Chapter 7: Colorful and Invisible Phytonutrients for Health

There may have been many different environments in which ancient man found it possible to survive, but it was the rich diversity of the plant world that provided the background for the evolution of man. *Homo sapiens* (the species of all humans today) evolved over 50,000 years ago in response to a nutritional environment that was largely plant-based and had been in existence for over 2 billion years evolving in response to predators and climate.

The plant foods available were most typically low in fat, high in fiber, and rich in the special preventive substances found only in plants (phytonutrients). This diverse diet provided all the elements needed for a long life, and we have evidence that ancient man knew the medicinal properties of the plant world as well. The discovery of agriculture 10,000 years ago meant that the biodiversity of the diet was narrowed by an emphasis on those plants that could be easily cultivated. The Industrial Revolution 200 years ago meant that many foods would be processed for economic gain, resulting in a further separation of man from his plant-based environment and further imbalances due to the refining away of the husks of grains, such as rice or the refining of oils resulting in the loss of vitamins.

Today we find ourselves with an epidemic of overnutrition and obesity in the industrialized world with many foods that, as part of a Western dietary pattern, may promote heart disease and cancer. While we derive more than enough calories from our foods, we have lost many of the natural preventive substances that provided the checks and balances in our bodies. The first thing to do is to make use of those foods that are protective, including colorful fruits and vegetables, spices and some whole grains, which have antioxidant phytonutrients.

Colorful fruits and vegetables provide vitamins, minerals, fiber and specialized substances with antioxidant activity called phytonutrients. Many phytonutrients are colorful, and recommending a wide array of colorful fruits and vegetables is an easy way to encourage increased fruit and vegetable intake to consumers. For example, red foods contain lycopene, the pigment in tomatoes, which is localized in the prostate gland and may be involved in maintaining prostate health, and which has also been linked with a decreased risk of cardiovascular disease. Green foods, including broccoli, Brussels sprouts and kale, contain glucosinolates, which have also been associated with a decreased risk of cancer. Garlic and other white-green foods in the onion family contain allyl sulphides, which may inhibit cancer cell growth. Other bioactive substances in green tea and soybeans have health benefits as well. Consumers are advised to ingest one serving of each of the seven color groups daily, putting this recommendation within the United States National Cancer Institute and American Institute for Cancer Research guidelines of five to nine servings per day. Grouping plant foods by color provides simplification, but it is also important as a method to help consumers make wise food choices and promote health.

Human food choices and dietary patterns have been driven by necessity and economics and have been influenced by the promotion of foods more on their merits of taste, cost or convenience, and less for their nutritional merits or health value. The diversity of human dietary patterns around the world has been well documented. Nevertheless, patterns associated with a lower risk of chronic diseases, including common forms of cancer, have also be noted.[1] In examining these diverse patterns, a consistently higher intake of fruits, vegetables, whole grains and plant proteins such as soy – in comparison with the typical American diet – is associated with a markedly reduced risk of cancer, heart disease and some chronic diseases of ageing. In the nutrition science and epidemiological literature, these dietary patterns have often been more simply characterized as low-fat, high-fiber diets. Such simplified terminologies led to the concept that fiber or phytochemical supplementation could reproduce the benefits of the healthy dietary patterns they represented, and ignored the benefits of not only the multitude of nutrients in plant foods, but also the health benefits of the dietary modality as a whole.

A diet rich in plant foods provides not only essential vitamins and minerals, but also over 25,000 phytonutrients that cannot be provided by a typical Western pattern based on refined grains, added oils, sugar and salt. Traditional plant-based diets in other countries may be rich in many of these phytonutrients.[5] Recent studies of existing hunter-gatherer populations have revealed that these individuals eat more than 800 different varieties of plant-based foods,[6] but when they move into urban areas and begin eating so-called street foods, they begin to develop nutritional deficiencies.[7] In the United States, most people eat only two to three servings of fruits and vegetables per day and a minority eats none at all.[8] The regular consumption of fruits and vegetables is associated with a reduced risk of cancer, cardiovascular disease, stroke and many functional declines associated with aging,[9] [10] [11] and it has been estimated that one-third of all cancer deaths in the United States could be avoided through dietary modification, which includes an abundant intake of fruits and vegetables.[12] Further, plant-based diets have a lower calorie density and increased nutrient density which are important factors in curbing the obesity epidemic.

Phytonutrients and Heart Health

Dietary antioxidants from fruits and vegetables get incorporated into LDL, and become oxidized themselves, thus preventing oxidation of polyunsaturated fatty acids. Phytonutrients also reduce platelet aggregation, modulate cholesterol synthesis and absorption and reduce blood pressure.[15] Systemic inflammation may also be a critical factor in cardiovascular disease. C-reactive protein, an inflammatory marker, may be a stronger predictor of cardiovascular disease than LDL cholesterol,[16] and the anti-inflammatory activity of phytonutrients may play an important role in the health of the heart.

Phytonutrients and Immune Function

Cytokines are peptide hormones secreted by inflammatory cells and stromal/adipocyte cells that mediate the inflammatory response, and these cytokines (e.g., IL-1, IL-6 and Tumour Necrosis Factor-alpha) are signals that stimulate tumor growth. Dietary lipids, such as omega-6 fatty acids, can independently stimulate inflammation by conversion to pro-inflammatory prostaglandins. The omega-3 and omega-6 fatty acids compete for the active sites on cyclo-oxygenase (COX) enzymes. There are two isoforms of COX, designated COX-1 and COX-2. COX-1 is a housekeeping gene that is expressed constitutively in many tissues. On the other hand, COX-2 is undetectable in most normal tissues but is induced by inflammatory and mitogenic stimuli. There is accumulating evidence that COX-2 is important in carcinogenesis.

The plant world is rich in inhibitors of cyclo-oxygenase. Compounds extracted from crabapple fruits have demonstrated activity in COX enzyme inhibitory and antioxidant bioassays[17] and alpha-viniferin, a trimmer of reseveratrol, has an inhibitory effect of COX-2 and inducible nitric oxide synthase.[18] Animal studies have also demonstrated the inhibition of colon cancer from curcumin in turmeric[19] and inhibition of skin and breast cancer from carnisol in rosemary.[20],[21]

Interactions and Potential Synergy of Different Phytonutrients

Phytonutrients from different plants can interact to inhibit cancer cell growth (e.g., soy isoflavones and green tea catechins).[61],[62] It has also been proposed that the additive and synergistic effects of phytonutrients in fruits and vegetables are responsible for their antioxidant and anti-cancer activities, and that the benefit of plant-based diets is attributed in part to the complex mixture of phytonutrients present in whole foods.[63]-[65] Evidence of the benefits of fruits and vegetables suggests that it is not premature to advise increased intake of a variety of colorful fruits and vegetables.

Selecting a Varied Diet Using Color

We all know fruits and vegetables are healthy. That is nothing new. What is new is that these foods can be classified according to colors – red, red/purple, orange, orange/yellow, yellow/green, green and white/green – according to the specific chemicals that absorb light in the visible spectrum creating the different colors. These chemicals are called phytonutrients or phytochemicals by scientists, and each of these colored compounds works in different ways to protect your genes and your DNA. By making sure you get a representative of each of these seven color-coded groups of the fruits and vegetables every day, you will be meeting the recommendations of many government agencies, including the National Cancer Institute, that you eat five to nine servings of fruits and vegetables every day.

You will be going further to insure that your body has what it needs to protect your DNA. Not all fruits and vegetables are the same. The different colors indicate how they differ, but you will also be getting another group of compounds called flavonoids, which are found throughout the Color Code, up to 1 gram per day.

Plant-eating animals naturally use color as an identifying marker of edible plant species. The changing color of ripening fruits and vegetables signify that they are at the peak of their taste and nutritive value. Many of the phytonutrients are actually the pigment molecules that lend ripe fruits and vegetables their distinctive hues.

Carotenoids are chemical compounds that absorb visible light and so determine that carrots are orange, tomatoes are red and marigolds are yellow. Approximately 700 different carotenoids have been isolated from plants and animals. About 50 to 60 of these are present in a typical diet. These carotenoids are specifically broken down by the body, often during the process of absorption into the blood stream from the small intestine. They make their way to specific tissues and organs where they have been shown to protect against the type of oxygen damage that can harm your DNA.

Because the color of a plant food can tell us so much about how it supports health, You can use a Color Code System to help you introduce more diversity into your diet. The different colors are important because the different plant chemicals they represent have different effects on the body.

The red group includes tomatoes, pink grapefruit and watermelon containing lycopene. Lycopene is more available from cooked tomato products and juices than from whole tomatoes, and these products are the primary sources of lycopene in our diet. So you would add red as pasta sauce, tomato soup, tomato juice and ketchup. As a practical matter, over 80 percent of the lycopene in the American diet comes from these tomato products.

The red/purple group includes pomegranate, grapes, red wine, grape juice, cranberries, blueberries, blackberries, strawberries, prunes (dried plums) and red apples. They contain anthocyanins, which are powerful antioxidants.

The orange group includes carrots, mangos, apricots, cantalopes, pumpkin, acorn squash, winter squash and sweet potatoes. These provide alpha- and beta-carotenes. In this group, carrots provide about half the alpha- and beta-carotene in the U.S. diet, with significant contributions from tomato products.

The orange/yellow group includes orange juice, oranges and tangerines, peaches, papaya and nectarines. These provide β-cryptothanxin, a minor carotenoid which accounts for only 0.03 mg of the 6 mg per day intake of all carotenoids by the average American. As a practical matter, 87 percent of cryptoxanthin comes from orange juice, oranges and tangerines. Other fruits providing smaller amounts include peaches, papaya and nectarines.

The yellow/green group includes spinach, collard, mustard, or turnip greens, yellow corn, green peas, avocado and honeydew melon. These provide lutein and zeaxanthin as well. These carotenoids concentrate in the eye and may contribute to eye health. Lower intakes have been associated with cataracts and age-related macular degeneration, the primary preventable cause of blindness in America.

The green group includes broccoli, Brussels sprouts, cabbage, Chinese cabbage or bok choi, and kale. These contain sulforaphane, isothiocyanate and indoles that stimulate the genes in your liver to turn on the production of enzymes that break down cancer-causing chemicals in the body.

The white/green group includes garlic, onions, celery, pears, white wine, endive and chives. Plants in the onion family contain allicin, which has been shown to have anti-tumor effects. Foods in this group are also rich sources of flavonoids, including quercetin and kaempferol. Of all the antioxidants in fruits and vegetables, it is the flavonoids that we eat in the largest quantity, up to 1 gram per day. There are many flavonoid structures, and researchers are developing methods for measuring the evidence that flavonoids have been eaten based on their breakdown products in the urine.

Choosing the Right Fruits and Vegetables for Weight Management

The average vegetable serving of 100 grams has only 50 calories and the average fruit has only 70 calories. There are not only colorful phytonutrients in fruits and vegetables, but also fiber and water. It is simple to get the recommended 25 grams of fiber per day by simply choosing five servings that have 5 grams of fiber per serving from the list below.

However, some fruits and vegetables have more calories than others. One cup of starchy vegetables (such as beans or potatoes) can pack in over 200 calories. Similarly, just 1/4 cup of dried fruit (like raisins) has over 100 calories. And, if you eat several bunches of grapes or several handfuls of cherries a day, you can slow or even stop your weight-loss efforts. By avoiding these particular vegetables and fruits and instead choosing the ones listed below, you will save calories while still getting all their health benefits. Canned vegetables and fruits, while often low in calories, can contain less vitamin C, fiber and other nutrients than their fresh varieties, so check the labels for calories, the vitamin and fiber content and any added sugars.

Vegetable	Portion	Calories	Fiber (g)
Artichoke	1 medium	60	6
Asparagus	18 spears	60	4
Beets	1 cup, cooked	75	3
Broccoli	2 cups, cooked	85	9
Brussels sprouts	1 cup, cooked	60	4
Butternut squash	1 cup, cooked	80	3
Cabbage	2 cups, cooked	70	8
Carrots	1 cup, cooked	70	5
Cauliflower	2 cups, cooked	55	6
Celery	3 large stalks	30	3
Corn	1 ear	75	2

Cucumber	1 average	40	2
Eggplant	2 cups, cooked	60	5
Green beans	2 cups, cooked	85	8
Kale	1 cup, cooked	35	3
Lettuce, romaine	4 cups	30	4
Mushrooms	1 cup, cooked	40	3
Onion	1 large	60	3
Peas	1 cup	140	8
Peppers, bell (raw)	1 large	45	3
Spinach	4 cups, cooked	30	4
Swiss chard	2 cups, cooked	70	7
Tomato (raw)	1 large	40	2
Tomato juice	1 cup	40	1
Tomato sauce	1 cup	100	5
Zucchini	2 cups, cooked	60	5

Fruit	Portion	Calories	Fiber (g)
Apple (with skin)	1 medium	100	4
Apricots	5 whole	85	4
Avocado	¼ fruit	80	2
Banana	1	90–180	2–4
Blackberries	1 cup	75	8
Blueberries	1 cup	110	5
Cantaloupe	½ medium	80	2
Grapefruit, yellow	1 fruit	75	2
Honeydew	1 cup cubes	60	1
Kiwi	1 large	55	3
Mango or papaya	½ fruit	80	3
Orange	1 large	85	4
Peach or nectarine	1 large	70	3
Pear, red	1 medium	100	4
Pineapple	1 cup, diced	75	2
Plum	3 small	100	3
Raspberries	1 ½ cup	90	12
Strawberries	1 ½ cup	75	6
Tangerine	2 medium	85	5
Watermelon	1 cup balls	50	1

Fruits to Avoid: Portions Difficult to Control

Fruit	Portion	Calories
Canned fruit	1 cup	60–188
Cherries	20 (1 cup)	98
Dried fruit	½ cup	225
Grapes	20 (1 cup)	82

Although the color method is superior to the current system of simply encouraging increased fruit and vegetable intakes, it does not account for actual phytochemical delivery to the consumer. Today, there is no labeling law that enables fruit and vegetable manufacturers to list the phytonutrients in their products. Further, fruits and vegetables are developed and preserved to transport them over long distances and extend their shelf life rather than for their flavor or nutritional content. Research in this area needs to continue on the more than 25,000 phytonutrients provided by fruits and vegetables. These important phytonutrients are widely distributed among different plant species, but the delivery of the phytonutrients and their effects on biomarkers relevant to health promotion and disease prevention need to be documented.

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