Rate of degradation of organic matter and neutral-detergent fibre in barley straw: effect of genetic variation and treatment with ammonia on degradation *in sacco* and *in vitro*

A. Gomez Cabrera* and J. M. van der Meer (Institute for Livestock Feeding and Nutrition Research, IVVO, P.O. Box 160, 8200 AD Lelystad, Netherlands)

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Abstract. The effect of ammonia treatment of barley straw on rate and extent of degradation in rumen juice was studied *in vitro* and *in sacco*. The straw of 2 varieties obtained from OECD differed in content of organic matter and digestibility of cell-wall. Ammonia treatment increased both degradation rate and digestibility.

Key words: barley straw, digestibility, degradation rate, *in sacco, in vitro*

Introduction. Fibrous by-products of cereal crops have a very limited value as feed for animal production because of their low digestibility. The nutritive value of these by-products can be improved by treatment with alkali (Jackson, 1978).
Under the auspices of a cooperative 'Cellulose programme' among member states of OECD (Theander et al., 1984), the present study has two objectives:
- to study the effect of straw variety and ammonia treatment on chemical composition of straw and carbohydrate composition of cell-walls;
- to study the effect of straw variety and ammonia treatment on degradation characteristics *in vitro* and in nylon bag incubations (*in sacco*) of organic matter and cell-wall components.

Materials and methods. Samples: untreated barley straw and treated barley straw with 3 % (v/v) ammonia (properties described by Theander et al., 1984) cv. Gold Spear (Maquire, Dunsinea Research Centre, Dublin) and cv. Sonja (Stewart, Rowett Research Institute, Aberdeen). Chemical analysis: sample preparation (ISO 6498), moisture content (ISO 6496), ash content (ISO 5984) and crude protein content (ISO 5983).
Cell-wall components were determined by the method of van Soest & Wine (1967), eliminating the use of sodium sulphite and decahydronaphthalene; total hemicellulose sugars and cellulose sugars and uronic acids were determined in hydrolysates by the colorimetric methods described by Gaillard (1958; 1966). Individual monosaccharides were estimated by HPLC by the method of Windham (1983).

* Present address: Department of Animal Production, ETSIA University of Cordoba, Spain.

The procedure *in vitro* followed Agriculture Handbook No 379 (USDA, 1975). Samples were incubated with rumen fluid of sheep for different periods and then extracted with neutral-detergent solution. To estimate rate and extent of breakdown *in sacco*, nylon bags with about 5 g of the straw were incubated in the rumen of lactating dairy cows fitted with large rumen cannula and fed on a basal diet of 10 kg of hay supplemented with 2 or 10 kg of concentrates. The nylon bags (size 19 × 10^2 cm) consisted of monofilament nylon gauze P41 (mesh width 41 μm). After removal from the rumen at different times, the contents of the nylon bags were treated with neutral-detergent solution.

The duration of both kinds of incubation were 0, 6, 12, 24, 48 and 76 h. The residue after treatment with neutral detergent was dried at 103 °C for one night, weighed, and then ashed and weighed again.

Results and discussion. The content of crude protein in the untreated 'Sonja' and 'Gold Spear' straw differed considerably (Table 1). Ammonia treatment increased content of crude protein in organic matter to 108 and 101 g/kg, respectively. The two varieties had the same content of neutral-detergent fibre. The reduction in neutral-detergent fibre on ammoniation is partly explained by the increase in content of crude protein and partly by the release of hemicellulose. There was also a reduction in the content of uronic acid in neutral-detergent fibre, perhaps by a chemical change with the added ammonia (Hartley, 1986). Breakdown in bags was influenced by the amount of concentrate the sheep received; when the amount of concentrate increased from 2 to 10 kg/d, the fraction of cell-wall components broken down from 24 h onwards was reduced by about 10 %.

With a kinetic model to describe the first-order degradation, lag time, degradation rate and indigestible residue were calculated. The lag time differed *in vitro* and

Table 1. Chemical composition of organic matter (g/kg) and degradation characteristics of its neutral-detergent fibre of straw untreated or treated with ammonia solution (30 ml/l). For the last three quantities, values in vitro are followed, in parentheses, by values for bags in rumen.

	Sonja		Gold Spear	
	untreated	treated	untreated	treated
Crude protein	66	108	15	101
Neutral-detergent fibre	727	690	726	672
Acid-detergent fibre	427	469	454	435
Acid-detergent lignin	95	99	82	71
Uronic acids	120	70	114	27
Anhydroglucose	330	333	335	388
Anhydroxylose	189	191	178	187
Anhydroarabinose	38	39	42	43
Lag time (h)	11 (2)	9 (1)	11 (4)	8 (x)
Degradation rate (%/h)	3.6 (2.8)	3.6 (3.5)	3.6 (3.6)	5 (x)
Indigestible residue (%)	53 (42)	31 (28)	44 (39)	19 (x)

in sacco, averaging 10 and 2 h, respectively. In general, digestibility in bags was higher for both organic matter and cell walls than *in vitro*. However after correction for the differences in lag time, the degradation rates for both procedures were the same. The overall degradation rate of cell-wall material was similar for the two varieties and the two techniques (for neutral-detergent fibre about 3.5 %/h). For ammonia-treated straw, cell-wall digestibility after incubation for 48 h was higher, in bags by about 30 % and *in vitro* by about 40 %. On the other hand, digestibility *in vivo* can also be predicted from the regression *in vitro* using standard samples with known values *in vivo* (van der Meer, 1986). If so, the improvement in digestibility would be smaller. The residue was larger for cv. Sonja. This result is explained by the higher lignin content of 'Sonja' (Table 1).

Conclusions. 'Sonja' and 'Gold Spear' straw samples contained equal quantities of NDF. The differences in NDF digestibility could be explained by the differences in lignin content. NH_3 treatment improved the digestibility in both straw varieties by about the same percentage.

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