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Lecture title: **Animal nutrition: Carbohydrates Digestion**

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Summary:

Most of the dietary carbohydrates are fermented in the rumen to form short chain fatty acids (SCFAs), namely, acetic acid, propionic acid, and butyric acid due to the action of microbial enzymes. The breakdown of carbohydrates to SCFAs in the rumen can be divided into two stages:

- the extracellular hydrolysis of carbohydrates (e.g., starch, cellulose, hemicellulose, and pectin) to monosaccharides, including pyruvate.
- the intracellular conversion of the monosaccharides into pyruvate and its intracellular metabolism to form SCFAs

Concentrations of SCFAs in the rumen depend on the balance between their rates of production and absorption into the rumen epithelial cells. SCFAs play a significant role in ruminant nutrition. First, acetate, propionate, and butyrate are the major sources of energy in ruminants. butyrate is the major substrate for ATP production in the epithelial cells of the large intestine and thus for maintaining the health of the hind-gut, second, propionate is used to synthesize glucose in the livers of ruminants, both of acetate and butyrate are converted into acetoacetate and β-hydroxybutyrate in the rumen wall and colonocytes.

The major factors affecting the utilization of forages by ruminants are:

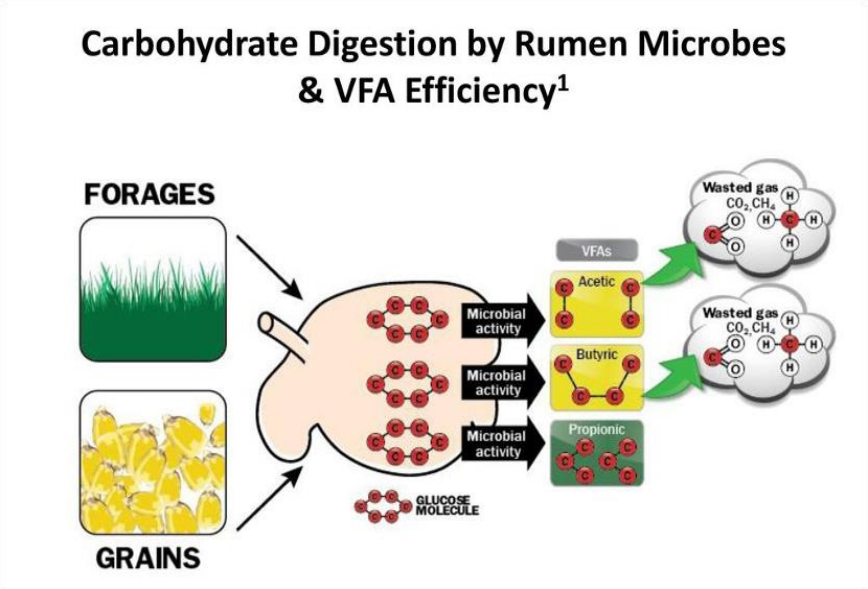
1. Animal species:
   the digestibility of alfalfa hay fiber is 44% in cattle, 45% in sheep, and 41% in goats.
2. Diet:
   rumen residence time is shorter for concentrate particles than that for roughages. In ruminants, the digestibility of total carbohydrates varies widely with the type of diet, ranging from 95% for molasses, to 75% for grass, 60% for hay, and 40% for straw.

The digestion of complex carbohydrates to simple sugars.This is brought about by extracellular microbial enzymes and is thus analogous to the digestion of carbohydrates in non-ruminants.

- Cellulose is decomposed by one or more 1,4-glucosidases to cellobiose, which is then converted either to glucose or, through the action of a phosphorylase, to glucose-1-phosphate.
- Starch is a major dietary constituent of concentrated feed in ruminants, such as dairy and feedlot cattle, Starch and dextrins are first converted by amylases to maltose and

isomaltose and then by maltases, maltose phosphorylases or 1,6-glucosidases to glucose or glucose-1-phosphate.

- Pentoses are the major product of hemicellulose breakdown, which is brought about by enzymes attacking the -1,4 linkages to give xylose and uronic acids. The latter are then converted to xylose.
- Uronic acids are also produced from pectins, which are first hydrolysed to pectic acid and methanol by pectinesterase. The pectic acid is then attacked by polygalacturonidases to give galacturonic acids, which in turn yield xylose. Xylose may also be produced from hydrolysis of the xylans, which may form a significant part of the dry matter of grasses.



The bacteria number 10^9–10^{10} / milliliter of rumen contents. Over 200 species have been identified, number of bacteria and the relative population of individual species vary with the animal's diet; for example, diets rich in concentrate foods promote high total counts and encourage the proliferation of lactobacilli, Protozoa are present in much smaller numbers (10^6/ml) than bacteria. The pathway through lactate and acrylate predominates when the ruminant's diet includes a high proportion of concentrates and threaten the animal with acidosis. pathways through succinate are employed when the diet consists mainly of fibrous roughages.

concentration of VFA varies widely according to:

- the animal's diet.
- the time that has elapsed since the previous meal.
  it is normally in the range of 70–150 mmol/l

The relative proportions of the acids also vary according to mature of grasses:

- Mature fibrous forages give rise to VFA mixtures containing a high proportion (about 70 %) of acetic acid.
- Less mature forages tend to give a rather lower proportion of acetic and a higher proportion of propionic acid.

The total weight of acids produced may be as high as 4 kg / day in cows.
Much of the acid produced is absorbed directly from the rumen, reticulum and omasum, although 10–20 % may pass through the abomasum and be absorbed in the small intestine. In addition, some of the products of carbohydrate digestion in the rumen are used by the microorganisms to form their own cellular polysaccharides. The rate of gas production in the rumen is most rapid immediately after a meal and in the cow may exceed 30 l/hour.

typical composition of rumen gases are:

- 40 % carbon dioxide
- 30–40 % methane
- 5 % hydrogen
- small proportions of oxygen and nitrogen (from ingested air).

Carbon dioxide is produced partly as a by-product of fermentation and partly by the reaction of organic acids with the bicarbonate present in the saliva, The basic reaction by which methane is formed is the reduction of carbon dioxide by hydrogen, some of which may be derived from formate. About 4.5 g of methane is formed for every 100 g of carbohydrate digested, and the ruminant loses about 7% of its food energy as methane, most of the gas produced is lost by eructation. if gas accumulates it causes the condition known as bloat, in which the distention of the rumen may be so great as to result in the collapse and death of the animal.

Bloat occurs most commonly in dairy cows grazing on young, clover-rich herbage and is due not so much to excessive gas production as to the failure of the animal to eructate, Frequently the gas is trapped in the rumen in a foam, whose formation may be promoted by substances present in the clover. It is also possible that the reflex controlling eructation is inhibited by a physiologically active substance that is present in the food or formed during fermentation. Bloat is a particularly serious problem on the clover-rich pastures, where it is prevented by dosing the cows or spraying the pasture with antifoaming agents, such as vegetable oils. Another form of bloat, termed ‘feedlot bloat’, occurs in cattle fattened intensively on diets containing much concentrate and little roughage. The extent to which cellulose is digested in the rumen depends particularly on the degree of lignification of the plant material.