

## SECTION 6

### Antioxidants and Phytochemicals

As you push your grocery cart down the aisle, you'll want to keep a lookout for foods that have special cancer-fighting properties. In this chapter, we'll focus on foods rich in protective compounds called *antioxidants* and *phytochemicals*. If these names sound a bit technical, don't worry; you'll soon know what they are and where to find them.

These cancer fighters are mainly found in vegetables and fruits. While we'll look in some detail at which vegetables and fruits are high in which protective compounds, the key message is *to be generous with a variety of vegetables and fruits* as you plan your menu. Studies have amply demonstrated the ability of diets rich in vegetables and fruits to reduce the likelihood that cancer will develop in the first place. And although fewer studies have investigated their effect on survival after diagnosis, some have suggested that cancer survivors who consume more vegetables and fruits do indeed live longer. As you'll see, researchers have begun to tease out reasons why this is so.<sup>1,2</sup>

#### Antioxidants

To understand antioxidants, let's start with how oxygen works in the body. Every minute of every day, we breathe in oxygen and breathe out carbon dioxide. Although oxygen is used for a variety of vitally important functions in the body, it happens to be a very unstable molecule. In the course of the normal chemical reactions that occur in the bloodstream or inside our cells, oxygen can easily be damaged, which is to say it can lose some of its electrons or perhaps gain some. And while electrons normally orbit a molecule's nucleus in as calm and orderly a fashion as the moon circles Earth, oxygen's electrons can slip into off-kilter orbits.

The point is that we have millions of oxygen molecules in our bodies, and they easily become unstable. When that happens, they become like piranhas, ready to take a bite out of the cells that make up your skin, blood vessels, internal organs, or any other part of your body. These piranhas—these unstable and dangerous oxygen molecules—are called *free radicals*. They can even attack your *chromosomes*, the strands of DNA that lie deep within your cells and hold all the genes that make you who you are. When oxygen

free radicals damage chromosomes, cells can lose their ability to control their basic functions. They can begin to multiply out of control—and that is the beginning of cancer. Biologists believe that much of the aging process and many cancers are caused by free radical damage.

Plants can be damaged by oxygen free radicals, too. So nature has given them the ability to produce natural compounds that act like shields to defend against these wild oxygen molecules. You can see why these natural compounds are called “antioxidants”—they protect the plant from oxygen free radicals. And when you eat plants, their antioxidants enter your bloodstream and act to protect you, too. When all goes well, the free radicals—the unstable oxygen molecules—attack the antioxidants and leave your cells and chromosomes alone in the same way that a bullet might dent the hardened surface of an armored car but spare the occupants inside.

## **Beta-Carotene**

One of the best-known antioxidants is *beta-carotene*, the yellow-orange pigment found in carrots, yams, and cantaloupes. Beta-carotene has long been looked on kindly by nutritionists because it provides vitamin A, which is important for good vision, among other functions. Beta-carotene is actually two molecules of vitamin A joined together.

However, beta-carotene does more than simply provide vitamin A. It enters the cell membrane that surrounds each of the cells that make up your body and then waits there to fend off free radicals that might approach.

You’ll find beta-carotene not only in orange-colored vegetables, but also in dark green vegetables. You can’t see it, because their chlorophyll hides beta-carotene in the same way that chlorophyll in tree leaves hides the plants’ underlying orange, red, and brown colors until the green color fades in autumn.

While you can buy beta-carotene supplements, it is much better to get beta-carotene from foods. In fact, studies testing beta-carotene’s cancer-fighting power in smokers (a group selected because they are at particular risk for cancer) showed that those whose diets were high in beta-carotene had a measure of protection, but those who got beta-carotene from supplements were actually *more likely to develop cancer* than were other smokers. The reason is not entirely clear, but it may be that, since supplements deliver high doses of only one antioxidant, they interfere with the absorption of others. Also, vegetables and fruits that are rich in beta-carotene are also loaded with

hundreds of other antioxidants, vitamins, minerals, and other protective compounds.

The moral of the story is that there is plenty of beta-carotene in vegetables and fruits, and they are the best sources. On the following page are some top foods for beta-carotene:

#### Beta-Carotene (mg)

Cantaloupe (1 cup)	3
Carrot (1 large)	16
Kale (1 cup)	4
Mango (1 cup)	4
Pumpkin (1 cup)	32
Yam (1 cup)	26

### Lycopene

You may not have heard much about *lycopene*, but you have certainly seen plenty of it. Just as beta-carotene is nature's yellow-orange pigment, lycopene is a bright red pigment, providing the color for tomatoes, watermelon, and pink grapefruit.

Lycopene is in the *carotenoid* family, meaning that it is beta-carotene's chemical cousin, and it is actually a much more powerful antioxidant. A study at Harvard University showed that men who had just two servings of tomato sauce per week had 23 percent less prostate cancer risk, compared to those who rarely had tomato products.<sup>3</sup> Men consuming ten or more servings of tomato products each week had a 35 percent reduction in risk, and that was true *even if their tomatoes came in the form of pizza sauce, spaghetti sauce, or ketchup*. In fact, the cooking process releases lycopene from the plant's cells, increasing your ability to absorb it.

Not all red foods contain lycopene, however, as nature has a couple of other similar pigments in its paint box. The red color in strawberries, for example, does not come from lycopene, but from a group of pigments called *anthocyanins*, which are powerful antioxidants in their own right. (Other anthocyanins provide the color for cherries, plums, red cabbage, and blueberries.)

Here are the top foods for lycopene:

Lycopene (mg)\*

Pink grapefruit (1)	10
Tomato (1 medium, raw)	4
Tomato juice (1 cup)	25
Tomato ketchup (1 Tbsp)	3
Tomato-based spaghetti sauce (1 cup)	56
Watermelon (1 slice, 368 g)	15

\*Source: Heinz Institute of Nutritional Sciences, [www.lycopene.org](http://www.lycopene.org).

## Vitamin E and Selenium

Vitamin E and the mineral *selenium* are also part of your antioxidant arsenal. Like beta-carotene and lycopene, they protect each cell's outer membrane from free radical attacks. Vitamin E is found in legumes (beans), whole grains, and plants rich in natural oils (e.g., nuts, seeds).

However, while a little bit of vitamin E is good—in fact, it is an essential part of your body's protection against free radicals—it is not at all certain that boosting vitamin E intake to high levels is a good idea. Some of the richest vitamin E sources, such as vegetable oils and nuts, also give you an unwanted load of fat. This may be the reason why one study found that, among women with breast cancer, those with the highest levels of vitamin E in their bloodstreams were actually *more likely* to succumb to the disease than those with more moderate levels—it may simply be a sign that they were getting too much fat in their diets.<sup>4</sup> So while more research is needed to sort out what is the right amount of vitamin E, it is prudent to choose foods that are moderate in the vitamin, rather than extremely high or low. These foods are listed in the chart below.

The amount of selenium in plants varies depending on the amount present in the soil where they grow. But, given modern food distribution patterns, your rice is likely to come from one place, your beans from another, and so on. So your selenium intake is likely to be reasonably generous if you include grains and legumes in your daily routine.

Good Vitamin E and Selenium Sources

(portions are 1 cup raw, unless specified)

Vitamin E (mg) Selenium (mcg)

Barley (cooked)	3	36
Brown rice (cooked)	1	14
Broccoli	2	3
Brussels sprouts (cooked)	1	2
Garbanzo beans (cooked)	2	6
Garlic	0	19
Pumpkin (cooked)	3	1
Pinto beans (cooked)	2	12
Sunflower seeds (1 Tbsp)	5	5

## Vitamin C

Vitamin C is a powerful and well-known antioxidant. But unlike the other antioxidants we've looked at so far, which defend cell membranes, vitamin C patrols the watery areas of the body—the bloodstream or the cell's interior.

What are the best foods for vitamin C? Well, citrus fruits are famous for it, but you'll find surprisingly large amounts in many vegetables. Here are some good sources:

Vitamin C (mg) (portions are 1 cup raw, unless specified)

Bell pepper, red	175
Broccoli	82
Brussels sprouts, cooked	97
Cantaloupe	68
Guava	303
Orange (1 medium)	59

Orange juice	124
Strawberries	82

## Phytochemicals

While antioxidants have the job of protecting you from the free radicals, plants have many other protective substances, too. Biologists call them *phytochemicals*. “Phyto” comes from the Greek word “phyton,” which means “plant,” so phytochemicals are simply natural chemicals found in plants.

Although researchers first turned their attention to these chemicals because of their apparent ability to prevent cancer, the possibility that these natural compounds can also enhance survival after cancer has been diagnosed is also now under study. Two groups are especially good to get to know: *cruciferous* vegetables and the *allium* family of vegetables.

Cruciferous vegetables, such as broccoli, cabbage, and collard greens, get their name from the cross-shaped flowers that adorn them in the garden (but which are long gone by the time they reach the grocery store). People who eat generous amounts of these vegetables have remarkably low cancer rates, and researchers have dedicated a great deal of effort to isolating the compounds that are responsible for their anti-cancer effects.

Broccoli, for example, contains *sulforaphane*, a compound that augments the liver’s ability to rid the body of toxic chemicals. Other phytochemicals in broccoli and other cruciferous vegetables have demonstrated the ability to arrest the growth of cancer cells.<sup>2,5</sup>

### Cruciferous Vegetables

Arugula	Cabbage	Kohlrabi	Turnips
Beet greens	Cauliflower	Mustard	Turnip greens
Bok choy	Collard greens	greens	Watercress
Broccoli	Horseradish	Radishes	
Brussels sprouts	Kale	Rutabaga	
		Swiss chard	

Cruciferous vegetables also affect the hormones that influence the progression of hormone-dependent cancers, such as breast cancer. In particular, these vegetables actually change the way estrogens are broken down and eliminated. Normally, estradiol—a potent estrogen in a woman’s bloodstream—is converted to *16a-hydroxyestrone*, a hormone that encourages the growth of cancer cells. However, the cruciferous extract *indole-3-carbinol* causes the body to convert more estrogen to a different estrogen called *2-hydroxyestrone*, which has anticancer actions.<sup>6</sup>

Researchers are starting to test out the effects of cruciferous vegetable extracts on patients. In one study, the extract indole-3-carbinol was given to women with abnormal cervical cells (the type of cells gynecologists check for on Pap smears). After 12 weeks, the abnormal cells had disappeared in half the treated patients, while patients given a placebo preparation showed no improvement.<sup>6</sup>

Because some vegetables, such as broccoli, are difficult to digest in their raw state, you may be wondering if cooking knocks out their protective effects. Studies show that, while cooking does indeed reduce the amount of phytochemicals in vegetables, it does not eliminate them.<sup>2</sup>

The *allium* group of vegetables includes garlic, onions, and hundreds of their botanical relatives. Yes, chefs value their flavors, but researchers are increasingly intrigued by the possibility that they may speed the body’s elimination of carcinogens and perhaps even block the start of cancer or inhibit the growth of cancer cells.

Garlic, in particular, has been subjected to a great deal of scientific study. When garlic cloves are cut or crushed, they produce a compound called *allicin*, which is responsible for both their scent and their biological activity. Several studies have shown that people who regularly include allium vegetables in their diets have less risk of cancer, particularly cancers of the stomach and colon.<sup>7</sup> In test-tube experiments, extracts from these plants have been shown to help the body eliminate carcinogens and slow the growth of cancer cells.<sup>8</sup> Researchers estimate the amount of garlic necessary for anti-cancer effects at three to five cloves daily.<sup>9</sup> Cooking temperatures eliminate garlic’s beneficial effects on cells unless the garlic is allowed to stand for about 10 minutes between being crushed and the cooking process.<sup>10</sup>

## Allium Vegetables

Chives	Onions
Garlic	Scallions
Leeks	Shallots

It should be noted that tests of garlic's ability to block cancer promotion have been carried out in cells, not in intact humans, so it remains to be established whether garlic can actually affect the course of cancer after diagnosis.

### Antioxidants in Foods

<i>Serving size = one cup raw unless otherwise specified.</i>	Vitamin C mg*	Beta-carotene mcg**	Vitamin E mg	Selenium mcg
<b>Daily target (minimum)</b>	Women 75 mg Men 90 mg	Women 800 mcg Men 1000 mcg	15 mg	55 mcg
<b>Vegetables</b>				
Broccoli	82	807	1.5	3
Brussels sprouts, cooked	97	669	1.3	2
Cabbage	29	69	1.5	1
Carrot, large (4 oz), 1	11	15,503	0.7	1
Carrot juice	20	12,559	1	1
Cauliflower	46	12	0.1	1
Garlic (1 clove)	0.9	0	0	0.4
Kale	80	3,577	0.5	1
Leeks, cooked	4	31	0.7	1
Mushrooms	2	0	0.3	8
White onions, cooked	11	0	0.8	1
Potato, medium, baked, 1	16	0	0.1	1
Pumpkin, cooked	10	31,908	2.6	1
Red bell pepper	175	2,840	0.7	0.3
Spinach	8	1,196	0.8	0.3
Acorn squash, cooked	26	627	1.6	2

Sweet potato, cooked	49	26,184	0.6	1
Tomato, medium, 1	23	446	1.1	0.5
Orange yam, baked	49	26,184	0.6	1
<b>Fruits</b>				
Apple, medium, 1	8	28	0.9	0.4
Apricots, 3	10	1,635	0.9	0.4
Banana, medium	11	57	0.4	1.3
Blueberries	19	87	2.7	1
Cantaloupe ( <sup>1</sup> / <sub>8</sub> melon)	29	1,325	0.2	0.3
Cantaloupe, cubes	68	3,072	0.5	0.6
Grapefruit sections	79	160	0.6	3
Grapes	4	54	0.3	0.2
Guava	303	750	1.8	1
Kiwi fruit, 2	114	164	1.7	0.6
Mango	46	3,851	1.8	1
Orange, medium, 1	59	52	0.4	1
Orange juice	124	92	0.5	0.2
Papaya	87	70	1.6	0.8
Peach, 1	6	260	1	0.4
Raspberries	31	48	0.6	0.7
Strawberries	82	23	0.4	1
Watermelon	27	634	0.4	0.3

#### Antioxidants in Food (continued)

<i>Serving size = one cup raw unless otherwise specified.</i>	Vitamin C mg*	Beta-carotene mcg**	Vitamin E mg	Selenium mcg
Daily target (minimum)	Women 75 mg Men 90 mg	Women 800 mcg Men 1000 mcg	15 mg	55 mcg

**Grains and Grain Products**

Barley, cooked	0	0	3	36
Brown rice, cooked	0	0	1.1	14
Millet, cooked	0	0	1.3	2
Oatmeal, cooked	0	0	0.2	19
Whole-wheat bread, 1 slice	0	0	0.3	10
Wheat germ, 2 Tbsp	0	0	2.6	11.4

**Beans and Legumes**

Black beans, cooked	0	10	1	2
Black-eyed peas, cooked	1	20	0.5	4
Garbanzo beans, cooked	2	28	2	6
Kidney beans, cooked	2	3	0.4	2
Lentils, cooked	3	11	1.2	6
Pinto beans, cooked	4	2	1.6	12
Soybeans, cooked	3	10	3.4	13
Split peas, cooked	1	11	1.6	1
Tofu, firm	1	0	0.1	44
White beans, cooked	0	0	2	2

**Nuts, Seeds, and Oils**

Almonds, _ oz, 2 Tbsp, 12 nuts	0	0	3.8	1
Brazil nuts, _ oz, 2 Tbsp, 3 nuts	0	0	1	420
Cashews, _ oz, 2 Tbsp	0	0	1	2
Peanuts, _ oz, 2 Tbsp, 17 nuts	0	0	1.1	1
Walnuts, _ oz, 2 Tbsp, 7 halves	3	0	0.4	0.6
Flaxseed, 1 Tbsp	1	0	0.1	6
Sunflower seeds, 1 Tbsp	0	3	5	5

Olive oil, 1 tsp	0	0	0.6	0
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\*mg=milligram, 1/1,000 of a gram

= rich in lycopene

\*\*mcg= microgram, 1/1,000,000 of a gram

## Meal Planning

Here are some simple tips that will help you build generous amounts of antioxidants and phytochemicals into your diet:

- Include plenty of vegetables and fruits in your routine, emphasizing the colorful varieties.
- Keep a bag of baby carrots (rich in beta-carotene) nearby. Try them plain or dipped in hummus or light vinaigrette.
- Limit storage of fruits and vegetables. Once carotenoids are separated from the plant, they begin to break down.
- Check out your local Asian or Latin American grocery store to discover some new vegetables. For fresh, seasonal produce, check out your local farmer's market.
- Avoid overcooking vegetables. While you still get a substantial amount of antioxidants in cooked vegetables, you will get much more if you don't cook them. There are a few exceptions, such as carrots, that actually release more carotenoids if you cook them. If you don't like cooked carrots, try puréeing your raw carrots to release more of their carotenoids.
- Have plenty of tomato products (rich in lycopene): Mix sun-dried tomatoes into bread dough or add them to a veggie sandwich. Top pasta with marinara sauce (and add frozen vegetables, such as spinach or kale, to the sauce as it cooks). Add canned tomatoes or salsa to a bean burrito, or top a veggie

burger with ketchup or salsa. Reach for tomato juice to quench your thirst. Or make a quick bruschetta by toasting baguette slices and then topping them with canned, diced tomatoes and a sprinkling of basil.

- For a refreshing start to your day, try a pink grapefruit (rich in lycopene and vitamin C).
- Crush a brazil nut (rich in selenium) on top of your vegetable salad.
- Enjoy beans and whole grains for vitamin E and selenium.
- Add blueberries (rich in vitamin E) to your cereal or fruit smoothie.
- Add barley (rich in vitamin E and selenium) instead of pasta to vegetable soups and stews.
- Add broccoli, cauliflower, or any other of the other cruciferous veggies to stir-fries, soups, stews, and sauces.
- Boost any salad's cancer-fighting potential by adding watercress, kale, cabbage, or collard greens.
- Use rutabagas or turnips in place of potatoes in your favorite potato dish.
- Add fresh garlic to almost any meal.

## **Recommended Recipes**

Fresh Spinach Salad (page 97)

Zippy Yams and Collards (page 108)

Mashed Grains and Cauliflower (page 104)

Mushroom Gravy (page 143)

Summer Fruit Compote (page 132)

## **To Do This Week**

Prepare one meal rich in beta-carotene and another rich in lycopene. This is easy, of course—it is as simple as cooking up some carrots and pouring tomato sauce over your angel hair pasta.

Select your recipes and plan a time that is convenient for you to pick up the ingredients you'll need.

When you enter the grocery store to pick up your ingredients, pause for a moment in the produce aisle. Notice the bright colors and the fact that the same colors tend to show up over and over. Which foods have beta-carotene's distinctive color? That's right—you see it in cantaloupes, sweet potatoes, carrots, and occasionally in other foods.

Which ones have lycopene? It just about jumps out of the tomato bins. And you'll see it in the big watermelon slices and pink grapefruit.

Look at chlorophyll's bright green color almost everywhere in the produce section, and all the various other intense colors. These pigments are not just there to look pretty in your shopping cart. They served to protect the plants, and they will protect you, too.

Also, try preparing any cruciferous vegetable that is new to you, or prepare an old favorite in a new way. For example, if Brussels sprouts always seemed like a punishment instead of a food, try this: Start with frozen petite Brussels sprouts—the smaller they are, the more tender their taste. Steam them until they are soft and tender, then splash on some soy sauce, apple cider vinegar, or balsamic vinegar. You will be amazed. Try the same sort of technique with broccoli, kale, or collards.

If you've never had Swiss chard, it's time to try this wonderful vegetable. A few minutes of steaming turns it into a delightfully tender side dish. Top it with lemon juice. You'll find that the tartness of lemon juice or apple cider vinegar cuts through the faintly bitter taste of many vegetables and makes them truly delectable.

## **Section 6 References**

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