Chapter 12: Fat Soluble Vitamins – An Overview

Learning Outcomes – Chapters 12 & 13

Upon Completion Student will be able to:

- Define the word *vitamin* and list 3 characteristics of vitamins as a group
- Classify & describe the vitamins according to whether they are fat or water-soluble
- List 3 important food sources for each fat-soluble vitamin
- List the major functions and deficiency symptoms for each fat-soluble vitamin
- List important food sources for water-soluble vitamins discussed
- Describe how fat & water-soluble vitamins are absorbed, transported, stored, and excreted in general terms.
- List the major functions of and deficiency symptoms for identified water-soluble vitamins
- Evaluate the use of vitamin and mineral supplements with respect to their potential benefits and risks to health

Vitamins

- Defining a vitamin
  - Essential organic substances
  - Body cannot synthesize enough to maintain health
  - Absence from the diet will produce deficiency signs and symptoms
- Yield no energy
- May be fat- or water-soluble
- Natural versus synthetic
Vitamins

**Water Soluble**
- B’s - Thiamin, Riboflavin, Niacin, Pantothenic Acid, Biotin, Vitamin B-6, Folate, Vitamin B-12, Vitamin C, Choline

**Fat Soluble**
- Vitamin A
- Vitamin D
- Vitamin E
- Vitamin K

Digestion & Absorption of Vitamins

- Fat-soluble are generally stored
  - except vitamin K
  - 40-90% absorbed (when consumed adequately)
- Water-soluble are generally excreted
  - except vitamin B12 and B6
  - 90-100% absorbed
- Fat malabsorption leads to deficiencies of fat-soluble vitamins
- Alcohol abuse affects absorption of most B vitamins
- Intestinal diseases affect absorption of some B vitamins

Digestion and Absorption
Functions of Vitamin A (Retinoids)

- **Forms** - group of substances called retinoids; including retinol, retinal, and retinoic acid. Known as preformed vitamin A. Plants contain carotenoids which can be converted to vitamin A in the body.
- **Daily Needs**: RDA 900 ug men 700ug women; UL =300ug

**Functions:**
- Growth and Development
- Cell Differentiation
- Vision
- Immune Function
- Dermatology

**Dietary sources Carotenoids**: dark green and yellow orange vegetables and fruits

**Dietary sources Retinoids**: liver, fish oils, fortified dairy products and eggs

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### Vitamin A

<table>
<thead>
<tr>
<th>Vitamin A Sources</th>
<th>Daily Value of 900 ug of Preformed Vitamin A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merguez, 2 cups</td>
<td>298%</td>
</tr>
<tr>
<td>Beef liver, 3 oz</td>
<td>190%</td>
</tr>
<tr>
<td>Chicken liver, 3 oz</td>
<td>125%</td>
</tr>
<tr>
<td>Tomato, 1 cup</td>
<td>93%</td>
</tr>
<tr>
<td>Carrots, 1 cup</td>
<td>81%</td>
</tr>
<tr>
<td>Kales, 1 cup</td>
<td>80%</td>
</tr>
<tr>
<td>Spinach, 1 cup</td>
<td>68%</td>
</tr>
<tr>
<td>Broccoli, 1 cup</td>
<td>65%</td>
</tr>
<tr>
<td>Asparagus, 1 cup</td>
<td>58%</td>
</tr>
<tr>
<td>Almonds, 1 cup</td>
<td>36%</td>
</tr>
<tr>
<td>Merguez, 1 cup</td>
<td>33%</td>
</tr>
<tr>
<td>Peaches, 1 cup</td>
<td>11%</td>
</tr>
</tbody>
</table>

*Calculated from International Units*
Absorption, Transport, Storage, and Excretion of Vitamin A

- **Absorption**
  - Packaged with chylomicrons and transported via the lymphatic system

- **Transport after the liver**
  - Retinoids are bound to retinol binding protein
  - Carotenoids are carried by VLDL

- **90% is stored in liver**

- **Excretion**
  - Small amount in urine

Measuring Vitamin A

- **International unit (IU)** - crude method of measurement
- **Retinol activity equivalent (RAE)** - current, more precise method of measurement

<table>
<thead>
<tr>
<th>Table 9-1</th>
<th>Conversion Values for Retinol Activity Equivalents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 retinol activity equivalent (RAE)</td>
<td>1 IU vitamin A activity</td>
</tr>
<tr>
<td>= 1 µg of all-trans-retinol</td>
<td>= 0.3 µg of all-trans-retinol</td>
</tr>
<tr>
<td>= 15 µg of dietary all-trans-retinol</td>
<td>= 5.6 µg of dietary all-trans-retinol</td>
</tr>
<tr>
<td>= 24 µg of dietary provitamin A carotenoids</td>
<td>= 7.2 µg of dietary provitamin A carotenoids</td>
</tr>
</tbody>
</table>
Carotenoids Functions

- Decrease risk of some diseases
  - Cancers
  - Cardiovascular disease
  - Eye diseases: e.g., macular degeneration

Vitamin A Diseases

- Rare in North America, but major problem in developing countries
- Deficiencies:
  - Night blindness
  - Xerophthalmia (irreversible blindness)
  - Follicular hyperkeratosis
- Toxicities
  - Hypervitaminosis A
  - Upper Limit: 3000 micrograms/d retinol
  - Acute, chronic and teratogenic toxicity

Vitamin D

- Known as the sunshine vitamin since it is made in the body with the help of ultraviolet rays from the sun.
- Functions:
  - Build and maintain bone strength.
  - Functions in maintaining bone health by regulating the absorption/uptake of calcium and phosphorus.
  - Much research in the area of vitamin D to maintain healthy cell growth & differentiation and the relationship to cancer and diabetes.
- Daily Needs:
  - Based on amount you need to meet needs not taken in from foods and also taking into account sun exposure. Since so variable. Adults need 15 – 20 micrograms (600 – 800 IU)
- UL = 4000IU adults (100 micrograms)
- Food Sources: milk, fortified cereals, yogurt, fatty fish, cod liver oil.
Vitamin D

- “Conditional” vitamin or a prohormone
- Vitamin D₃ in Foods:
  - Fatty fish, cod liver oil, fortified dairy products and some fortified breakfast cereals
- Vitamin D₂ is formed in skin from cholesterol:
  - Sunlight changes 7-dehydrocholesterol to cholecalciferol
  - Travels to liver and then kidneys, where converted to bioactive form (calcitriol)
- Requirement: sunlight 2-3 times/week for 10-15min
  - Several factors influence this

Absorption, Transport, Storage and Excretion of Vitamin D

- Absorption and Transportation
  - Absorbed via micelles and transported via chylomicrons in the lymphatic system
  - Bound to a protein in the blood
  - Synthesis of the active form is regulated by parathyroid hormone and kidneys
- Stored in adipose tissue
- Excretion
  - In bile urine and small amount in urine
Vitamin D – Regulation of Calcium

Vitamin D Deficiency

- Rickets – poor bone mineralization in children
- Osteomalacia – soft bones in adults
- Vitamin D resistance – problem with synthesis of active form or defective receptor binding
- Osteopenia
- Osteoporosis
Vitamin E

- Several forms exist but most active is alpha-tocopherol.
- **Function** - Acts as an antioxidant. Helps to inhibits blood platelets from unnecessary clotting/clumping together and forming undesirable blood clots in the blood vessels. Prevents breakdown of red blood cell membranes (hemolysis)
- **Daily Needs** - RDA Adults - approx 15 mg.
- **Food Sources** - vegetable oils, nuts, seeds; and some green leafy vegetables and fortified cereals.

Vitamin E Functions

- **Antioxidant**
  - Stops lipid peroxidation (chain reactions) caused by free radicals
  - Works with vitamin C
Absorption, Transport and Excretion of Vitamin E

- Absorption and Transportation
  - Depends on fat intake
  - Passively via micelles into chylomicrons
  - Transported from liver via lipoproteins
- Stored in adipose tissue
- Excretion
  - Bile, urine and skin

Vitamin E Diseases

- Deficiency
  - Hemolytic anemia -- rare in humans
  - Pre-term infants and smokers are most susceptible
  - Immune function impairment and neurological changes
- Toxicity
  - Can interfere with Vitamin K and cause hemorrhaging
  - Upper Limit:
    - 1000mg natural sources (1100 IU from synthetic sources)

Vitamin E

[Table showing vitamin E levels in different foods]
Vitamin K

- **Two forms**: menaquione and phylloquione
- **Functions**: Essential for blood clotting. Also coenzyme in the process of calcium binding in bones to maintain bone strength.
- **Daily Needs**: Adults AI women 90 micrograms and adult men need 120 micrograms
- **Food Sources**: Green Vegetables such as broccoli, asparagus, spinach, salad greens, brussel sprouts, cabbage. Also vegetable oils and margarines.

Absorption, Transport, Storage, and Excretion of Vitamin K

- **Absorption and Transportation**
  - Absorbed in small intestine, via chylomicrons in lymphatic system.
  - Transported from liver via lipoproteins
- **Stored in the liver** (limited)
- **Excretion**
  - Primarily bile; small amount urine
**Vitamin K - Blood Clotting**

[Diagram of vitamin K's role in blood clotting]

**Vitamin K**

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Adult men Al = 120 µg</th>
<th>Daily Value = 80 µg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada col.</td>
<td>2 tbsp</td>
<td></td>
</tr>
<tr>
<td>Soybean col.</td>
<td>2 tbsp</td>
<td></td>
</tr>
<tr>
<td>Green peas, ½ cup</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Looseleaf lettuce, ½ cup</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabbage, ½ cup</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asparagus, ½ cup</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broccoli, ¼ cup</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brussels sprouts, ½ cup</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turnip greens, ½ cup</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spinach, ½ cup</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kale, ½ cup</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>% Daily Value</th>
<th>0%</th>
<th>50%</th>
<th>100%</th>
<th>150%</th>
<th>200%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult women Al</td>
<td>100%</td>
<td>150%</td>
<td>200%</td>
<td>331%</td>
<td>331%</td>
</tr>
<tr>
<td>Adult men Al</td>
<td>100%</td>
<td>150%</td>
<td>200%</td>
<td>230%</td>
<td>230%</td>
</tr>
</tbody>
</table>

**Vitamins in Health Maintenance**

[Diagram showing various vitamins' benefits]
Nutrient Supplements

- Dietary substance to supplement the diet
- Product intended to supplement the diet that contains one of the following:
  - Vitamin
  - Mineral
  - Herb or other botanical
  - Amino acid
- $23 billion/year industry in United States
- Little regulation by FDA

The Dietary Supplement Health and Education Act (DSHEA) ‘94

- Classifies vitamins, minerals, amino acids, herbal remedies as “foods”
- Prevents the U.S. FDA from regulating them as heavily as additives or drugs
- FDA must prove this “food” is unsafe before it can be pulled from the shelf
- Dietary supplements can be sold without FDA approval

Disclaimer on Claims

- “This statement has not been evaluated by the Food and Drug Administration. This product is not intended to diagnose, treat, cure, or prevent any disease”
- Many people still buy the products without clear understanding of the function and effects of the product can have on their body
Nutrient Supplements

- Rationale to recommend supplement use
  - North Americans unwilling to change food habits
  - Risk for birth defects with folate deficiency
  - Older adults at risk for vitamin B₁₂ deficiency
- Rationale for obtaining nutrients from food
  - Phytochemicals
  - Fiber
  - Bulkiness of calcium
  - Low absorption of magnesium, zinc, and copper
  - Megadoses present risk for toxicity
  - Drug-nutrient interactions

- People most likely to need supplements
  - Women of childbearing age
  - Women with excessive menstrual bleeding
  - People with low energy intakes
  - Strict vegans
  - Newborns
  - Older infants
  - Limited milk intake and restricted sun exposure
  - People with lactose maldigestion or intolerance
  - Older adults
  - People with diets low in plant oils
  - People with fat malabsorption
  - Drug-nutrient interactions
  - Picky eaters
  - Smokers and alcohol abusers
How Should You Get Your Vitamins???

Supplementation Is Not a Substitute for a Poor Diet

- Some individuals may benefit
- Things to look for:
  - No more than 100% Daily Value
  - USP certification
  - Diet and supplement shouldn’t exceed UL’s
  - Check for superfluous ingredients