Chapter 6 : Water &Minerals

Minerals

- they are found in all body fluids and tissues
  - Only 4% of body weight

Minerals

- **Major minerals**
  - present in the body in amounts greater than 5 g (the equivalent of 1 teaspoon)
  - Calcium, phosphorus, magnesium, sulfur, sodium, potassium, and chloride
- **Trace minerals**
  - they are present in the body in amounts less than 5 g
  - Iron, iodine, zinc, selenium, copper, manganese, fluoride, chromium

- 30 other potentially harmful minerals are present in the body such as lead, gold, and mercury. Their presence appears to be related to environmental contamination

General Chemistry

- Unlike the energy nutrients and vitamins, minerals are **inorganic** elements that originate from the earth's crust, not from plants or animals.

- Minerals do not undergo digestion nor are they broken down or rearranged during metabolism

- minerals are not destroyed by light, air, heat, or acids during food preparation. In fact when food is completely burned, minerals are the ash that remains

General Functions of Minerals

Functions	Examples
Provide structure	Calcium, phosphorus, and magnesium provide structure to bones and teeth Phosphorus, potassium, iron, and sulfur provide structure to soft tissues Sulfur is a constituent of skin, hair, and nails
Fluid Balance	Sodium, potassium, and chloride
Acid–base balance	Sodium hydroxide and sodium bicarbonate are part of the carbonic acid–bicarbonate system that regulates blood pH Phosphorus is involved in buffer systems that regulate kidney tubular fluids
Nerve cell transmission and muscle contraction	Sodium and potassium are involved in transmission of nerve impulses Calcium stimulates muscle contractions Sodium, potassium, and magnesium stimulate muscle relaxation
Vitamin, enzyme, and hormone activity	Cobalt is a component of vitamin B_{12} Magnesium is a cofactor for hundreds of enzymes Iodine is essential for the production of thyroxine Chromium enhances the action of insulin

Mineral Balance

- ***Releasing minerals from storage for redistribution***
  - calcium is released from bones to restore normal serum calcium levels
- ***Altering rate of absorption.***
  - 10% of the iron consumed is absorbed, but the rate increases to 50% when the body is deficient in iron
- ***Altering rate of excretion***
  - The only way the body can rid itself of excess sodium is to increase urinary sodium excretion.

Mineral Toxicities

- Minerals that are easily excreted, such as sodium and potassium, do not accumulate to toxic levels in the body under normal circumstances

- Stored minerals can produce toxicity symptoms when intake is excessive
  - Supplements
  - environmental or industrial exposure
  - human errors in commercial food processing
  - Alterations in metabolism

Major electrolytes

Summary of Major Electrolytes

Electrolyte and Sources	Functions	Deficiency/Toxicity Signs and Symptoms
Sodium (Na) Adult AI: 19–50 yr: 1.5 g 50–70 yr: 1.3 g 71+ yr: 1.2 g Adult UL: 2.3 g • Processed foods; canned meat, vegetables, soups; convenience foods; restaurant and fast foods	Fluid and electrolyte balance, acid–base balance, maintains muscle irritability, regulates cell membrane permeability and nerve impulse transmission	***Deficiency*** Rare, except with chronic diarrhea or vomiting and certain renal disorders; nausea, dizziness, muscle cramps, apathy ***Toxicity*** Hypertension, edema

QUICK BITE

sodium additives

Examples of sodium additives

To enhance flavor:
- Sodium chloride
- Monosodium glutamate (MSG)
- Soy sauce
- Teriyaki sauce

To preserve freshness:
- Brine
- Sodium benzoate
- Sodium nitrate or sodium nitrite
- Sodium propionate
- Sodium sulfite (for dried fruits)

As a leavening agent:
- Sodium bicarbonate (baking soda)
- Baking powder

As a stabilizer:
- Sodium citrate
- Disodium phosphate

Potassium (K)
Adult AI: 4.7 g
No UL

- Canned tomato products, sweet potatoes, soy nuts, pistachios, prunes, clams, molasses, yogurt, tomato juice, prune juice, baked potatoes, cantaloupe, dried peas and beans, orange juice, bananas, peanuts, artichokes, fish, beef, lamb, avocados, apple juice, raisins, plantains, spinach, asparagus, kiwifruit, apricots

Fluid and electrolyte balance, acid–base balance, nerve impulse transmission, catalyst for many metabolic reactions, involved in skeletal and cardiac muscle activity

Deficiency
Muscular weakness, paralysis, anorexia, confusion (occurs with dehydration)

Toxicity (from supplements/drugs)
Muscular weakness, vomiting

potassium deficiency

Calcium

calcium deficiency

making up about half of the body's total mineral content. Almost all of the body's calcium (99%) is found in bones and teeth

Mineral and Sources	Functions	Deficiency/Toxicity Signs and Symptoms
Calcium (Ca) *Adult AI* 19–50 yr: 1000 mg 51+ yr: 1200 mg Adult UL: 2.5 g/day • Milk, yogurt, hard natural cheese, bok choy, broccoli, Chinese/Napa cabbage, collards, kale, okra, turnip greens, fortified breakfast cereal, fortified orange juice, dried peas and beans	Bone and teeth formation and maintenance, blood clotting, nerve transmission, muscle contraction and relaxation, cell membrane permeability, blood pressure	*Deficiency* Children: impaired growth Adults: osteoporosis *Toxicity* Constipation, increased risk of renal stone formation, impaired absorption of iron and other minerals

CALCIUM SUPPLEMENTS

- Multivitamins contain much less calcium than calcium supplements.
- Calcium carbonate and calcium citrate are the preferred types of calcium supplements.
- Calcium from supplements is absorbed best in doses of 500 mg or less; spread tablets out over the course of the day.
- Calcium carbonate is the least expensive calcium supplement. It can cause constipation and is best absorbed when taken *with* food.
- Calcium citrate contains acids that promote calcium absorption, which is beneficial in elderly people who normally produce less stomach acid than younger adults. It is less likely to cause constipation than calcium carbonate and is better absorbed on an *empty stomach.*
- Look for supplements that contain vitamin D to maximize absorption.
- Take with milk because the lactose and vitamin D will promote calcium absorption.
- Avoid calcium supplements with dolomite, unrefined oyster shell, or bonemeal without a USP symbol. They may contain contaminants.
- Avoid taking calcium supplements at the same time as iron supplements.

Phosphorus (P) ***Adult RDA*** Men and women: 700 mg Adult UL: To age 70: 4 g/day 70+ yr: 3 g/day • All animal products (meat, poultry, eggs, milk), ready-to-eat cereal, dried peas and beans; bran and whole grains; raisins, prunes, dates	Bone and teeth formation and maintenance, acid–base balance, energy metabolism, cell membrane structure, regulation of hormone and coenzyme activity	***Deficiency*** Unknown ***Toxicity*** Low blood calcium

phosphorus deficiency

Iron

- Iron in foods exists in two forms:
  - heme iron, found in meat, fish, and poultry
  - nonheme iron, found in plants such as grains, vegetables, legumes, and nuts.
- the overall rate of iron absorption, which includes both heme and nonheme iron, is only 10% to 15% of total intake
  - In times of need, the absorption increases (up to 50%)
    - Growth
    - Pregnancy
    - Iron deficiency

The bioavailability of Iron

- Heme :
  - The rate of heme iron absorption is normally about 15% and is influenced only by need, not by dietary factors
- Non heme:
  - Enhanced or inhibited by numerous dietary factors

- Iron recommendations for vegetarians are 1.8 times higher than that for nonvegetarians because of the lower bioavailability of iron from a vegetarian diet

QUICK BITE

Nonheme iron absorption

Nonheme iron absorption is *enhanced* when consumed at the same time as:

- Vitamin C-rich foods, such as orange juice or tomato products
- Heme iron, found in meat, fish, and poultry

Nonheme iron absorption is *impaired* when consumed at the same time as:

- Coffee
- Tea
- Calcium
- Phytates found in dried peas and beans, rice, and grains
- Oxalates found in spinach, chard, berries, chocolate

TRACE MINERALS

iron deficiency

Mineral and Sources	Functions	Deficiency/Toxicity Signs and Symptoms
Iron (Fe) ***Adult RDA*** Men: 8 mg Women: 19–50 yr: 18 mg 51+ yr: 8 mg Adult UL: 45 mg • Beef liver, red meats, fish, poultry, clams, tofu, oysters, lentils, dried peas and beans, fortified cereals, bread, dried fruit	Oxygen transport via hemoglobin and myoglobin; constituent of enzyme systems	***Deficiency*** Impaired immune function, decreased work capacity, apathy, lethargy, fatigue, itchy skin, pale nail beds and eye membranes, impaired wound healing, intolerance to cold temperatures ***Toxicity*** Increased risk of infections, apathy, fatigue, lethargy, joint disease, hair loss, organ damage, enlarged liver, amenorrhea, impotence Accidental poisoning in children causes death

Zinc (Zn) ***Adult RDA*** Men: 11 mg Women: 8 mg Adult UL: 40 mg • Oysters, red meat, poultry, dried peas and beans, fortified breakfast cereals, yogurt, cashews, pecans, milk	Tissue growth and wound healing, sexual maturation and reproduction; constituent of many enzymes in energy and nucleic acid metabolism; immune function; vitamin A transport, taste perception	***Deficiency*** Growth retardation, hair loss, diarrhea, delayed sexual maturation and impotence, eye and skin lesions, anorexia, delayed wound healing, taste abnormality, mental lethargy ***Toxicity*** Anemia, elevated LDL, lowered HDL, diarrhea, vomiting, impaired calcium absorption, fever, renal failure, muscle pain, dizziness, reproductive failure

zinc deficiency

Mineral and Sources	Functions	Deficiency/Toxicity Signs and Symptoms
Iodine ***Adult RDA*** 150 micrograms Adult UL: 1100 micrograms • Iodized salt, seafood, bread, dairy products	Component of thyroid hormones that regulate growth, development, and metabolic rate	***Deficiency*** Goiter, weight gain, lethargy During pregnancy may cause severe and irreversible mental and physical retardation (cretinism) ***Toxicity*** Enlarged thyroid gland, decreased thyroid activity
Selenium (Se) ***Adult RDA*** Men and women: 55 micrograms Adult UL: 400 micrograms /day • Brazil nuts, tuna, beef, cod, turkey, egg, cottage cheese, rice, enriched and whole-wheat bread	Component of antioxidant enzymes, immune system functioning, thyroid gland activity	***Deficiency*** Enlarged heart, poor heart function, impaired thyroid activity ***Toxicity*** Rare; nausea, vomiting, abdominal pain, diarrhea, hair and nail changes, nerve damage, fatigue

iodine deficiency
selenium deficiency

Copper (Cu) *Adult RDA:* 900 micrograms Adult UL: 10,000 micrograms • Organ meats, seafood, nuts, seeds, whole grains, cocoa products, drinking water	Used in the production of hemoglobin; component of several enzymes; used in energy metabolism	***Deficiency*** Rare; anemia, bone abnormalities ***Toxicity*** Vomiting, diarrhea, liver damage
Manganese (Mn) ***Adult AI*** Men: 2.3 mg Women: 1.8 mg Adult UL: 11 mg • Widely distributed in foods. Best sources are whole grains, oat bran, tea, pineapple, spinach, dried peas and beans	Component of enzymes involved in the metabolism of carbohydrates, protein, and fat, and in bone formation	***Deficiency*** Rare ***Toxicity*** Rare; nervous system disorders
Fluoride (Fl) ***Adult AI*** Men: 4 mg Women: 3 mg Adult UL: 10 mg • Fluoridated water, water that naturally contains fluoride, tea, seafood	Formation and maintenance of tooth enamel, promotes resistance to dental decay, role in bone formation and integrity	***Deficiency*** Susceptibility to dental decay, may increase risk of osteoporosis ***Toxicity*** Fluorosis (mottling of teeth), nausea, vomiting, diarrhea, chest pain, itching
Chromium (Cr) ***Adult AI*** Men: 19–50 yr: 35 micrograms 51+ yr: 30 micrograms Women 51+ yr: 30 micrograms 19–50 yr: 25 micrograms Adult UL: Undetermined • Broccoli, grape juice, whole grains, red wine	Cofactor for insulin	***Deficiency*** Insulin resistance, impaired glucose tolerance ***Toxicity*** Dietary toxicity unknown Occupational exposure to chromium dust damages skin and kidneys
Molybdenum (Mo) *Adult RDA:* 45 micrograms Adult UL: 2000 micrograms • Milk, legumes, bread, grains	Component of many enzymes; works with riboflavin to incorporate iron into hemoglobin	***Deficiency*** Unknown ***Toxicity*** Occupational exposure to molybdenum dust causes gout-like symptoms

copper
magnasese
fluoride
chromium

WATER

- It is the single largest constituent of the human body

- Although most people can survive 6 weeks or longer without food, death occurs in a matter of days without water.

Functions of Water

- ***Provides shape and structure to cells***
  - *Muscle cells (75% water) vs. fat cells (25%)*
  - *Men vs Women*
- ***Regulates body temperature***
  - Because water absorbs heat slowly
  - Evaporation of water (sweat) from the skin cools the body
- ***Aids in the digestion and absorption of nutrients***
  - Approximately 7 to 9 L of water is secreted in the gastrointestinal tract daily
- ***Transports nutrients and oxygen to cells***
  - By moistening the air sacs in the lungs, water allows oxygen to dissolve and move into blood for distribution throughout the body.
  - 92% of blood plasma is water.

Functions of Water

- ***Serves as a solvent for vitamins, minerals, glucose, and amino acids.***
- ***Participates in metabolic reactions***
  - synthesis of hormones and enzymes.
- ***Eliminates waste products***
  - through urine, feces, and expirations.
- ***Is a major component of mucus and other lubricating fluids***
  - reduces friction in joints where bones, ligaments, and tendons come in contact with each other and it cushions contacts between internal organs that slide over one another.

Water Balance

- a state where output and intake are approximately equal.

Water Output

water output

Sources and Average Amounts of Daily Water Loss

Source of Water Loss	Average Amount Lost (mL/day)
Respiratory	200–350
Urinary	1000–2000
Fecal	100–200
Skin	450
Total	1750–3000

Source: National Academy of Sciences, Institute of Medicine (2004). *Dietary Reference Intakes for water, potassium, sodium, chloride, and sulfate*. Washington, DC: National Academies Press.

Water Output

- **Sensible water losses**
  - from urine and feces
- **insensible water losses**
  - respirations and the skin.
    - Extreme environmental temperatures (very hot or very cold),
    - high altitude,
    - low humidity,
    - strenuous exercise

Water Intake

- **Drinking Water.**
  - both tap water and bottled water
  - Soda water, tonic water, and club soda are carbonated soft drinks, not different varieties of water.
- **Other Beverages**
  - Juice, carbonated beverages, coffee, tea, and milk
- **Solid Foods**
  - Approximately 19% to 25% of total water intake comes from the water in food
  - Fruits and vegetables are the highest
  - Fats and oils are the lowest

QUICK BITE

Percentage of water in selected foods

	% water by weight
Lettuce	95
Watermelon	92
Broccoli	91
Milk	89
Carrot	87
Yogurt	85
Chicken	65
Whole wheat bread	38
Honey	17
Vegetable oil	0

percentage of water in selected food
lettuce watermelon

Water Recommendations

- Water is an essential nutrient because the body cannot produce as much water as it needs.
- actual requirements vary greatly among individuals
- For men aged 19 to older than 70 years, the **AI** is 3.7 L/day,
  - which includes 3 L as drinking water and other beverages
  - and the remainder coming from solid food.
- For women of the same age, the AI is 2.7 L,
  - of which approximately 2.2 L comes from drinking water and beverages

- Intakes higher than the AI are recommended for rigorous activity in hot climates
- Because the body cannot store water, it should be consumed throughout the day.

Water recommendations

- For healthy adults, **thirst** is usually a reliable indicator of water need
- fluid intake is assumed to be adequate when the color of urine produced is pale yellow

- For the elderly and children, the sensation of thirst is blunted and may not be a reliable indicator of need.
  - and during hot weather or strenuous exercise

- drinking fluids should not be delayed until the sensation of thirst occurs because by then fluid loss is significant.

Water recommendations

Methods to Estimate Fluid Needs

fluid needs

Method	Recommendation	Example (for a 70 kg person consuming 2000 cal/day)
1	30 mL/kg body weight	70 kg × 30 mL/kg = 2100 mL/day
2	1 mL/cal consumed	1 mL/cal × 2000 cal/day = 2000 mL/day
3	100 mL/kg for the first 10 kg,	100 mL/kg for the first 10 kg = 1000 mL
	50 mL/kg for the next 10 kg,	50 mL/kg for the next 10 kg = 500 mL
	15 mL/kg for each remaining kg of body weight	15 mL/kg for the remaining 50 mg = 750 mL
		Total 2250 mL/day

Source: Bossingham, M., Carnell, N., & Campbell, W. (2005). Water balance, hydration status, and fat-free mass hydration in younger and older adults. *The American Journal of Clinical Nutrition, 81*, 1342–1350.

Water recommendations

- In clinical situations, actual water requirement is highly variable:
  - Vomiting, diarrhea,
  - Fever
  - thermal injuries
  - uncontrolled diabetes
  - Hemorrhage
  - certain renal disorders
- increase water losses as does the use of drainage tubes

Dehydrations

- impaired mental function
- impaired motor control
- increased body temperature during exercise
- Increased resting heart rate when standing or lying down
- and an increased risk of life-threatening heat stroke

High intake of water

- A chronic high intake of water has not been shown to cause adverse effects in healthy people who consume a varied diet as long as intake approximates output

- may cause hyponatremia, but it is rare in healthy people who consume a typical diet

WATER AND MINERALS IN HEALTH PROMOTION

- Adequate water
- Less sodium
- More potassium

Less sodium

TIPS FOR LOWERING SODIUM INTAKE

- Avoid or limit convenience foods, such as boxed mixes, frozen dinners, and canned foods.
- Eat home-cooked meals more often.
- Eat more fresh or frozen vegetables.
- Compare labels to choose brands or varieties with the lowest amount of sodium.
- Use fresh veggies in place of pickles.
- Substitute low-sodium tuna and roasted chicken for deli meats.
- Replace sausages and hot dogs with fresh meats such as rotisserie chicken.
- Use cheese sparingly.
- Choose nut butters with no sodium added.
- Cook rice and pasta without salt.
- Switch to pasta sauce without added salt or combine equal parts of no-salt-added tomato sauce with bottled pasta sauce.
- Choose cereals with no added salt, such as shredded wheat, puffed whole-grain cereal, and unsalted oatmeal.
- Use lower salt condiments, such as salt-free ketchup, Worcestershire sauce, vinegar, and low-sodium mayonnaise.
- Substitute homemade vinegar and oil dressing for bottled varieties.
- If you use canned vegetables, drain away liquid and rinse thoroughly.
- Limit salty snacks.
- Instead of salt, season food with spices, herbs, lemon, vinegar, or salt-free seasonings.

DESCRIPTORS OF SODIUM CONTENT

If the label says . . .	One serving contains. . .
Sodium free	<5 mg
Very low sodium	<35 mg
Low sodium	<140 mg
Reduced or less sodium	At least 25% less sodium compared with a standard serving size of the traditional food
Light in sodium	50% less sodium than the traditional food (restricted to >40 calories per serving or >3 g fat per serving)
Salt free	<5 mg
Unsalted or no added salt	No salt added during processing (this does not necessarily mean the food is sodium free)

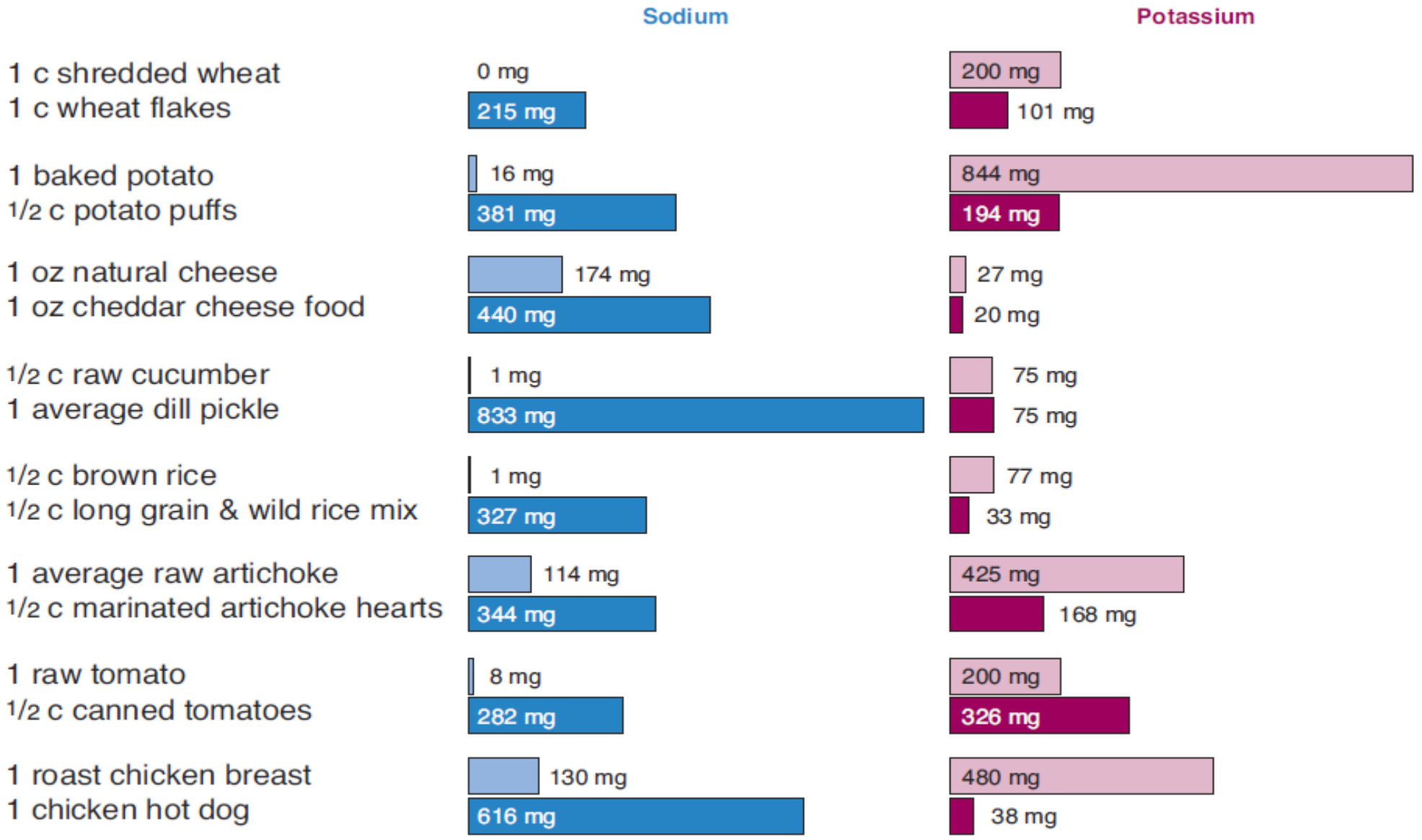

FIGURE 6.4 Effect of food processing on the sodium content of selected foods.

More Potassium

- Food sources are recommended over supplements,
- and fruits and vegetables are preferred because potassium is better absorbed from them than from meat, milk, and cereal products