In Vitro Digestibility of Fiber Fraction of Aerobically Deteriorated Silage

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The influence of aerobic deterioration on the chemical composition and fermentation quality of silage is well known⁹⁾, but limited information is available concerning its influence on silage digestibility. The digestibilities of crude protein and nitrogen-free extracts (NFE) appear to be consistently decreased by aerobic deterioration^{5,7,8)}. However, the influence of aerobic deterioration on the digestibility of fiber fractions such as crude fiber, neutral-detergent fiber (NDF) and acid-detergent fiber (ADF) is rather inconsistent. In our previous digestion trials^{7,8)} with wether sheep, it was shown that the digestibilities of fiber fractions of aerobically deteriorated silages were higher than those of undeteriorated control silages. Similar enhancement of fiber digestion by aerobic deterioration was also noted by DEOKA *et al.*⁴⁾.

This paper presents results from an *in vitro* digestion trial using as a substrate, the silages used in a previous *in vivo* trial⁸⁾ to discuss the nature of this enhancement.

Materials and Methods

Preparation of substrate : High- and low-moisture silages with and without aerobic

exposure treatment used in a previous study⁸⁾ were used as a substrate after being freeze-dried and ground to pass through a 1-mm screen.

A broad outline of the aerobic exposure treatment is as follows : after removal from silos, each of the high- and low-moisture silages which contained about 80 and 55% moisture, respectively, being made from the same grass material, was divided into two parts. Each first part was stacked in the open air for 7 days, then immediately stored in a refrigerator and used as undeteriorated control silage. More details have been reported previously⁸⁾.

Washed silages were also prepared as a substrate to remove the effects of differences in fermentation quality between deteriorated and control silages.

The silages were treated as follows : about 30 g of above ground silages (unwashed silages) was put into 1 l beaker and then about 600 ml of distilled water was added. The beaker was kept in an icebox overnight, and the content was stirred occasionally. After adjusting the pH content to 6.8 with N-Na₂CO₃ or N-HCl, the beaker was put in an icebox again for

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several hours. The content was strained through two layers of surgical gauze and then the strained fluid was centrifuged at $18,000 \times g$ for 20 min. After mixing the precipitate with the strained residue, the whole residue was freeze-dried to be used as washed silage.

In vitro digestibility trial: The *in vitro* digestibility of dry matter was determined by the two-stage method of TILLEY and TERRY¹¹, in which the ground substrates were incubated with buffer solution and rumen liquor strained through a filter cloth for 48 hours in the first stage. Those of NDF and ADF were determined by a modified method³ in which the second stage in the two-stage method is substituted with a neutral- or acid-detergent extraction. Quintuplicate samples of each ground silage were used for this determination.

Analyses: The chemical composition of the silages were determined by the methods given in a previous report⁷.

Results and discussion

A precious *in vivo* trial⁸ showed that dry matter digestibility of deteriorated silages was lower than that of control silages, even when the fiber digestibility was higher. In this

study, similar results were obtained (Table 1). This is probably because the depression in crude protein and NFE digestibilities by aerobic deterioration overcomes the enhancement of fiber digestibility. It is considered that the depression in crude protein digestibility is primarily due to denaturation of protein⁵ and the loss of soluble protein⁸ by aerobic deterioration, and that in NFE is due to the loss of readily digestible carbohydrates such as WSC and organic acids such as lactic acid and VFA⁸.

The *in vitro* trial (Table 1) showed that digestibilities of NDF and ADF were significantly higher for the deteriorated silages than for the control silages. However, the differences were considerably smaller, than those in a previous *in vivo* trial⁸, in which for high-moisture silage, the digestibilities of NDF for deteriorated and control silages were 72.8 and 65.5%, ADF 65.0 and 62.9%; and for low-moisture silage, NDF 78.2 and 67.3%, ADF 71.9 and 64.9%, respectively. In a previous report⁸, it was pointed out that the following factors might contribute to the higher fiber digestibility of the deteriorated silage: (1) it contained more isoacids which stimulated fiber digestion in the rumen¹; (2) it contained less

Table 1. Chemical composition and *in vitro* digestibility of fiber fraction of aerobically deteriorated silage

	High-moisture silage						Low-moisture silage					
	Unwashed		SE	Washed		SE	Unwashed		SE	Washed		SE
	C	D		C	D		C	D		C	D	
Chemical composition (% on dry matter basis)												
Dry matter	94.4	93.2		92.5	92.3		90.6	90.0		91.9	91.7	
Crude protein	14.1	12.6		9.3	10.9		14.5	13.8		10.1	10.9	
WSC	5.4	4.9		3.2	2.5		8.4	6.6		3.2	2.4	
NDF	56.2	67.7		75.5	79.0		58.4	66.2		74.2	75.8	
ADF	35.7	47.5		49.3	55.8		38.3	48.3		51.5	55.3	
Digestibility (%)												
Dry matter	65.5	61.3**	±0.46	51.5	49.4**	±0.57	64.2	61.2**	±0.40	56.2	57.7**	±0.26
NDF	59.9	62.9*	±0.94	56.6	58.3*	±0.52	61.2	64.9**	±0.83	58.2	60.3**	±0.63
ADF	61.9	65.5**	±0.87	56.0	58.5**	±0.49	64.5	67.6**	±0.73	65.0	67.4**	±0.59

C: Control (undeteriorated) silage D: Deteriorated silage SE: Standard error

*, **: Significantly different ($P < 0.05$, $P < 0.01$, respectively) from the value for control silage.

water-soluble carbohydrates (WSC) which lowered fiber digestibility above a certain level²⁾; (3) its pH was higher, resulting in a higher pH value in the rumen, whose condition was suitable for the activity of fiber digesting microorganisms¹⁰⁾; and (4) its fiber fraction changed to become more easily digested. (1), (2) and (3) derived from the changes in fermentation quality caused by aerobic deterioration, and are considered to affect fiber digestion less *in vitro* than *in vivo*, because the concentration of substrate in *in vitro* digestibility trials is only about 1%, w/v, much less than in the rumen, where it is 8–18%, w/v⁶⁾. This is reflected in the result that for NDF and ADF digestibilities, the differences between deteriorated and control silages were smaller *in vitro* than *in vivo*.

In this study, silage samples were washed with water to remove as much as possible the effects of differences in fermentation quality, including pH value, lactic acid, VFA, isoacids, WSC contents and so on. As a result, the NDF and ADF digestibilities of washed silages were still significantly higher for the deteriorated silages than for the control silages, although the differences were somewhat small as compared to those of the unwashed silages. This difference is considered to indicate increased fiber digestibility caused by the change in the fiber fraction itself.

As mentioned above, the differences between NDF and ADF *in vitro* digestibilities between the deteriorated and control silages were apparently smaller than those *in vivo*⁸⁾, and the differences after washing treatment with water were still significant. From these results, it is considered that the higher *in vivo* digestibility of fiber in the deteriorated silage is mainly due to the changes in fermentation quality and due in small part to changes the fiber itself caused by aerobic deterioration.

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