Carbohydrates

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Carbohydrates

Composed of carbon, hydrogen and oxygen
$(CH_2O)_n$ and joined by glycosidic bonds
Glycosidic bonds differ in their linkage – α- or β-

- the nature of the glycosidic bond determines digestibility

Carbohydrate Classification

a) Simple Sugars
   - Monosaccharides and disaccharides
   - Monosaccharides require no digestion prior to absorption
   - Disaccharides must be hydrolyzed to simple sugars (lactose, sucrose)

b) Oligosaccharides
   1. 3 to 9 sugar units
   2. divided into subgroups depending on number of carbons e.g. triose (3 carbons)

c) Polysaccharides (complex carbohydrates)
   - More than 9 sugar units
   - Starches (amylase, amylopectin, glycogen)
   - Fibre (hemicellulose, cellulose)
   - Lignin is included as fibre but is not a carbohydrate (phenolic)
   - Pectin, gums

Dietary Requirement

Readily available source of energy
CNS and erythrocytes require glucose for energy
Muscles can utilise substrates such as fatty acids for energy
Inadequate CHO – amino acids (glucogenic amino acids via the gluconeogenic pathway) are shunted away from growth and production to be used for glucose synthesis

Functions of Dietary Carbohydrates

a) Energy
   - Energy is provided in the form of ATP from glycolysis and the TCA

b) Heat Production
   - Oxidation of glucose releases free energy that dissipates as heat

c) Precursors of Other Nutrients
   - Ascorbic acid is an oxidation product of an aldohexose

d) Production of Glycogen or Fat
- Glycogen is synthesised from an XS of simple CHOs and starches
- Glucose converted to fatty acid during high dietary CHO intake
  - Triacylglycerols stored as large fat globules

e) Increasing Intestinal Bulk and Water
- Maintains proper gut motility
- Stores a reserve of fluid for absorption during dehydration, respiration and urinary losses

f) Maintaining Gut Health
- End products of microbial fermentation (acetate, proprionate, butyrate) are important in maintaining colon health
- Fibre decreases luminal pH through production of short chain fatty acids
- Increases population of anaerobic flora
- Antibacterial properties of SCFAs may
  - decrease pathogenic intestinal bacteria,
  - increase resistance of gut to colonisation by pathogenic bacteria
- SCFAs facilitate absorption of Na, Cl and H_2O in colon
- Absence of SCFAs
  - Colonic mucosa atrophy, inflammation and decreased resistance to bacterial translocation
  - SCFAs not important source energy if short intestinal tract or fast transit time

Starch Polysaccharides

Starch consists of straight chains that are linked by α-glycosidic bonds so considered to be nutritionally available

Digested by endogenous digestive enzymes

Plant starch = amylase and amylopectin, animal starch = glycogen

Nonstarch Polysaccharides

β-glycosidic bonds resist enzymatic digestion in the small intestine

a) Cellulose
- structural component of plant cell wall
- β-glucans are relatives of cellulose in small amounts in grasses, larger amounts in oats and barley (associated with bran)

b) Hemicellulose
- Consists of α- and β- bonds
- Close association with lignin
- Varies taxonomically

C) Lignin
- Not a carbohydrate but a polyaromatic compound
- Makes up structural part of plant
- Resistant to enzymatic degradation
- Higher proportion in older tissues
- Can reduce digestibility of other CHOs and protein

- Provides physical and chemical barrier to microbes

Chitin

Occurs as β- linkages in cell walls of fungi and exoskeleton of invertebrates
Similar in structure to cellulose
Chitinase activity in:

- starlings, raptors and variety of seabirds
- Low in chickens
- Absent in African grey parrots and pigeons

Soluble Fibre

Fibre classified according to solubility

Soluble = Rapidly fermentable: pectins, β-glucans, some gums
Covalently linked to lignin: comparatively soluble
Greater water-holding capacity
Insoluble = Slowly fermentable: cellulose, Hemicellulose

Fermentation

a) Postgastric
- Frugivores, nectarivores, florivores
- Posterior to gastric stomach
- Enzymatic digestion occurs prior to fermentation
- Postgastric fermentation benefits species that feed on easily digestible foods

b) Pregastric
- Incompatible with flight
- Mature leaves, stems, branches
- Fermentation of nutrient rich foods is not efficient

Variations in fibre digestion depends on access to caeca

Sucrase

Sucrose is a disaccharide consisting of glucose and fructose
Some species lack the ability to break down sucrose
Berries and cherries
- predominantly monosaccharides

Apricots, nectarines, peaches, bananas, cantaloupes and mangos consist
- predominantly disaccharides