Lecture 3

Utilization of roughages in ruminant feeding

Roughages comprise over 50% of all feedstuffs fed to livestock animals especially ruminants. Roughages are plant-based feedstuffs. Technically, forage and herbage are defined as plant materials, with a higher fiber content, available for consumption by animals.

The National Research Council classifies roughage as a feedstuff with a minimum crude fiber content of 18% and a maximum content of total digestible nutrients (TDN) of 70%.

Roughages provide a range of nutrients to animals. They also function to maintain and optimize the efficiency of the GI tract for selected species.

Fibrous carbohydrates function to maintain structure, activity, and microbial population of the GI tract, essential for optimal function of the GI tract.

Roughages are a link to the efficient utilization of earth's resources.

Roughages alone are of minimal value to humans. However, roughages consumed by selected species provide a means for conversion of relatively low-quality raw materials to relatively high-quality products such as food and fiber that may be used to fulfill human needs.

Roughages may be fed either in a fresh, dried, or ensiled state.

Types of roughages used as feedstuffs include grazed roughages (e.g. pasture and range), preserved roughages (e.g. hay and silage), and crop residues and by-products (e.g. Straw, Stover, and Hulls).

Roughages are high in fibrous carbohydrates such as hemicelluloses and cellulose. Fibrous carbohydrates are primarily present in the cell wall of the plant cell. As fibrous carbohydrates are associated with the structural components of plants, fibrous carbohydrates are often referred to as structural carbohydrates. Roughages may also contain relatively high amounts of lignin. Lignin content increases with plant maturity.

In a nutrition analysis, the fiber components of roughages may be expressed as crude fiber, acid detergent fiber (ADF), and/or neutral detergent fiber (NDF). Crude fiber contains cellulose and a portion of the lignin.

ADF contains cellulose and lignin. NDF contains hemicellulose, cellulose, and lignin.

The plant cell contents also contribute to the roughage. The cell contents include such components as non fibrous carbohydrates, proteins, and lipids.

The non fibrous carbohydrate content is comprised of simple sugars (i.e. fructose, glucose, and sucrose), starches, and/or fructosans. The protein component in forages is comprised of both true protein and non protein nitrogen compounds. Protein content varies by roughage; from 2% up to 30% on a dry matter basis.

In general, the protein content of legumes is greater than the content of grasses.

The mineral content of roughages is influenced by roughage and mineral content of the soil. In general, compared to concentrates, roughages are higher in calcium, potassium, and microminerals and moderate to low in phosphorus. Legumes have a higher calcium and magnesium contents compared to grasses. Regarding vitamins, compared to concentrates, roughages are higher in fat-soluble vitamins. Roughages are also a good source of the B-complex vitamins.

Roughages may contain one or more antinutritional factors such as alkaloids, cyanogenic glycosides, toxic amino acids, and/or mycotoxins.

The nutritional value of roughages varies. In addition to other factors such as plant species, the nutritional value of roughages depends on the proportion of cell contents to cell wall components and on the extent of cell wall lignification.

Most roughages can be effectively incorporated into at least one type of ration.

Effective use of roughage requires matching nutrient requirements of an animal with the nutritional value of roughage. Effective use of roughage also requires appropriate processing and supplementation.

As the population of rumen microorganisms is dependent upon the feedstuffs consumed, the composition of the diet influences the extent and rate of digestion of roughages. Feeding of high-energy feedstuffs has a negative associative effect on the degree of utilization of roughage. A negative associative effect occurs when the addition of one feedstuff negatively influences the utilization of another feedstuff.

One of the primary species responsible for the digestion of roughages is cellulolytic bacteria.

The primary end-product of digestion of roughages is acetate. Acetate is a relatively weak acid.

The primary end-product of fermentation of high-energy feedstuffs is propionate.

Propionate is a relatively strong acid.

An additional end-product of microbial fermentation of high-energy feedstuffs is lactate. Lactate is also a strong acid.

Compared to roughages, the digestion rate and extent are higher and the resultant pH of the rumen is lower for high-energy feedstuffs.

The lower pH has a negative effect on the microorganisms responsible for digestion of roughages; the cellulolytic microbes are inhibited by a pH of 6.0 or lower.

Therefore, the incorporation of high-energy, high-nonfibrous carbohydrate feedstuffs decreases the utilization of roughages.

Management strategies to increase the utilization of roughages include:

1) addition of buffers, such as bicarbonate, to the diet;

2) increasing particle size of roughage to increase the production of bicarbonate in the animal; and/or

3) reducing the rate of fermentation of high-energy feedstuffs either by substitution with another feedstuff or applying an alternative method of processing.

As with other feedstuffs, addition of roughages to rations is dependent on the GI tract.

As roughages are high in fibrous carbohydrates and microbial enzymes are required for digestion of fibrous carbohydrates,

Utilization efficiency of roughages is dependent on the site and extent of microbial fermentation in the GI tract. Roughages are primarily added to the rations of herbivores. The proportion of forage in the ration varies with species and class of animal and also cost of feedstuffs.

Based on the relatively high utilization efficiency of roughages in the GI tract and roughages are a source of fibrous carbohydrates to maintain optimal functioning of the GI tract,

Generally, roughages are added to ruminant rations. Although the utilization efficiency is less, roughages are also used in the rations of horses. In the horse, the caecum is the primary site of microbial fermentation. As the caecum is located posterior to the primary site of absorption, horses may practice coprophagy or consumption of feces to increase efficiency of utilization.

For monogastric such as swine and poultry, the low utilization efficiency limits the use of roughages in rations. Roughages can be added to the ration of swine with low nutrient requirements.