General Anatomy of the Ruminant Digestive System[1]

J.E. Umphrey and C.R. Staples[2]

The dairy cow is a magnificent producer of food. In approximately 10 months, a good cow can produce 496 pounds of protein, 784 pounds of energy in the form of the sugar lactose, 560 pounds of fat, and 112 pounds of minerals all in 16,000 pounds of milk. This is enough protein to supply the needs of a man for nearly 10 years, enough energy for 5 years, and enough calcium for 30 years.

The supply of high quality feedstuffs to the cow's highly complex digestive system helps accomplish this wonderful feat. An understanding of this digestive system is a must for making intelligent feeding decisions.

STARTING THE DIGESTIVE PROCESS

Chewing is the first step in processing the feed. This is no small task as the cow makes 40,000 to 60,000 jaw movements per day as it chews and rechews regurgitated feed. Then it passes down a 2 1/2 to 3 foot tube called the esophagus into a large fermentation vat of 40 to 50 gallon capacity. Here digestion of feed goes on by 500,000 billion bacteria and 50 billion protozoa living and multiplying there. These small organisms have several unique characteristics which allow the cow to thrive in situations which would be impossible for other animals to live. They digest fiber found in hay, silage, and pasture for energy, make protein from nitrogen, and synthesize B vitamins for their host, the cow.

FORESTOMACH (RETICULORUMEN)

This fermentation vat is composed of two areas called the reticulum and the rumen. The reticulum has a distinctive "honeycomb" appearance. It aids to help bring boluses of feed back up to the mouth for rechewing. It also serves as a receptacle for heavy foreign objects that she eats. A condition known as "Hardware Disease" may occur if a metal object such as wire or a nail is swallowed and punctures the reticulum wall. This condition may prove lethal for two reasons. First, the bacteria and protozoa can contaminate the body cavity resulting in peritonitis and second, the heart and diaphragm may be punctured by the object causing failure of these tissues.

The rumen is, by far, the largest compartment. Its purpose is to store large quantities of feed, keep the feed mixing by strong contractions, and to provide a suitable environment for the bacteria and protozoa to live. This environment is kept agreeable to the microorganisms by maintaining a relatively constant temperature and pH and by removing many of their waste products. Most of the waste products are volatile fatty acids. These volatile fatty acids are the primary sources of energy for the cow. They are absorbed by thousands of "finger-like" projections lining the bottom and sides of the rumen wall. These can be 1/2 inch long and they increase the surface area of the rumen so as to increase her ability to absorb volatile fatty acids.

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2. Extension Agent I and Associate Professor, respectively, Department of Dairy Science, Institute of Food and Agricultural Sciences, University of Florida, Gainesville.

OMASUM

Once the feed has been reduced in size by chewing and digestion by the bacteria and protozoa, it can pass into a third compartment called the omasum. This area has been nicknamed the "many-plies" due to its unique structure. It has the appearance of an open book with three sides bound. The tissues within are likened to the pages of a book and are called leaves. Up to 100 leaves can be found in the omasum. These leaves have small papillae on them which absorb a large portion of the volatile fatty acids that were not absorbed through the rumen wall. Water and electrolytes such as potassium and sodium are likely absorbed here as well thus drying out the feedstuffs before they enter the next compartment.

ABOMASUM

This fourth and last compartment which make up the cow's stomach is the abomasum or "true" stomach as it is called because it functions in a very similar way to the stomach of a man or pig. As in the omasum, the abomasum contains many folds to increase its surface area. These leaves enable the abomasum to be in contact with the large amounts of feed passing through it daily. The walls of the abomasum secrete enzymes and hydrochloric acid. The pH of the digesta coming into the abomasum is around 6.0 but is quickly lowered to about 2.5 by the acid. This creates a proper environment for the enzymes to function. The chief digestive function of the abomasum is the partial breakdown of proteins. The enzyme pepsin is responsible for this. Proteins from the feed and the microorganisms coming from the rumen are broken down to smaller units called peptides before leaving.

SMALL INTESTINE

The next stop in the digestive process is the small intestine, a 130 foot-long, 2 inch-wide tube. As the feed enters the small intestine, it mixes with secretions from the pancreas and liver which elevate the pH of the digesta from 2.5 to between 7 and 8. This higher pH is necessary for enzymes in the small intestine to work. In order for feedstuffs to become available to the cow, they must be broken down into smaller molecules. These enzymes do just that by reducing any remaining proteins to amino acids, starch to glucose, and complex fats into fatty acids. Much of that occurs in the small intestine using enzymes and hormones from the pancreas, liver, and small intestine. Absorption of these nutrients also occur in the lower half of the small intestine. The intestinal wall contains numerous "finger-like" projections called villi that increase the surface area of the intestine to aid in the absorption process. Muscular contractions aid in mixing the digesta and moving it down to the next section.

LARGE INTESTINE

The cecum, colon, and rectum make up the rest of the digestive tract. They are collectively referred to as the large intestine. Its primary purpose is to absorb water from the digesta thus making it more solid. Bacteria living in the intestine work at digesting any feedstuffs which escaped digestion earlier. Usually this contributes less than 15% of the total digestion. Between these bacteria and those which passed out of the rumen, up to 50% of the dry weight of the feces can be of microbial origin.

CALF DIGESTIVE TRACT DEVELOPMENT

The digestive tracts of calves are more like humans than cows. They have no functioning rumen with bacteria and protozoa working for her. In a young calf (1 month or less), the abomasum is the largest compartment of the stomach. It makes up approximately 50 to 70% of the total stomach area. When the calf suckles from the dam or a bottle, the milk bypasses the reticulorumen by going through the esophageal groove. During the suckling process, impulses from the brain send messages to the esophageal groove, causing the sides of the groove to curve upward forming a tube. This allows a direct flow of milk into the abomasum. At this point, the enzyme rennin is secreted from the walls of the abomasum, causing the milk to coagulate or curdle. This slows the passage of milk through the abomasum to allow ample time for the milk to be digested. As the calf gets older and starts to consume grain and hay, the rumen begins to develop. This growth is due to the volatile fatty acids produced by the digestive action of microorganisms in the rumen. This also stimulates the growth of the papillae which are developing. By the end of the fourth week, the calf should be able to utilize grain and quality hay to a large extent. At eight weeks of age, the abomasum comprises only 30% of the total capacity of the stomach, and only 9% when the stomach reaches full mature size.