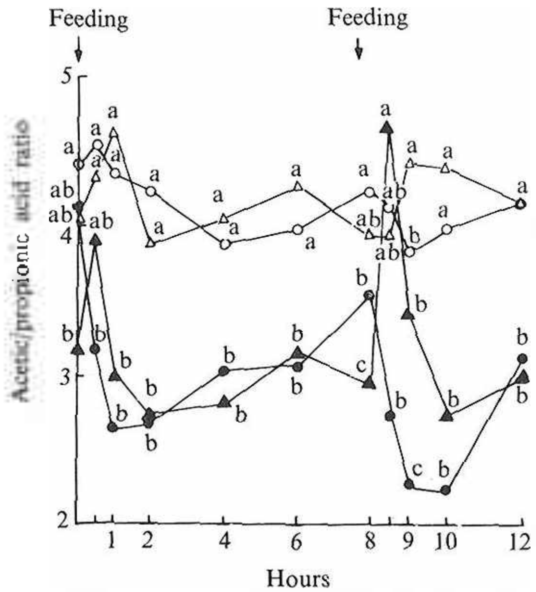

Figure 6. Time course of acetic / propionic acid ratio in the rumen of goats fed hay (H:○), wilted silage (WS:●), pressed cake hay (PCH:△) and pressed cake silage (PCS:▲) made from Italian ryegrass. The data show means of 4 goats. Those with different letters in the same hour are statistically different at 5% level.

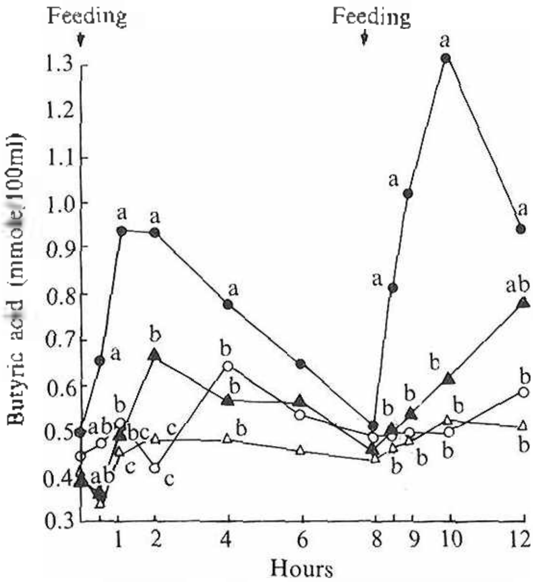

Figure 7. Time course of ruminal butyric acid concentration of goats fed hay (H:○), wilted silage (WS:●), pressed cake hay (PCH:△) and pressed cake silage (PCS:▲) made from Italian ryegrass. The data show means of 4 goats. Those with different letters in the same hour are statistically different at 5% level.

Acknowledgements

The authors are grateful to Dr. T. Okajima for his valuable advice on statistical analysis and to Mr. T. Nagatomo for his technical assistance.

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