Module III - Carbohydrates

A. Types Of Carbohydrate

1. Monosaccharides
   a. Glucose
      1) Basic unit of starch and cellulose
      2) Type of sugar in blood, table sugar, etc.
      3) Major type used in human energy metabolism
      4) Part of sucrose and lactose
   b. Fructose
      1) Sugar found commonly in fruit and honey
      2) Sweeter than any other sugar
      3) High fructose corn syrup
   c. Galactose
      1) Structure similar to glucose
      2) Found in milk and dairy products
      3) Part of lactose
      4) Present as monosaccharide in small intestine after digestion

2. Disaccharides
   Most common are sucrose and lactose
   a. Sucrose
      1) Found in fruit, plants, table sugar
      2) Made up of glucose and fructose
      3) Digestible
      4) Absorbed as glucose and fructose
   b. Maltose
      1) Found in small intestine after starch breakdown
      2) Made up of two glucoses
      3) Digestible
      4) Absorbed as glucose
   c. Lactose
      1) Found in milk products
         a) Up to 1/2 of the energy in milk
         b) Less in some cheeses (Swiss and cheddar) and yogurt
      2) Made up of glucose and galactose
      3) Digestible
         a) By most children (< five years old)
         b) Not by most adults
            • Lactose intolerance
            • Fermented in large intestine (diarrhea, bloating)

3. Oligosaccharides
   Sugars that have several monosaccharides linked together.
   a. Starch products
      1) Multiple glucose units
      2) Found in some sports drinks
      3) Digestible and absorbed as glucose
   b. Bean sugars
      1) Indigestible
      2) Fermented in large intestine

4. Polysaccharides
   a. Very long carbohydrate chains
      1) Composed of many monosaccharide units, primarily glucose
   b. Known as complex carbohydrates
   c. Major types of polysaccharides
      1) Starch
      2) Glycogen
      3) Dietary fiber (cellulose, pectin, etc.)
B. Carbohydrate Digestion

1. Mouth
   a. Mixing and grinding with saliva
   b. Saliva has amylase (an enzyme)
   c. Amylase digests (breaks down) amylase to:
      1) Glucose (that’s what makes starch sweet)
      2) Maltose
      3) Oligosaccharides

2. Stomach
   a. Mixing with acid
   b. Acid stops mouth amylase from working
   c. Protein Digestion

3. Pancreas
   a. Excretes amylase, and other enzymes, into small intestine

4. Small Intestine
   a. Amylase
      1) Enzyme from pancreas
      2) Starch digestion
   b. Disaccharidases (located on wall of intestine)
      1) Sucrase
         a) Sucrose digestion
         b) Enzyme from small intestine
      2) Maltase
         a) Maltose digestion
         b) Enzyme from small intestine
      3) Lactase
         a) Lactose digestion (mainly children)
         b) Enzyme from small intestine

5. Large Intestine
   a. Fermentation of undigested material

C. Carbohydrate Absorption

1. Occurs only in small intestine
2. Passive diffusion
   Fructose
3. Active Transport
   Glucose
   Galactose

D. Primary Functions of Carbohydrates

1. Provision of Energy (Essential)
   a. Glucose
      1) Primary form of carbohydrate used for energy (ATP)
      2) When metabolized, carbohydrates release 4 kcal/gram
      3) Glucose is metabolized to produce energy
         a) ATP is formed
         b) ATP is the form of energy used by most processes
         c) Oxygen is needed for complete metabolism
      4) Glucose available for cell
         a) from blood
         b) from glycogen
   b. Glycogen
      1) Primarily stored in liver and muscles
      2) Degraded by glycogenolysis to supply glucose
      3) Degradation of glycogen to glucose - Vitamin B6 dependent
Module III - Carbohydrates

2. Carbohydrate is an essential nutrient
   a. Minimum intake should be approximately 50 to 100 gram/day
   b. When carbohydrate consumption is less than adequate:
      1) Blood glucose is lowered
      2) Glycogen is used to maintain blood glucose
         a) glycogen is depleted
      3) Protein catabolism is increased
         a) breakdown of muscle tissue
         b) most amino acids can be used to make glucose
         c) most amino acids can be used to make energy (ATP)
      4) Fat catabolism is increased
         a) fatty acids are incompletely catabolized
         b) forms ketones (acetone)
         c) Ketogenesis
            "fat burns in a carbohydrate flame"
         d) energy requirements met by oxidation of fat and protein

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5. Blood glucose is regulated by hormones
   a. Insulin (protein, hormone)
      1) From pancreas
      2) Released when blood glucose is high
      3) Causes increased glucose uptake by cells
      4) Decreases blood glucose
   b. Glucagon (protein)
      1) From pancreas
      2) Released when blood glucose is low
      3) Causes glycoegenolysis (breakdown of glycogen)
         a) Glycogen to glucose
         b) Glucose from liver to blood
      4) Increases blood glucose
   c. Epinephrine (adrenaline) (lipid derived hormone)
      1) From adrenal gland
      2) Released when stressed
      3) Causes glycoegenolysis
         a) Blood glucose increases
      4) Causes triglyceride (fat) breakdown
         a) Increases blood fatty acids for metabolism

Module III - Carbohydrates

E. Regulation Of Blood Glucose
   1. Blood glucose is maintained within a narrow range 80-100 mg/dl (4-6 mmol/liter)
   2. High or low levels can be dangerous
   3. HYPERGLYCEMIA: HYPER-GLYC-EMIA
      high-glucose-blood stream
   4. HYPOGLYCEMIA: HYPO-GLYC-EMIA
      low-glucose-blood stream
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F. Disorders in Carbohydrate Metabolism

1. Diabetes mellitus
   a. Inability to regulate blood glucose levels
   b. Poor control of blood glucose can lead to abnormally low or high levels of glucose, metabolites, and other nutrients
   c. Types: Type 1, Type 2, Gestational

1) Type I
   a) age at onset
      - Childhood (usually)
   b) Mechanism
      - pancreas does not secrete insulin
      - onset occurs abruptly
      - hyperglycemia after eating carbohydrate
      - blood glucose increases
      - glucose uptake is not increased (lack of insulin)
      - Fat is used for energy
      - ketone production
      - severe ketosis
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3) Gestational
   a) develops during pregnancy
   b) cells become resistant to insulin
   c) Treatment
      - Same as Type II
   d) avoid weight loss until after birth

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Symptoms of Type 1 and Type 2 Diabetes</th>
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</thead>
<tbody>
<tr>
<td><strong>Type 1 Diabetes</strong></td>
<td><strong>Type 2 Diabetes</strong></td>
</tr>
<tr>
<td>Frequent urination</td>
<td>Any of the type 1 symptoms</td>
</tr>
<tr>
<td>Unusual thirst</td>
<td>Frequent infections</td>
</tr>
<tr>
<td>Extreme hunger</td>
<td>Blurred vision</td>
</tr>
<tr>
<td>Unusual weight loss</td>
<td>Cuts/bruises that are slow to heal</td>
</tr>
<tr>
<td>Extreme fatigue</td>
<td>Tingling/numbness in the hands or feet</td>
</tr>
<tr>
<td>Irritability</td>
<td>Recurring skin, gum, or bladder infections</td>
</tr>
</tbody>
</table>

*Some people with type 2 diabetes experience no symptoms.

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2) Type II
   a) age of onset
      - adult (usually > 40 years old)
   b) mechanism
      - pancreas secretes insulin
      - Gradual onset
      - cells are resistant to insulin (don’t respond)
      - hyperglycemia
   c) common diagnosis secondary to obesity
      - large fat cells become insulin resistant
      - Ketosis is less frequent than in Type I
   d) Symptoms (see Type I symptoms)
   e) Treatment
      - Reduce weight
      - Exercise
      - Reduce energy intake
      - Consistent meal times
      - Decrease intake of fat
      - Decrease intake of simple carbohydrates
      - Increase intake of complex carbohydrates
      - Medications

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2. Hypoglycemia
   a. Blood glucose levels are below normal
   b. Symptoms
      1) Feeling shaky, nervous, tired, sweaty, cold, hungry, confused, irritable or impatient
   c. Treatment
      1) Small frequent meals
      2) Decrease intake of simple carbohydrates
      3) Increase intake of complex carbohydrates

G. Maintenance of Blood Glucose
1. Fasting
   a. Blood glucose levels fall
   b. Glucagon released
   c. Glycogen is used to maintain blood glucose levels

2. Meal
   a. Blood glucose levels rise
   b. Insulin is released
   c. Glucose is taken into cells
   d. Glycogen is made

3. Early Starvation
   a. Similar to Fasting
   b. Protein broken down to amino acids
   c. Amino acids used to make glucose
   d. Glucose used to help metabolism of fatty acids

4. Prolonged Starvation
   a. Protein used to maintain essential levels of glucose
   b. Fatty acids used for energy
   c. Ketones produced
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H. SUGAR - Is it Bad?

1. Sugar consumption in the US
   a. Added sugars
   b. Sources of added sugars
      a. Sugar sweetened beverages – soda, juice, sports drinks, energy drinks
      b. Cakes, cookies, candy, etc.

2. Are there direct health risks?
   a. Blood lipids
      1) Shown to increase LDL and decrease HDL
      2) Risk factors for heart disease
   b. Diabetes and Obesity
      1) Excess sugar = excess calories = weight gain = obesity
      2) Type II diabetes associated with obesity
   c. Hyperactivity
      1) No good evidence for long term effects
      2) Short-term may be due to caffeine instead
      3) High in chocolate and sodas
   d. Dental Decay
      1) Simple sugars (especially sticky and if stays a long time)
         a) acid production by mouth bacteria
         b) erosion of tooth enamel

3. Indirect health effects
   a. Refined sugars = empty calories
   b. Contributes to increased energy consumption
   c. Weight gain
      1) Obesity
      2) Increased risk of chronic disease

4. Recommendation for simple sugar intake
   a. Moderation
   b. Forms of sugar commonly added to foods
      a. Corn syrup, high fructose corn syrup, brown sugar, cane sugar, dextrose.

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I. Alternative Sweeteners
   1. Aspartame: Nutrasweet (Equal®)
      a. Dipeptide: aspartic acid + phenylalanine
      b. 4 kcal/g
      c. 180 times sweeter than sucrose
      d. ADI (Acceptable Daily Intake)
         1) 50 mg per kg body weight per day
      2) PKU patients should avoid
         a) Phenylalanine part of nutrasweet
         b) Disordered metabolism
         c) Can lead to mental retardation
   2. Saccharin (Sweet N Low®)
      a. Zero kcal/g
      b. 300 times sweeter than sucrose
      c. No link between saccharin and cancer in humans
   3. Sugar alcohols
      a. sorbitol, mannitol, xylitol
      b. 2-4 kcal/g
      c. sweet as sucrose
      d. Possible GI complications
   4. Acesulfame potassium (Sunnette® and Sweet One®)
      a. 200 times sweeter than sucrose
      b. Heat stable

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Portion Sizes

- 12 oz Soda = 10 tsp of sugar 140 kcals
- 64 oz Soda = 53 tsp of sugar 742 kcals

http://www.idq.com/NCPublic/#
Module III - Carbohydrates

5. Sucralose (Splenda®)
   a. Made from sucrose
   b. heat stable
   c. recognized as safe

6. Stevia (Truvia® or Sun Crystals®)
   a. Herb derived from a plant
   b. 0 kcals
   c. 200-300 times sweeter than sugar
   d. Generally Recognized as Safe (GRAS)

Module III - Carbohydrates

J. Fiber

1. Mostly polysaccharide in nature
   a. Chemical bond linking monosaccharide units cannot be digested by human enzymes
   b. Some types of dietary fiber can be fermented by colonic bacteria

2. Fiber definitions
   a. Dietary fiber – the nondigestible carbohydrate part of plants
   b. Functional fiber – Fiber added to foods or in supplements

3. Classification
   a. Insoluble Fiber
      1) Cellulose, hemicellulose, lignin (non-carbohydrate)
      2) Does not dissolve in water
      3) Forms structural parts of plants
      4) Health benefits
         a. Increased fecal bulk
         b. Decreased fecal transit time
      5) Food Sources
         a. grains (bran)
         b. seeds

   b. Soluble fiber
      1) Pectins, gums, mucilage, some hemicelluloses
      2) Dissolves or swells in water
      3) Health benefits
         a) Delays gastric emptying
         b) Slows nutrient absorption
         c) Helps control blood glucose
         d) Lowers blood cholesterol level
         e) Provides energy to colon
      4) Food sources
         Oat bran, oat products, fruits, vegetables, beans, psyllium

4. Recommendations
   a. 14g of fiber for every 1000 calories per day
      1) AI = 25g day for women, AI= 38g day for men
   b. Consume different types of dietary fiber
   c. Food sources vs. supplements
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5. Health risks associated with very high dietary fiber intake
   a. More than 50 g/day
   b. Intestinal blockages
   c. Binds minerals
calcium, zinc, iron
d. Intestinal gas or cramping
e. Energy dilution
   1) Children
   2) Vegans (no animal products)

Module III - Carbohydrates

K. Low Carbohydrate Diets

1. Atkins, South Beach, Sugar Busters etc.
2. Similar mechanism to fasting
3. Generally also low in calories
4. Lose water weight and muscle mass
5. Side effects
   a. bad breath
   b. constipation
   c. fatigue, nausea, dizziness
   d. bone loss

Module III - Carbohydrates

l. Carbohydrate Recommendations

1. 45-65% of total daily energy needs
2. Increase fresh fruit and vegetable intake
3. Consume at least half of all grains as whole grains
4. Limit consumption of sugar sweetened beverages
5. Add legumes to meals (average 6 grams of fiber per serving)