Carbohydrates

Carbohydrates (CHO) are a category of compounds derived from plant foods which provide one molecule of water with each carbon. Nutritionally important carbohydrates are sources of glucose and/or short chain fatty acids. Simple sugars, starches, and dietary fiber are the nutritionally important carbohydrates. Simple sugars are distinguished from complex carbohydrates by the nature of their structures which consist of either a monosaccharide or disaccharide unit. Complex carbohydrates are polysaccharides that contain multiple monosaccharide units connected by more than one glycosidic bond. Complex carbohydrates may be classified as either starches, which have alpha glycosidic linkages, which are readily digested by intestinal amylases or as dietary fiber which have beta linkages which are resistant to these enzymes. Sources of simple sugars or starches that undergo processing are considered refined carbohydrates. Refined carbohydrate sources can be distinguished from their unprocessed counterparts by their greater solubility and lower dietary fiber content. Simple sugars and refined starches are more readily absorbed than complex carbohydrates with a higher fiber content. A detailed description of the different classes of carbohydrate is provided in the table below:

Simple Carbohydrates		**Complex Carbohydrates**	
Digestible SIMPLE Carbohydrates		**Digestible COMPLEX Carbohydrates**	
Monosaccharides	**Examples**	**Polysaccharides**	**Examples:**
Glucose	Fruit, honey, corn syrup	Starch and dextrins	Grains, legumes & vegetables
Fructose	Fruit, juices, honey, high fructose corn syrup	Glycogen	Meats
Galactose	Fruit, honey	**Partially Digested COMPLEX Carbohydrates**	
Mannose	Pineapple, olives, carrots	Inulin	Jerusalem artichokes, onions, garlic
		Mannosans	Legumes
Disaccharides		Raffinose	Sugar beets, kidney beans, lentils navy beans
Sucrose	Cane sugar, molasses, maple syrup	Stachyose	Dried beans
Lactose	Milk and milk products	Pentosans	Fruits and gums
Maltose	Malt products and some breakfast cereals	**Indigestible COMPLEX carbohydrates (Dietary Fiber)**	
Carbohydrate Derivatives		Cellulose	Vegetables and seeds
Ethyl alcohol	Fermented grains	Hemicellulose	Vegetables and seeds
Lactic acid	Milk products	Pectins	Citrus Fruits
Malic acid	Fruits	Gums & mucilages	Oats, barley, seeds

* Source: Mahan, L.K. and Escott-Stump, S. Krause's Food, Nutrition & Diet Therapy, 10th ed., 2000.

Carbohydrates which yield glucose are nutritionally important because glucose is the preferred fuel source of tissues. Glucose is more efficiently oxidized than fatty acids of equal carbon chain length and can be utilized under both aerobic and anaerobic conditions. It is also the primary energy source of brain, nervous tissue, retina, kidney, and red blood cells. Consequently, a minimum of 50% of total energy consumed should be digestible carbohydrate. The energy value of one gram of carbohydrate is 4 kilocalories. In contrast to digestible carbohydrate, dietary fiber and other indigestible carbohydrates yield only minimal energy from intestinal microbial fermentation. Metabolism of fermentable fiber yields short chain fatty acids which are absorbed by the colon. Butyrate is utilized within the colonocyte while propionate and acetate are absorbed and transported to muscle and liver, respectively. Fermentable fiber provides approximately 2 kcal/g of energy. Indigestible components of fiber benefit the intestinal tract by facilitating transport of nutrients and waste which lowers intralumenal pressure and promotes regularity.

The primary metabolic fate of carbohydrate is to provide energy. A limited amount of glucose is stored as glycogen in liver and skeletal muscle. Liver glycogen is maintains blood glucose levels during periods of fasting while muscle glycogen provides a supply of energy for contraction and other metabolic processes that sustain activity. Contrary to popular belief, excess carbohydrate is not converted to fat in significant amounts even with very high energy intakes. However, excess energy consumed as carbohydrate will contribute to weight gain since preferential utilization of glucose as a fuel source will inhibit mobilization of body fat stores and decrease the rate of fat oxidation.

Considerations

Whole grains provide the most nutrient-dense source of complex carbohydrates. Oatmeal, whole wheat bread, brown rice and barley are examples of whole grain products that are also rich in vitamins, rninerals, fiber, and other biologically active components called phytochemicals. Refined carbohydrates such as white bread, white rice, sugar-sweetened foods and beverages provide energy, but with less nutritional value and fiber content.

High intakes of simple sugars from refined sources (e.g., baked goods), instead of from natural sources such as fruits, may contribute to increased risk of diabetes, obesity, and hypertension through effects that promote insulin resistance. No direct causal link has been established between refined sugars and these or any other condition, with the exception of dental caries.

Carbohydrate intake is a focus of dietary management to control blood glucose levels in patients with diabetes mellitus and hypoglycemia. A carbohydrate-rich diet is recommended for endurance athletes who wish to maximize muscle glycogen stores. Sucrose and dextrose replenish glycogen stores more rapidly than fructose or other types of carbohydrate and are thus the preferred type of carbohydrate to consume during athletic events. However, following activity, consumption of starch or high fiber carbohydrate sources are as effective as simple sugars in replenishing glycogen stores.

Requirements

Carbohydrates should comprise 55-65% of total energy consumed daily. Although individual energy needs may vary, carbohydrate requirements range from 300-450 grams daily for healthy adults requiring 2000 and 3000 kilocalories, respectively. The total carbohydrate and fiber content of commonly consumed foods are listed in the table below.

Food Item	**Total Carbohydrates** (grams)	**Total Fiber** (grams)
Milk Group		
Skim milk, 1 cup	12	0
Chocolate milk, low-fat, 1 cup	26	0
Pudding, low-fat, 1/2 cup	34	0
Yogurt, low-fat, 1 cup	46	0
Frozen low-fat yogurt, 1 cup	37	0
Beans		
Garbanzo beans, 1/2 cup	22	6.2
Black beans, 1/2 cup	22	5.5
Pinto beans, 1/2 cup	22	7.4
Fruits		
Apple, medium	32	5.7

Applesauce, 1/2 cup	14	1.5
Apple juice, 1 cup	29	0
Banana, medium	28	2.8
Cantaloupe, wedge	6	0.6
Raisins, 2 Tbl	15	0.8
Grapes, 1 cup	28	1.6
Grape juice, 1 cup	24.5	.5
Orange, medium	16	3.1
Orange juice, 1 cup	24.5	0
Pear, fresh	25	4
Pineapple, 1/2 cup	9.6	1
Strawberries, 1/2 cup	5.8	2
Watermelon, 1 slice	20.5	1.4
Vegetables		
Carrots, 1/2 cup raw	8	2.3
Green beans, 1/2 cup ckd	4	1.9
Green peas, 1/2 cup ckd	11.4	4.4
Corn, 1/2 cup, ckd	16.0	2.0
Potatoes, white, 1/2 cup ckd	26.5	2.4
Potatoes, sweet, 1/2 cup ckd	34.0	4.0
Grains		
Bagel, white, large	47.5	2.0
Bagel, whole wheat, large	56.4	4.0
Bread, white, 1 sl	12.4	0.6
Bread, whole wheat, 1 sl	13.0	2.0
Cereal, cornflakes, 1 cup	24.2	0.8
Cereal, raisin bran, 1 cup	46.0	8.0
Cereal, granola, 1/2 cup	33	3.6
Cereal, oatmeal, 1 cup	25.3	4.0
Crackers, saltines, 8	17.1	1.0
Crackers, whole wheat, 8	25.6	1.3
Potato chips, 1 oz	15.8	1.3
Pretzels, 1 oz	22.5	1.0
Popcorn, 1 cup	19.0	3.7
White pasta, 1 cup ckd	39.7	2.0
Whole wheat pasta, 1 cup ckd	37.2	3.9
White rice, 1 cup ckd	44.5	0.6
Brown rice, 1 cup ckd	44.8	3.5