INTAKE, DIGESTIBILITY, RUMINAL CHARACTERISTICS AND RATE OF PASSAGE OF ORCHARDGRASS DIETS FED TO SHEEP

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Summary

Four orchardgrass diets ranging in cell wall content from 60 to 78% were fed to sheep, and relationships among intake, digestion, passage and ruminal measurements were determined. As cell wall concentration increased, dry matter intake, digestible energy intake, dry matter digestibility and excretion rate decreased, while cell wall intake, rumen volume, rumen cell wall and retention time increased. Indigestible cell wall intake was similar with each diet. It appeared that as digestible energy intake decreased, the sheep attempted to adapt by increasing ruminal ingesta volume, increasing ruminal ingesta cell wall and decreasing rate of passage; as cell wall concentration increased, indigestible cell wall limitation was manifested in decreased levels of feed and energy intake. Rate and extent of digestion appeared to be related to indigestible cell wall and appeared to be key factors in the control of cell wall turnover and feed intake.

(Key Words: Forage, Intake, Turnover, Cell Wall, Ingesta.)

Introduction

Rumen fill is a factor in limiting the intake of forages (Blaxter et al., 1961; Campling and Balch, 1961; Baumgardt, 1969). Van Soest (1965) suggested that fiber mass in the rumen appears to limit intake when the cell wall content of the diet is 60% or more on a dry matter basis. Van Soest (1975) indicated that the amount of high fiber diets that ruminants can consume varies with the proportion of structural carbohydrates. In general, grasses contain more cell wall and less lignin than legumes at similar vegetative stages, which limits the intake of grasses more than that of legumes.

The role of rumen fill or rumen distension in controlling intake is a matter of controversy. Fell et al. (1964) and Tulloh (1966) found that rumen volume increased during lactation in sheep and cattle, respectively, while Forbes (1968, 1969) concluded that rumen volume changed little during lactation and early gestation in ewes. In slaughter studies, Ulyatt et al. (1967) found that rumen volume varied little among sheep consuming different forages. Ingalls et al. (1966) concluded that fill in the lower gastrointestinal tract did not appear to limit intake. Distension of the rumen probably controls day-to-day variations in intake (Hervey, 1969), whereas long-term control of intake is physiological and responsive to changes in energy metabolism (Conrad et al., 1964; Campling, 1970).

Numerous researchers have studied variables thought to control, or at least be related to, intake. Few have examined simultaneously such variables as intake, cell wall turnover, rate of digestion, rate of passage, et cetera. Mertens (1973) suggested that rate of passage, rate of digestion and cell wall turnover are major factors regulating dry matter intake, but he lacked well-controlled, supportive animal data.

The objective of this study was to determine the relationship of intake to several variables, including cell wall turnover, rumen volume, rate of passage and digestibility of orchardgrass hay fed to sheep.

Materials and Methods

A 4 x 4 Latin square design was used. Four mature wethers fitted with ruminal cannulas were fed four hay diets ranging from low to high in cell wall content. The diets were: (A) 60:40 (w/w) vegetative orchardgrass hay and mechanically separated alfalfa leaves, (B) orchardgrass hay at early head, (C) orchardgrass

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hay at late head and (D) orchardgrass hay at seed. All diets were chopped through a 13-mm screen to equalize particle size. Sheep were kept in elevated collection stalls and were fed enough feed twice daily to effect about 10% refusal. Water and trace mineralized salt blocks were provided *ad libitum*.

Each period consisted of 7 days of adjustment to diets followed by 7 days of collection, during which feed offered, feed refused, feces and urine were measured, sampled and composited. Following the collection period was a 7-day period for determining rate of passage. Rumens were emptied manually, volume and weight of ingesta were measured and samples were obtained for analyses. Ingesta was returned completely and immediately; 10.0 µCi of 144Ce (in solution) was injected throughout the ingesta with a disposable 25-cc syringe. Feces were collected before dosing (0 hr) and at 12, 18, 24, 28, 32, 36, 48, 72, 96, 120, 144, 168 and 192 hr after dosing. Samples of feces were stored at 4 C in double plastic bags until counted with a liquid scintillation detector (Coffman, 1968).

Forage fiber (Goering and Van Soest, 1970) and N (AOAC, 1970) were determined on composite samples. Densities of feces and ingesta were determined according to the method of Baile and Pfander (1967), and particle size according to the method of Waldo *et al.* (1971).

Analysis of variance was performed with animals used as columns, periods as rows and forages as treatments; means were compared by Least Significant Difference (Snedecor and Cochran, 1967).

### Results and Discussion

Chemical composition of the forages is presented in table 1. Analyses were typical, and, although the range in cell wall contents (60 to 78%) was less than anticipated, it appeared large enough to affect expected intake and digestibility differences. Crude protein content characteristically decreased from 18 to 10% as fiber level increased; no attempts were made to equalize N content of forages because of possible interactions between forage and protein supplement.

Density and geometric mean diameter (GMD) of the diet and ingesta of orchardgrass hay are presented in table 2. Density of ingesta (.9706 g/ml) was greater (*P*<.05) than that of the diet (.1285 g/ml) because of hydration of the rumen contents, which averaged 88% water. Densities of diets B, C and D were similar; density of diet A was considerably higher than that of the others, probably because of a large amount of soluble material associated with alfalfa leaves, which were 47% cell wall and 18% protein. A decrease in forage particle size has been shown to increase voluntary intake (Conrad *et al.*, 1964); the effect of particle size appeared to be minimized by the chopping of forages through a 13-mm screen, as indicated by the similarity in GMD (table 2) among the diets. Particle size of ingesta was smaller (*P*<.05) than the particle size of diets (558 vs 857 µm GMD), presumably because of chewing and rumination to facilitate digestion in, and passage from, the reticulo-rumen.

Digestion values for detergent fibers, dry matter and protein are presented in table 3. Dry matter digestibility of forage A (60%) was significantly higher than that of each of the other three forages (49 to 53%), which were similar. Digestibility of acid and neutral detergent fiber followed the pattern, diet A>B>C, with all differences significant; diet D was similar to diet A in fiber digestibility, despite having the highest neutral detergent fiber content (78%, table 1). The reason that forage D had apparently aberrant values is not evident; significantly higher digestibilities for diet A probably were due to greater quantities of soluble carbohydrates and greater protein content of alfalfa leaves (table 1). Increasing cell wall content was accompanied by decreasing dry matter and fiber digestibilities, except in diet D.
Dry matter intake, cell wall intake and ruminal measurements are presented in table 4. There were significant treatment effects on dry matter intake, cell wall intake and digestible cell wall intake. Sheep consumed more (P<.05) dry matter from diet A (1,742.5 g/day or 72.15 g/body weight kg^{-0.75} [MBS]/day) than from the other diets; intake tended to decrease from diet B to diet C to diet D, but differences among means were not significant (P<.15). Cell wall intake (44.35 g/MBS) and digestible cell wall intake (27.12 g/MBS) were greater for sheep fed diet A than for those fed the other diets (ranges of 33.88 to 36.35 and 19.33 to 23.21 respectively). Although not significant, there was a trend for intake of cell wall and of digestible cell wall to increase from diet B to diet C to diet D; this was in the opposite direction from dry matter intake and reflected increasing cell wall concentration of the diets. Indigestible cell wall intake was similar with each diet (range of 13.58 to 15.79 g/MBS/day).

Digestible energy intake of sheep (megacalories/day, table 4) decreased from diet A (4.43) to diet B (2.97) to diets C (2.48) and D (2.53).
TABLE 4. DRY MATTER INTAKE, CELL WALL INTAKE AND RUMINAL CHARACTERISTICS OF SHEEP FED ORCHARDGRASS HAY DIETS

<table>
<thead>
<tr>
<th>Item</th>
<th>Significant effects</th>
<th>Diet</th>
<th>SD</th>
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<tbody>
<tr>
<td>Dry matter intake, g/day</td>
<td>P, T</td>
<td>A</td>
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</tr>
<tr>
<td>Dry matter intake, g/MBS/day</td>
<td>T</td>
<td>B</td>
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<td>Cell wall intake, g/MBS/day</td>
<td>T</td>
<td>C</td>
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<tr>
<td>Digestible cell wall intake, g/MBS/day</td>
<td>T</td>
<td>D</td>
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<tr>
<td>Indigestible cell wall intake, g/MBS/day</td>
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<tr>
<td>Ruminal ingesta volume, ml/day</td>
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<tr>
<td>Ruminal ingesta density, g/ml</td>
<td>P</td>
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<tr>
<td>Ruminal ingesta cell wall, g/MBS</td>
<td>A, T</td>
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<td>Mean retention time, hr</td>
<td>A</td>
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<td>Maximum excretion rate, %/hr</td>
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<td>Metabolic body size, kg</td>
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<td>DE maint, req., Mcal/day</td>
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<td>DE intake, Mcal/day</td>
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aContains 40% alfalfa leaves by weight.
b,c,dMeans in same row with different superscripts differ (P<.05).
e,fMeans in same row with different superscripts differ (P<.01).
h,iMeans in same row with different superscripts differ (P<.15).
kEffects of period (P; P<.05), animals (A; P<.05) and(or) treatment (T; P<.01).
MBS = body weight (kg)\(^{79}\).

As a result of decreased concentration of digestible energy and decreased dry matter intake. Digestible energy content appeared to meet maintenance needs in diets A and B but not in diets C and D. Because of the increase in cell wall content from diet B to C to D and the decrease in cell wall digestibility from diet B to C, a possible limit to the amount of indigestible cell wall tolerated physically by the gastrointestinal tracts of the sheep was manifested by decreasing levels of feed intake. Thus, even though the sheep fed the higher cell wall diets were apparently deficient in digestible energy intake, the indigestible cell wall load limited compensatory intake of cell wall and, therefore, of feed. Ruminal ingesta volume increased (435, 502 and 483 ml/MBS) and ruminal ingesta cell wall increased (29.70, 40.83 and 38.25 g/MBS) from diet B to diets C and D, respectively; this apparently represented an attempt by the animals to accommodate greater cell wall and feed intake and to overcome their digestible energy deficit.

Mean retention time increased from 34.13 hr with diet A to 43.87 hr with diet D while excretion rate decreased from 2.39%/hr with diet A to 1.93%/hr with diet D, indicating that cell wall turnover decreased as cell wall intake increased. Decreasing dry matter and cell wall intake of animals from diet A to D concurrent with increased retention time suggests that rates of digestion of dry matter and cell wall, as well as extent of digestion, must have decreased (table 3). This suggests that both rate and extent of digestion had key roles in regulating intake and utilization of forages in that higher fiber forages were digested more slowly, contributed to a greater rumen cell wall load and resulted in an indigestible cell wall load that was manifested by reduced forage intake. Diet A was associated with greater intakes of dry matter, cell wall and digestible cell wall, greater ruminal ingesta volume and a greater excretion rate than the other diets. This could have been due to the alfalfa leaves in diet A; alfalfa diets appear to have digestion-passage dynamics much different from those of orchardgrass diets (Robles, 1977).

Although the forages were processed as similarly as possible, particle size of the diets
did vary somewhat. This did not appear to be a major factor; although particle size of diet D was greater than that of diet C, most intake and ruminal ingesta measurements of sheep fed the two diets were similar in magnitude.

**Literature Cited**


