# FIRON AN.

NUTRITION | Dietary Sources of Energy: Carbohydrates

### Carbohydrates

Carbohydrates are the most important fuel for endurance athletes. This essential fuel, which is used during both aerobic and anaerobic training, is stored in limited quantities in the body and burned for energy at twice the rate of fats. Because carbohydrates are often the focus of many trendy diets, weight loss plans and nutrition controversies, their role in fueling the body of the endurance athlete is often misunderstood, as is the terminology used to describe the various forms of carbohydrates in our diet.

The carbohydrate family includes sugar, starch and fiber. Plants are the main sources of carbohydrates. There are simple and complex forms of carbohydrates, which describe their structure in food or the number of molecules they contain. In the endurance athlete's training and race diet, carbohydrates from these naturally occurring sources are present not only in foods, but in various manufactured forms designed to fuel athletes before, during, and after exercise in forms that deliver needed nutrients and which are well-tolerated. Manufactured carbohydrates from various food sources can be found in carbohydrate-electrolyte beverages, recovery beverages, gels, shots, blocks and other products.

#### A. Simple carbohydrates

Simple carbohydrates are often called "sugars" and consist of one or two molecules. One molecule carbohydrates, are called monosaccharides. There are three: glucose, fructose, and galactose.

#### 1. Monosaccharides

Glucose is the most abundant

monosaccharide, though much of it is linked to other sugars in our diet to form complex carbohydrate. In the body, glucose circulates in our blood and is often call "blood sugar."

#### 2. Dissacharides

Carbohydrates containing two monosaccharides are called disaccharides. Naturally occurring forms



are maltose, sucrose and lactose. High fructose corn syrup is a manufactured dissaccharide.

Maltose consists of two linked glucose molecules. It does not contribute a large amount of carbohydrate to the diet, but can be found in sprouted grains, malted cereals and beer. Sucrose is a common table sugar composed of one glucose and one fructose molecule. Large amounts are found naturally in plants such as sugarcane, sugar beets and maple tree sap. These sucrose sources can be purified and common forms are brown, white, and powdered sugar.

Lactose consists of one glucose and one galactose molecule and is the primary sugar in milk and milk products. Many people are not able to digest large amounts of lactose because they do not produce enough of the enzyme lactase, which breaks the bond between glucose and galactose. This can result in intestinal gas, bloating and cramping.

#### "Sugars"

Many terms are used to describe these monosaccharides and dissacharides and products containing sugars, including simple sugars. Currently, food labels combine all the sugars either naturally present in foods or added during manufacturing into one category, listing them as "sugars." For example, a yogurt containing fruit may have sugar from naturally occurring lactose (milk) and fructose (fruit), as well as added sucrose. The total amount of sugar on the label reflects all these sugar sources.

#### B. Complex Carbohydrates

Carbohydrates that contain three to 20 sugar units are oligosaccharides. Two found in foods are raffinose and stachyose, which are found in onions, cabbage, broccoli, whole wheat and legumes. These carbohydrates cannot be broken down by our digestive enzymes and instead are passed into the large intestine where they are metabolized by bacteria.



#### 1. Polysaccharides

Polysaccharides are complex carbohydrates that often contain hundreds to thousands of glucose molecules. Some are digestible, such as starch, and some are mostly indigestible such as fiber. Starches exist in a variety of forms and include amylase, amylopectin and resistant starch. Starch is the major polysaccharide in our diet and is found in plant foods such as potatoes, pasta, breads, cereals, rice, rye, barley and corn.

A carbohydrate that has more than ten glucose molecules is also

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known as a glucose polymer. Maltodextrin is a manufactured glucose polymer found in sports nutrition products.

#### Glycogen

Glycogen, the storage form of carbohydrate in humans also contains many glucose units linked together. It has a highly branched structure that allows it to be quickly broken down by enzymes in the cells where it is stored. Liver and muscle cells are the major storage site for glycogen.

#### Fiber

Total fiber refers to dietary fiber that occurs naturally in foods, as well as functional fiber that can be added to food to provide health benefits. Currently, food labels only include dietary fiber.

Dietary fibers can be insoluble, because they do not dissolve in water. These fibers increase intestinal transit time, prevent constipation and lower risks for various diseases of the colon. Sources of insoluble fiber include cellulose (skins of fruits and vegetables, legumes, celery and whole grains), hemicelluloses (whole grains and some vegetables) and lignans (seeds of fruits, bran layer of whole grains).

Soluble fiber dissolves easily in water and becomes gel like in consistency. Soluble fibers include pectins (fruits), some hemicelluloses (oat bran) gums and mucilages (legumes, and psyllium). Psyllium is a fiber that is mainly water soluble, but which also have some insoluble properties. Specific foods can contain several types of fiber. Fiber can be found in many of the same foods as starch.

#### Carbohydrates in Foods

Carbohydrates are found in a wide variety of foods including jam, honey, fruit, fruit juices, vegetables, rice, potatoes, pasta, cereals and breads. Carbohydrate containing foods such as milk, yogurt, dried beans, lentils, corn and peas also contribute protein. Some carbohydrate containing foods also contribute fat to our diets.

Added sugars are sugars and syrups that are added to foods or beverages when they are processed or prepared. This does not include naturally occurring sugars such as those in milk and fruits. You can read labels of processed foods and find a number of terms that indicate added sugars. This includes anhydrous dextrose, brown sugar, confectioner's powdered sugar, corn syrup, corn syrup solids, dextrose, fructose, highfructose corn syrup, honey, invert sugar, lactose, malt syrup, maltose, maple syrup, molasses, nectars, pancake syrup, raw sugar, sucrose, sugar and white granulated sugar.

The type of carbohydrate found in sports drinks varies depending on the manufacturer, with taste, osmolality (the concentration of particles) and gut tolerances being the primary considerations for these blends. Many blends provide both glucose or a carbohydrate form that quickly breaks down to glucose (such as maltodextrin) and sugars that break down to fructose, as well as added fructose. This combination allows them to meet the requirements for "multiple transportable carbohydrates." Glucose and fructose can be absorbed through separate and simultaneous mechanisms through the small intestine, allowing for more carbohydrate to enter the endurance athlete's bloodstream, better fueling the athlete.

Some carbohydrates commonly listed on sports drinks labels include maltodextrin, glucose, sucrose, glucose polymers and fructose.

Other sports nutrition products such as gels also contain various forms of carbohydrate and may contain manufactured ingredients with familiar names such as dried cane sugar and honey and unfamiliar names such as isomaltulose.

#### Requirements

How much carbohydrate an endurance athlete requires daily varies with the intensity and duration of the exercise.

The food lists below can guide an endurance athlete in choosing the right amount of nutritious foods required to reach their daily carbohydrate target. Packaged foods also provide food labels that list carbohydrate amounts per portion. These food lists provide the portion for specific carbohydrate amounts.

For example, the grains, starches, and fruits are given a designated portion for 15 g carbohydrate, while dairy foods and dairy substitutes have 12g and 20 g portions, and vegetables are 10 g carbohydrate portions. An athlete may consume multiple units of one food at a meal, as well as several to many servings from one food group during the training day.

The adequate intake of fiber is based on a goal of 14 g per 1000 calories consumed. For adults up to age 50, the adequate intake is 25 g for women and 38 g for men. After age 50 the adequate intake falls to 21 g and 30 g daily respectively. The Daily Value used for fiber on food and supplement labels is 25 g for a 2000 calorie diet. Fiber content of a food or type of food is listed when available.



Types of Dietary Carbohydrates			
Monosaccharides	Dissacharides	Polysaccharides	
Glucose	Sucrose	Plant Starch	
Fructose	Maltose	Amylose	
Galactose	Lactose	Amylopectin Resistant Starch	
		Human Starch	
		Glycogen	
Insoluble Fibers	Soluble Fibers	Other Carbohydrates	
Cellulose	Gums	Sorbitol (sugar alcohol)	
Hemicellulose	Pectins	Ribose	
Lignans	Mucilages	Deoxyribose	
	Psyllium		

Common Food Measurements			
Gram (g)	a unit of weight.		
Milligram (mg)	1/1000 of a gram		
Microgram (mcg)	1/1000 of a milligram (1 millionth of a gram).		
Teaspoon (tsp)	contains 5 g. 5 cc (cubic centimeters) or 5 mL (milliliters).		
Tablespoon (Tbsp)	15 grams or 3 teaspoons.		
Ounce (oz)	30 grams or 2 tablespoons.		
Cup (c)	8 ounces (oz.)		



<b>Grains and starches</b> 15 g carbohydrate servings			
Food	Imperial units	Metric units	Fiber (g)
Breads			
Bread, whole wheat	1 ounce (1 slice)	28 g	1.9
Bread Crumbs	½ cup	28 g	1.0
Bagel	½ large	28 g	1.7
Chapati	1 small (6″ across)	18 g	3.0
Cornbread	1½ ounces	42 g	0.5
Dinner roll	2″ square, 2″ high	28 g	0.8
English muffin, wheat	½ whole (1 oz)	28 g	2.6 g
Muffin, homemade	½ medium (1.5 oz)	28 g	<1.0
Naan	½ large 10″ diameter	35 g	<0.5
Pancake	4" across	38 g	<0.5
Pita pocket	½ of 6" diameter	30 g	1.3
Hamburger bun	½ whole (1 oz)	28 g	0.7
Taco shell	2 shells, 5″ across	37 g	2.0
Tortilla, corn	1 medium 6″ across	24 g	1.2
Tortilla, flour	½ medium (7-8" across)	23 g	1.5
Waffle	1, 4" across	33 g	0.8
Cereals			`
Granola, low fat	½ cup (2 ounces)	25 g	1.5
Granola, regular	½ cup	30 g	3.2
Grits, cooked	½ cup	121 g	0.25
Muesli	1⁄2 сир	25 g	2.0
Oats, dry	½ cup	20 g	2.0
Oatmeal	½ сир	120 g	2.0
Shredded wheat	1 rectangular biscuit	24 g	2.6
Sugar coated	½ cup	20 g	0.25
Unsweetened, ready to eat	¾ cup	25 g	2.2



Carbohydrate and fiber content of foods				
Food	Imperial units	Metric units	Fiber (g)	
Grains				
Amaranth, cooked	¼ cup	82 g	1.7	
Buckwheat groats, cooked	½ cup	84 g	2.25	
Millet, cooked	¼ cup	58 g	0.8	
Pasta, wheat, spaghetti, cooked	¼ cup	46 g	2.1	
Polenta, cooked	¼ cup	102 g	1.0	
Quinoa, cooked	¼ cup	56 g	3.3	
Rice noodles, cooked	½ cup	88 g	0.9	
Soba noodles, cooked	⅔ cup	76 g		
Wheat germ, toasted	½ cup or 4 tbsp.	28 g	3.65	
Wheat flour, whole wheat	½ cup	24 g	2.9	
Wild rice, cooked	½ cup	82 g	1.5	
Starchy Vegetables				
Cassava or yucca, cooked	<sup>1</sup> ∕₃ cup	83 g	1.0	
Corn on cob, cooked	1 ear	77 g	2.2	
Parsnips, cooked	4" long	80 g	3.2	
Peas, cooked	½ cup	80 g	4.4	
Plantain, ripe, sliced, cooked	<sup>1</sup> ∕₃ cup	51 g	1.2	
Potato, baked, w/skin	½ medium	86 g	1.9	
Pumpkin, cooked, mashed	1 cup	245 g	2.7	
Squash, winter, cooked, mashed	1 сир	245 g	6.4	
Legumes				
Baked beans	<sup>1</sup> ∕₃ cup	84 g	4.6	
Beans, cooked (black, kidney, pinto, white), cooked	<sup>½</sup> cup	57 g	7.5	
Chickpeas or garbanzo	¼ cup	54 g	4.0	
Lentils	½ cup	99 g	7.8	
Peas, split or black-eyed	½ cup	89 g	7.4	
Refried beans, canned	½ cup	126 g	6.7	



Carbohydrate and fiber content of foods			
Food	Imperial units	Metric units	Fiber (g)
Crackers and Snack Foods			
Crispbread, whole grain	2 rectangular wafers (1 oz)	26 g	0.8
Melba toast	4 toasts	20 g	0.3
Ritz crackers	1½ cracker	30 g	0.5
Round crackers	1 oz	30 g	0.2
Saltines	8 crackers	28 g	0.6
Wheat crackers	12 thin squares	28 g	1.2
Wheat thins	16 crackers (1 oz)	29 g	0.9
Whole wheat crackers	7 crackers (1 oz)	28 g	3.0
Fruit			
Apple	1 medium	138 g	3.7
Apricots	4 apricots	155 g	3.7
Banana	½ medium	14 g	2.2
Blackberries	1 cup	144 g	7.6
Blueberries	¾ cup	109 g	2.9
Cantaloupe	1 cup pieces	177 g	1.4
Cherries	1 cup	117 g	2.7
Dates	3	24 g	1.8
Dried fruit	2 tbsp.	16 g	1.1
Figs, fresh	2 medium	100 g	3.4
Grapefruit, large	1 whole medium	236 g	2.6
Grapes	1 cup	92 g	0.9
Honeydew melon	1 cup pieces	177 g	1.1
Kiwi	1 medium	76 g	2.6
Mango	½ medium	103 g	1.8
Nectarine	1 medium	136 g	2.2
Orange	1 medium	131 g	3.1
Рарауа	½ medium	150 g	2.75
Peach, fresh	1 large	120 g	2.5



Carbohydrate and fiber content of foods				
Food	Imperial units	Metric units	Fiber (g)	
Fruit				
Pears, fresh	1 small or ½ large	140 g	3.0	
Pineapple, fresh	1 cup pieces	155 g	1.9	
Plums, small	2 small	130 g	2.0	
Raspberries	1 cup	123 g	8.4	
Strawberries	1.25 cups	318 g	4.0	
Tangerines	2 medium	170 g	3.8	
Watermelon	1½ cups cubes or 1 slice	190 g	1.0	
Fruit and Vegetable J	uices	1		
Apple juice/cider	4 fluid oz	120 ml	0.35	
Fruit juice blend	4 fluid oz	120 ml	0.00	
Grape juice	4 fluid oz	120 ml	0.15	
Orange juice	4 fluid oz	120 ml	0.00	
Pineapple juice	4 fluid oz	120 ml	0.00	
Prune juice	4 fluid oz	120 ml	1.3	
Tomato Juice	12 fluid oz	360 ml	1.5	
Vegetable blend juice	12 fluid oz	360 ml	2.8	
<b>Vegetables</b> 10 g carbohydrate servings				
Vegetables				
Asparagus, cooked	1 cup	180 g	1.4	
Baby corn, cooked	1 cup	120 g	4.0	
Bamboo shoots, cooked	4 cups	480 g	4.8	
Bean sprouts	2 cups	248 g	2.0	
Beets, cooked	⅔ cup	110 g	2.2	
Broccoli, cooked	1 cup	180 g	2.9	
Brussels sprouts, cooked	¾ cup	136 g	3.5	
Cabbage, raw, shredded	1 cup	70g	1.6	
Carrots, cooked	⅔ cup	48g	3.4	
Cauliflower, cooked, pieces	2 cups	200g	3.0	



Carbohydrate and fiber content of foods			
Food	Imperial units	Metric units	Fiber (g)
Vegetables			
Celery, raw	6 medium stalks	240 g	4.2
Collard greens, chopped, cooked	1 сир	190 g	5.3
Cucumber, raw, with peel	1 medium	201 g	2.4
Eggplant, cooked	1½ cups	150 g	3.75
Green onions, chopped	1½ cups	125 g	3.25
Jicama, raw, slices	1 cup	120 g	5.9
Kale, chopped, cooked	1½ cups	162 g	3.25
Leeks, cooked, 1 cup	1 cup	124 g	1.2
Mushrooms, raw, chopped	2 cups	280 g	3.2
Okra, cooked	8 pods	106 g	2.6
Onions, raw, chopped	³⁄₄ cup	120 g	2.1
Pea Pods, raw	2 cups	130 g	3.2
Peppers, sweet (bell)	1¼ whole	148 g	1.5
Radishes, red, raw, sliced	2½ cups	146 g	2.25
Spinach, cooked	1 cup	190 g	5.8
Summer squash, sliced, cooked	1¼ cups	141 g	2.6
Swiss chard, chopped, cooked	1¼ cups	218 g	4.6
Tomato, raw, sliced	2 cups	246 g	2.8
Tomato sauce	½ cup	120 g	1.7
Turnips, cubed, boiled	1½ cups	195 g	3.8
Water chestnuts, raw, sliced	¼ cup	46 g	1.4

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Food	Imperial units	Metric units	Fiber (g)
<b>Dairy and Dairy Substitutes</b> 12 g Carbohydrate servings and 20 g Carbohydrate servings			
Dairy			
Yogurt, low fat, plain	10 oz	300 ml	0
Yogurt, fruited	6 oz	180 ml	0
Malted milk	4 heaping tsp.	28 g	0.2
Food	Imperial units	Metric units	Fiber (g)
Custard	½ cup	120 ml	0
Chocolate milk, low fat	6 oz	180 ml	1.0
Frozen yogurt, fat free	½ cup	120 ml	0
lce cream, regular, vanilla	½ cup	120 ml	0.5

#### Label Reading

The Nutrition Facts panel on food labels can help an endurance athlete reach their carbohydrate target. Carbohydrates contain four calories per gram. Carbohydrates are listed for total carbohydrate grams. This total carbohydrate amount also includes the sugar, both naturally occurring and those added, in a food.