MASTICATION AND RUMINATION EFFECTS ON DIGESTION AND PASSAGE
Michael R. Murphy and Kathryn E. Cowles

TAKE HOME MESSAGES

• Mastication enhances both solubilization and rate of degradation of feedstuffs.
• A synergy exists between rumination and fermentation in the rumen. Fermentation increases the effectiveness of rumination in reducing particle size and rumination enhances subsequent fermentation.
• About one-third of masticated chopped hay is small enough to pass from the reticulorumen when initially swallowed. Rumination helps reduce the remaining two-thirds of this material to a passable size.
• Knowledge is currently limited because no information exists for mixed diets and few data are available for forages, none for silages or which examine the effects of maturity.

INTRODUCTION
The size of large particles consumed by cattle must clearly be reduced before passage from the reticulorumen can occur. Mastication and rumination accomplish this and are important determinants of rumen function, nutrient digestion, and animal productivity. Our objective was to examine available evidence addressing the specific effects of mastication and rumination on digestion and passage.

DIGESTION
Mastication – Does it enhance digestion?
Olubobokun, J. A. et al. (1990. Effects of mastication and microbial contamination on ruminal in situ forage disappearance. J. Anim. Sci. 68:3371-3381) incubated masticated or nonmasticated (but chopped) samples of alfalfa, orchardgrass, or bermudagrass hays in the rumen for up to 96 h. More dry matter was soluble in masticated than nonmasticated hays. Effects of mastication on the digestion of dry matter, crude protein, neutral detergent fiber, and acid detergent fiber were inconsistent, perhaps because nonmasticated hays were chopped to a much smaller size than normally swallowed prior to fermentation.

In contrast, Bailey (1962. Rates of digestion of swallowed and unswallowed dried grass in the rumen. Can. J. Anim. Sci. 42:49-54) chopped samples of brome/orchard grass to approximate the size of swallowed grass before in situ ruminal digestion. He reported that digestion of dry matter in the swallowed material was significantly greater than that in unswallowed material in the first 24 hours ($P < 0.01$). Reanalysis of his data indicated that swallowed grass was degraded at a 42% faster rate than unswallowed grass (9.2 vs. 6.4 %/hour).
Although direct studies of this topic have been somewhat confounded by experimental techniques, mastication seems to enhance the solubilization and rate of degradation of feedstuffs in the reticulorumen.

**Rumination – How does it affect particle size and digestion?**

The effects of rumination on particle size after feeding cattle chopped alfalfa, reed canary grass, bromegrass, or red clover hays were examined by Kennedy (1985. Effect of rumination on reduction of particle size of rumen digesta by cattle. Aust. J. Agric. Res. 36:819-828). Figure 1 shows that the particle size of swallowed material must be reduced considerably by rumination before passing through the rest of the digestive tract and being voided as feces. By comparing the size distribution of particles in a regurgitated bolus with what is reswallowed after rumination, it is clear that many large particles are reduced to passable size in a single rumination cycle.

![Figure 1. Size distribution of masticated, regurgitated, reswallowed, and fecal particles in steers fed chopped alfalfa, reed canary grass, bromegrass, or red clover hays (Adapted from Kennedy, 1985).](image-url)
Suzuki et al. (2001. Change of particle comminution by chewing during rumination cycle with time after feeding in cattle. Anim. Sci. J. 72:J343-J350) fed cattle either orchardgrass or alfalfa hay once daily to study the effects of time after feeding on reduction of particle size during rumination (Table 1). They found that rumination was more effective and particles were more fragile 18 to 24 hours after feeding than 6 to 12 hours after feeding. This means that microbial fermentation in the rumen combines with rumination by the animal to accelerate particle size reduction.

### Table 1. Time after feeding and reduction of particle size in one rumination cycle ($P < 0.05$ within hay). Adapted from Suzuki et al. (2001).

<table>
<thead>
<tr>
<th>Measure</th>
<th>Orchardgrass hay</th>
<th>Alfalfa hay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6-12 h</td>
<td>18-24 h</td>
</tr>
<tr>
<td>Effectiveness, $^1$ %</td>
<td>62.1</td>
<td>82.0</td>
</tr>
<tr>
<td>Specific fragility $^2$</td>
<td>12.1</td>
<td>14.2</td>
</tr>
</tbody>
</table>

$^1$Large particles (>0.05 inches) reduced to <0.05 inches in one rumination cycle as a percentage of large particles retained for rechewing.

$^2$Large particles (>0.05 inches) in milligrams reduced to <0.05 inches per chew per gram of large particles retained for rechewing.

In another study, Suzuki et al. (2000. Relationship between comminution of feed particles during rumination and fiber fermentation in cattle. Anim. Sci. J. 71:J331-J337) compared ruminal digestion of neutral detergent fiber from orchardgrass or alfalfa hay particles retained in the mouth for rechewing with that of those reswallowed after rechewing (Table 2). Rumination enhanced subsequent fermentation, particularly of alfalfa particles.
Table 2. Ruminal digestion after 48 hours of neutral detergent fiber from material retained for rechewing or reswallowed after rechewing during rumination ($P < 0.01$ within hay). Adapted from Suzuki et al. (2000).

<table>
<thead>
<tr>
<th></th>
<th>Orchardgrass hay</th>
<th>Alfalfa hay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retained</td>
<td>46.5%</td>
<td>8.1%</td>
</tr>
<tr>
<td>Down</td>
<td>49.4%</td>
<td>25.2%</td>
</tr>
</tbody>
</table>

**PASSAGE**

About one-third of masticated chopped hay is of passable size when initially swallowed. Rumination helps reduce the remaining two-thirds of this material to a size that will allow it to pass from the reticulorumen. Small size is a necessary but not sufficient condition for passage. Other factors involved in this process include feed intake, flow of fluid from the rumen, fermentation by rumen microbes, and buoyancy of particles in the rumen.

A quantitative understanding of factors involved in reduction of particle size, and the dynamics of their interactions, may allow digestion and passage to be manipulated for optimal production. Our knowledge about these phenomena is currently limited because no information exists for mixed diets and few data are available for forages, none for silages or which examine the effects of maturity.