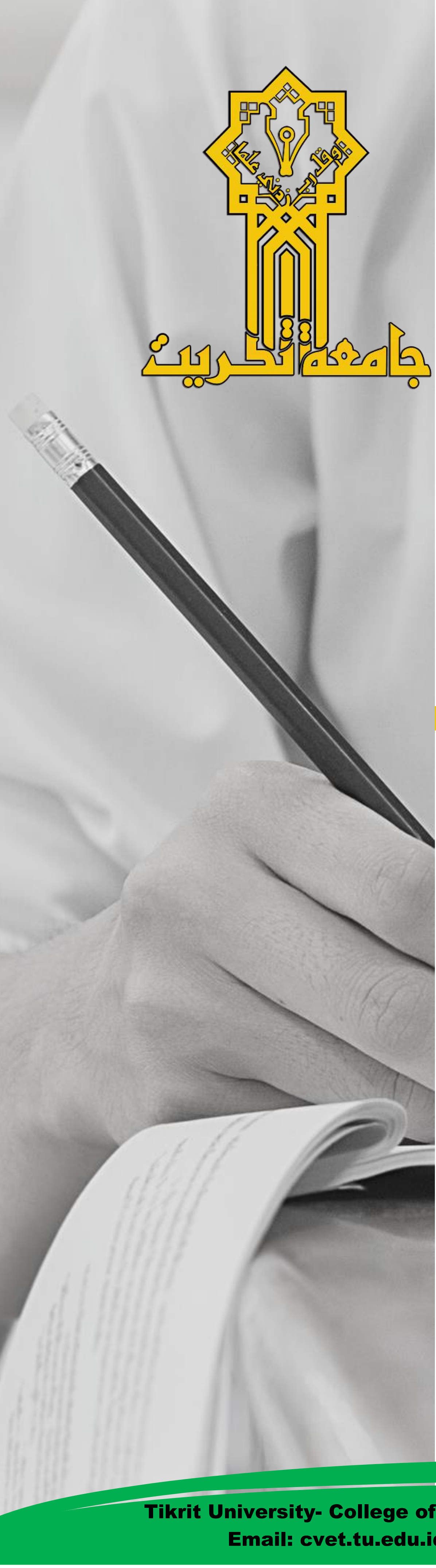

Tikrit University
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Carbohydrates, Digestion and Absorption

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Carbohydrates, Digestion and Absorption

The main organ for the absorption of dietary nutrients by the monogastric mammal is the small intestine. This part is specially adapted for absorption because its inner surface area is increased by folding and the presence of villi. Although the duodenum has villi, this is primarily a mixing and neutralizing site, and the jejunum is the major absorptive site. Absorption of a nutrient from the lumen of the intestine can take place by passive transport, involving simple diffusion, provided there is a high concentration of nutrient outside the cell and a low concentration inside another method of absorption is by pinocytosis 'cell drinking', in which cells have the capacity to engulf large molecules in solution or suspension. Such a process is particularly important in newborn suckled mammals in which immunoglobulins present in colostrum are absorbed intact. The digestion processes is important and may be grouped into:

Mechanical: The mechanical activities are mastication and the muscular contractions of the alimentary canal.

chemical : The main chemical action is brought about by enzymes secreted by the animal in the various digestive juices

microbial : Microbial digestion of food, also enzymic, is brought about by the action of bacteria, protozoa and fungi, microorganisms that are of special significance in ruminant digestion

Carbohydrates digestion:

It's a major component of plant tissues comprise about 70% of dry matter in forages , in cereals grains carbohydrates concentrations reach to about 85% . The carbohydrates are a major source of energy in animal life

Microbial Digestion In Ruminants:

Ruminants have evolved a special system of digestion that involves microbial fermentation of food before its exposure to their own digestive enzymes. Herbivores other than ruminants, such as the horse, have adopted systems of microbial digestion that differ from those of ruminants.

Ruminant teeth and Powerful muscles help in chewing actions of feeds and are adapted for the efficient comminution of fibrous foods. The food is diluted with copious amounts of saliva, first during eating and again during rumination: typical quantities of saliva produced per day are 150 l in cattle and 10 l in sheep. Rumen contents contain 850–930 g water/kg on average, but they often exist in two phases: a lower liquid phase, in which the finer food particles are suspended, and a drier upper layer of coarser solid material.

Saliva is about 99 % water, the remaining 1% consisting of:

- **mucin**

 inorganic salts
 enzymes -amylase
 complex lysozyme.

New Terms
Amylase
Dextrins
Disaccharidase
Maltase
Nonstarch polysaccharides
Sucrase
Volatile fatty acids

lecture Objectives

- To discuss the digestion and/or fermentation carbohydrates in food-producing animals
- To discuss carbohydrate fermentation-related disorders in ruminant animals

The primary site of carbohydrate digestion is in the lumen of the small intestine, where pancreatic amylase begins the digestion of starch granules (amylose and amylopectin). In some birds, there is some salivary amylase action in the mouth, but not in farm animals.

There are two forms of amylase, one that cleaves α 1,4 bonds in a random fashion, while the other removes disaccharides units (maltose) from the polysaccharide chain. Pancreatic amylase does not act on α 1,6 bonds that form the branch points in the structure of amylopectin. The end products of amylase digestion include a mixture of glucose, maltose, and dextrins (residues containing α 1,6 branch points). Dextrins are acted upon by α 1,6 glucosidase.

The small intestine is the site of the digestion of carbohydrates in farm animals.

Dietary simple sugars, such as glucose and fructose, do not need to be digested, as they can be absorbed through the intestinal epithelium directly. The end products of starch digestion diffuse into the brush border, where the final digestive processes occur. Disaccharides such as maltase and isomaltase on the intestinal brush border then complete the degradation and are hydrolyzed to their constituent monosaccharides by enzymes on the brush border, and the monosaccharides released are absorbed into the enterocyte. Sucrose is acted upon by sucrase to yield glucose and fructose for absorption. In young animals kept on milk (preweaning), lactose is acted upon by lactase to yield glucose and galactose. Amylase activity is very low in young animals consuming milk and is stimulated by solid food consumption.

The end product of carbohydrate digestion in monogastric animals is mainly glucose.

Carbohydrate-Digesting Enzymes

- **Amylase**
- **Disaccharidase**
- **Maltase**
- **Sucrase**
- **Lactase**

Monosaccharides are absorbed both by simple diffusion and adenosine triphosphate (ATP)-dependent active transport. A sodium-dependent glucose transport protein binds glucose and Na+ and transports them through the enterocyte and releases them in the cytosol.

Table 4.1. Overview of carbohydrate digestion: Site, enzymes, and end products produced in monogastric animals

Site	Enzyme	Product
Mouth	Salivary Amylase	Not too significant
Small Intestine	Pancreatic Amylase Di/oligosaccharidases	Monosaccharides
Large Intestine	None	Some volatile fatty acid

Monogastric animals do not secrete enzymes that digest the complex carbohydrates, glucans, cellulose) that are components of plant fiber (e.g., wheat, barley) and are acted upon by hindgut microbes to yield volatile fatty acids (VFAs). High levels of NSP and glucans in a monogastric diet can cause viscous digesta and can interfere with digestion processes leading to malabsorption. In poultry, high-

NSP-containing diets (e.g., barley, rye) can produce wet litter, dirty eggs, and diarrhea.

Carbohydrate Digestion in Ruminants

Carbohydrate digestion in ruminant animals is through microbial fermentation in the rumen. Dietary carbohydrates are degraded (fermented) by rumen microbes (bacteria, fungi, protozoa). The purpose of rumen fermentation is to produce energy as ATP for the bacteria to use for protein synthesis and their own growth. VFAs, also known as short-chain fatty acids (shown below), are produced as a product of rumen fermentation and are absorbed through the rumen wall and are utilized by the animal as an energy source.

Major Volatile Fatty Acids Produced in the Rumen

- **Acetic acid**
- **Propionic acid**
- **Butyric acid**

The three major VFAs are acetic (C2), propionic (C3), and butyric acid (C4;).

- **The end products of digestion in ruminants are volatile fatty acids and some monosaccharides.**

In young ruminants, rumen and the reticulum are not fully developed and are relatively small. The reticular/esophageal groove reflex, a tube-like fold of tissue, channels milk or water that is sucked from a nipple directly through the omasum to the abomasum. This is a reflex, stimulated by sucking. When the animal is weaned, it normally loses this reflex. Solid food, such as creep feed, passes into the small rumen and fermentation starts. The neonatal ruminant animal has no ruminal bacterial population but from birth, it starts to pick up bacteria from the mother and environment, particularly through contact. Solid food is then fermented forming VFAs, which stimulate the growth and development of the rumen, particularly the growth of the papillae for absorption.

All the digested and absorbed monosaccharides and volatile fatty acids enter into the liver.

The end products of rumen fermentation are microbial cell masses, or microbial protein-synthesized VFA, and gases such as carbon dioxide, methane, hydrogen, and hydrogen sulfide.

The products of fermentation will vary with the relative composition of the rumen microflora. The microbial population also depends on the diet, since this changes the substrates for fermentation and subsequently the products of fermentation. For example, starch is the major dietary constituent in concentrate-fed ruminants (e.g., feedlot cattle). The rumen of such animals will have higher amylolytic bacteria than cellulolytic bacteria present in the rumen of roughage- and pasture-fed animals. Factors such as the forage:concentrate ratio, the physical form of the diet (ground vs. pelleted), feed additives, and animal species can affect the rumen fermentation process and VFA production.

Molar ratios of VFAs are dependent on the forage:concentrate ratio of the diet. Cellulolytic bacteria tend to produce more acetate, while amylolytic bacteria produce more propionic acid. Typically three major VFA molar ratios are 65:25:10 with a roughage diet and 50:40:10 with a concentrate-rich diet. Changes in VFA concentration can lead to several disorders of carbohydrate digestion in ruminants. Rumen acidosis occurs when animals are fed high-grain-rich diets or when animals are suddenly changed from pasture- or range-fed to feedlot conditions.

Carbohydrate metabolism

In farm animals, dietary carbohydrates provide well over one-half of the energy needs for maintenance, growth, and production. Glucose is a primary energy source for certain animal tissues and a precursor for lactose synthesis in the mammary gland. Consequently, understanding carbohydrate digestion and absorption, dietary glucose availability, and the involvement of gluconeogenesis in the regulation of glucose homeostasis is essential for the manipulation of the production and quality of agricultural foods.

The Hormonal Control of Carbohydrate Metabolism

The blood sugar level is mainly maintained by the antagonistic actions of insulin, which depresses it, on the one hand, and the gluco~ genic actions of adrenaline, pituitary and cortical hormones on the other. Adrenaline acts by stimulating glycogenolysis in the liver and is therefore of little value where the liver glycogen is already depleted. Cortical hormones act mainly by stimulating the formation of glucose from protein. The beneficial effects of A.C.T.H. and cortisone in the treatment of ruminant ketosis can be explained on this action. They also stimulate ketogenesis but this effect is probably more than counterbalanced by their facilitation of the use of the ketone bodies by the tissues. Although A.C.T.H. and cortisone are of benefit in ruminant ketosis this is no proof that the condition is primarily a cortical deficiency. It must be remembered that many other diseases which show such a response (e.g. arthritis) are not associated with hypo~ corticism.

In our opinion the basic cause of ketosis is dietary and hormonal therapy merely assists the body in its adaptation to a disturbed carbohydrate metabolism.