

# Introduction

## What is the Special Nutritional Power found in Fruits and Vegetables?

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Plant foods have long been known to promote health and wellness. Cultures whose diet primarily features plant-based foods such as fruits, vegetables, whole grains and legumes have been found to have increased longevity and reduced rates of the many cancers and chronic diseases so common in populations consuming the standard American diet.

Researchers traditionally have attributed the health-promoting affects of plant foods to their comprehensive array of vitamins, minerals, and fiber. More recently, however, research studies are uncovering a new story. Plant foods contain thousands of other compounds in addition to the macronutrients (complex carbohydrates, proteins, fats, and fiber), and the micronutrients (vitamins and minerals). These many other compounds are collectively known as *phytonutrients* (phyto=plant). Simply put, phytonutrients are active compounds in plants that have been shown to provide benefit to humans when consumed. Particularly in the area of cancer prevention, phytonutrients show special promise for lowering the risk of health problems.

The major classes of phytonutrients include:

- *Organo-sulfurs*: For example, the glucobrassins found in crucifers and the allyl

sulfur compounds in garlic.

- *Terpenoids*: These include the basic terpenoids like limonene found in citrus foods and menthol, as well as the carotenoids (vitamin A precursors), coenzyme Q10, the phytosterols, and the tocopherols and tocotrienols.
- *Flavonoids*: Flavonoids are the plant pigments that give plants their colors, like the deep blue of blueberries, the purple of grapes, the orange of pumpkins, or the red of tomatoes. Flavonoids include the anthocyanidins in blueberries and quercetin found in onions.
- *Isoflavonoids* and *lignans*: For example, genistein and diadzein found in soy foods, and the lignans in flaxseed and rye.
- *Organic acids*: For example, ferulic acid, which is found in whole grains, and the coumarins, which are found in parsley, licorice and citrus fruits.

Phytonutrients provide plants with protection from the environmental challenges they face, such as damage from ultraviolet light, and, when we consume plants rich in phytonutrients, they appear to provide humans with protection as well. Investigating the ways in which phytonutrients provide this protection is one of the most exciting areas in nutrition research today, and recent findings are providing science-based explanations as to how plant foods support our health and wellness.

## **What are phytonutrients?**

Phytonutrients are plants' home security services--think of them as the Plant Police, Fire Department and Coast Guard. As defenders, phytonutrients protect their plant from free radical attack from excess ultraviolet radiation and from predator pests. And phytonutrients do their job with style, providing plants with their sensory characteristics such as their color, flavor and smell.

Unlike us, plants can't move, put on a fan or air conditioning when it gets too hot, or put on sunscreen or sunglasses. But, even more than we, plants are exposed to damaging radiation, toxins, and pollution, and this toxic exposure results in the generation of free radicals within their cells. Free radicals are reactive molecules that can bind and damage proteins, cell membranes and DNA. Since plants can't move away from these insults, nature has provided them with a means of protection: they can make a variety of types of protective compounds--the phytonutrients. Like plants, we're exposed to ultraviolet radiation or pollution, we also generate reactive, free radicals, and although we cannot produce our own phytonutrients, when we consume plants, their

phytonutrients also protect us against damage from these free radicals.

Most plants use sunlight as an energy source. Although to the eye sunlight appears as a single, clear, bright force, it is actually made up of many different wavelengths, some of which the plant captures for the generation of energy. Others, however, are wavelengths from which the plant needs protection. Each plant contains literally thousands of different phytonutrients that can act as antioxidants, providing protection from potentially damaging free radicals. Many of these compounds also provide the plants with color, their different colors each reflecting a different variety of protection they provide.

## **Plants Contain Thousands of Phytonutrients**

If a plant was only one color, with no shades or variations in that color, it would only be able to receive and protect against one specific wavelength of light. A plant with several different colors is like a television set with an antenna, and a plant with many different colors is like a television with a satellite dish. Most plants have a satellite dish's worth of colors - even ones that look very green to us when we eat them. Like the primer used beneath a coat of paint, these other colors are simply overshadowed by the primary color that we see.

## **How are Phytonutrients Classified?**

Some researchers estimate up to 40,000 phytonutrients will someday be fully catalogued and understood. In just the last 30 years, many hundreds of these compounds have been identified and are currently being investigated for their health-promoting qualities. At research organizations like the National Institute of Cancer, and at many universities around the world, different individual phytonutrients are being studied to identify their specific health benefits.

Phytonutrients are classified by their chemical structure. This classification is extensive and can be confusing since many of the phytonutrients appear to provide similar types of protection. Still, these names help scientists differentiate between phytonutrients' different chemical structures. Because there are so many compounds, phytochemicals are also lumped together in families depending on the similarities in their structures. Names such as *terpenes* are used to describe *carotenoids*, some of which are precursors to vitamins A, and which provide the orange, red and pink colors in foods such as

carrots, tomatoes, and pink shellfish; *limonoids*, which are found in citrus fruits and provide them with their distinctive smell; and *coumarins*, natural blood thinners found in parsley, licorice and citrus fruits.

The *phenols*, or polyphenols (poly=many) is another family of phytochemicals that has received much research and discussion in the scientific literature. In fact, some of the most talked about phytonutrients are in this family. They include the *anthocyanidins*, which give blueberries and grapes their dark blue and purple color, and the *catechins*, found in tea and wine, which provide the bitter taste as well as the tawny coloring in these foods. Flavonoids are also commonly considered phenols, although the term "flavonoids" can refer to many phytonutrients. Lastly, the *isoflavones* are usually categorized as members of this family. Isoflavones, which are found in soy, kudzu, red clover, flax and rye, have been researched extensively for their ability to protect against hormone-dependent cancers, such as breast cancer.

Other phytonutrients include the *organosulfur compounds*, such as the *glucosinolates* and *indoles* from brassica vegetables like broccoli, and the *allylic sulfides* from garlic and onions, all of which have been found to support our ability to detoxify noxious foreign compounds like pesticides and other environmental toxins. *Organic acids* are another common family of phytonutrients and include some powerful antioxidants, like *ferulic acid*, which is found in whole grains.

To help you appreciate how plant foods and their phytochemical components can help prevent chronic disease and foster your vitality, here is an introduction to four types of phytonutrients that are abundant in delicious and commonly eaten fruits, vegetables, whole grains and tea. These examples will help you further understand why including phytochemical-rich plant foods in your diet will contribute so much to your health and wellness.

## **Phytochemicals in Fruit - Anthocyanidins**

With over two thousand known plant pigments presently identified, the chemicals that give foods their colors may also translate into vibrant health. Notable among these phytochemical pigments are the bioflavonoids known as anthocyanidins. These are the purple-blue pigments that give fruits such as blueberries, blackberries, raspberries, black currants, and red and purple grapes their unique coloration, and which protect them from the damaging effects of oxidation. Anthocyanidins' antioxidant properties are now being investigated by health care researchers who are determining that these

phytonutrients not only support the health of plants, but can support the health of humans as well.

As researchers confirm that metabolites of oxidation, known as free radicals, are at the root of the progression of both chronic diseases (such as arthritis, atherosclerosis, diabetes and cancer) and other signs of aging, such as the loss of skin elasticity and cognitive function, antioxidants are gaining an ever more important place in health promotion. Among the antioxidants, anthocyanidins have been found to have some unique features. They are able to protect cells and tissues from free radical damage in both water-soluble and fat-soluble environments. And, their free radical scavenging capabilities are thought to be more potent than many of the currently well-known vitamin antioxidants; anthocyanidins are estimated to have fifty times the antioxidant activity of both vitamin C and vitamin E.

Much of the research on anthocyanidins has focused on their ability to protect collagen, such as the collagen that makes up our joints or provides the structure to our capillaries, from the destructive effects of free radical damage. This protection of capillary integrity manifests in the ability of anthocyanidins to reduce the fragility and permeability of these small blood vessels. Anthocyanidins are therefore thought to be able to reduce edema (swelling) as well as vascular conditions such as varicose veins and hemorrhoids. Their ability to inhibit the degradation of collagen found in blood vessels and cartilage has led researchers to propose that anthocyanidins may play a role in the prevention of atherosclerosis and arthritis.

## **Phytochemicals in Vegetables - Glucosinolates**

Just like our mothers told us, the foods we loved to hate as kids have turned out to be especially healthy for us. Members of the brassica family of vegetables, including broccoli, Brussels sprouts, cabbage, kale and bok choy appear to have significant cancer-preventive properties. Studies have shown that people who consume these vegetables frequently have a lower risk of developing a variety of cancers, including cancers of the colon, stomach and lung.

While these vegetables contain significant vitamin and mineral profiles, the key to their unique health-promoting abilities may be the presence of phytochemicals known as *glucosinolates*, members of the organosulfur chemical family. In plants, glucosinolates react with an enzyme called myrosinase that converts them into related compounds known as *indoles* and *isothiocyanates*. These chemicals serve several important

functions in the plant including defending them against predator insects.

The potential of indoles and isothiocyanates to defend our health against cancer seems to be primarily related to the beneficial effect that they have on the liver, the organ in the body primarily responsible for neutralizing cancer-causing chemicals. These phytochemicals seem to reduce the potential of carcinogens through their ability to beneficially modulate liver detoxification enzymes - they inhibit certain enzymes that normally activate carcinogens while also inducing other enzymes that help to dismantle active carcinogens.

One specific example of glucosinolate's affect on liver enzymes is the ability of one of the phytonutrients, indole-3-carbinol, to beneficially support the metabolism of estrogen. The liver metabolizes estrogen into either 16-alpha-hydroxyestrone or 2-hydroxyestrogen with the former suggested to promote cancer development and the latter suggested to oppose cancer development; the ratio of these two estrogen derivatives is used as a biomarker for the risk of developing hormone-dependent cancers such as those of the uterus and breast. Indole-3-carbinol promotes the conversion of estrogen to 2-hydroxyestrogen, and decreases the amount of 16-alpha-hydroxyestrogen, a process that occurs in the liver. This promotion of 2-hydroxyestrogen confers a decreased cancer risk.

### **Phytochemicals in Whole Grains - Ferulic Acid**

Diets that feature significant amounts of whole grains have been shown to offer protection against the development of cardiovascular disease and certain types of cancer. While whole grains provide an array of important constituents such as fiber, resistant starches, vitamins and minerals, the whole story of whole grains can't be told without appreciating the important health contribution of the phytochemicals that they contain.

The germ and bran of whole grains such as rice, barley and oats contain a concentrated amount of important phytochemicals that belong to the organic acid family. Included among this family of compounds are caffeic acid, ellagic acid as well as ferulic acid, a phytochemical at the crux of recent research efforts. While whole grains are significant sources of ferulic acid, certain fruits and vegetables such as spinach, parsley, grapes and rhubarb are also known to contain this important compound.

In support of the observations that whole grain consumption may be protective against

cancer, ferulic acid has been investigated by scientists and shown to prevent colon cancer in animals and other experimental models, researchers have hypothesized a variety of ways in which it may offer this protection. Ferulic acid has been found to be a potent antioxidant that is able to scavenge free radicals as well as protect against radiation-induced oxidative damage to cells and tissues. It has also been shown to be able to inhibit the formation of the cancer promoting n-nitroso compounds.

## **Phytochemicals in Tea - Catechins**

While drinking tea is a cultural ritual of community in Asia, it is now becoming a cultural ritual of wellness in the West. This is because green tea consumption has been shown to have many health benefits that researchers believe are related to the phytochemicals that it contains. Of these phytochemicals, the ones receiving the most attention are called the catechins, and include individual compounds called epicatechin, epicatechin gallate, and epigallocatechin gallate. In addition to being an important feature of green tea, catechins are also featured in other plant-based foods such as apples, grapes, raspberries and avocados.

Catechins first gained widespread interest after researchers began to notice that people in Japan who consumed green tea had a lower risk of developing cancer. Once they were isolated and tested in animals, in cell cultures and other types of research tests, catechins showed many potentially health-promoting qualities: they are powerful antioxidants, support healthy gastrointestinal tract function, support detoxification function, and support repair of damaged DNA.

Catechins have been shown to appear in the bloodstream (which shows they get into circulation) relatively quickly and at levels that can be beneficial from drinking just a few cups of tea a day. Research has shown a connection between catechin intake and a decreased risk of many types of cancers; recent research has suggested similar relationship between increased green tea intake and decreased risk for cardiovascular disease. In addition to their other health-promoting activities, catechins have been found to be able to inhibit the oxidation of low-density-lipoproteins (LDL), the form of cholesterol that, when oxidized, is one of the contributing causes of atherosclerosis.

In one very large scale study, the catechins in tea have been shown to lower risk of stroke by approximately 20% when consumed in plentiful but still customary amounts. One cup of green or black tea in the morning, another in the afternoon, and a third in the evening were shown to provide the 30-50mg amount associated with risk reduction for

stroke.

## **What amount of food phytochemicals is healthy?**

Although research is supporting their significant health benefits, phytochemicals are presently considered "non-essential" nutrients. Unlike vitamins and minerals, there are no RDAs or DRIs for them. One reason for the difficulty in setting a level is that there are so many of these phytonutrients that appear to provide health benefits; hundreds are presently being researched for their health-promoting effects. Another reason for the difficulty in setting standards for consumption is that many of these phytonutrients have similar activities. Instead of a lot of one specific compound, it may be more important to have a certain level of a family of compounds, but you can have different amounts of the individual compounds and still get the health-benefit.

Finally, new research is uncovering that many of these phytonutrients act synergistically; that is, they help each other and provide more benefit when taken with other phytonutrients than alone. This is a major reason for eating whole foods over taking an individual supplement of beta-carotene or vitamin C. The whole food can contain not only the beta-carotene or vitamin C, but also other phytonutrients that act synergistically to support even more benefit to your health.

Many health care practitioners and public health organizations have realized the importance of these vital nutrients, however, and suggest that people eat a varied diet concentrated in fruits, vegetables, whole grains and legumes to obtain a high level of phytonutrients. Maybe what our Grandmothers used to say is right: "Eat a colorful meal!" With a range of colors in your food, and a high level of vegetables, fruits, whole grains and legumes in your diet, you will obtain a beneficial level of phytonutrients to support your good health.

The phytonutrients in fruits and vegetables have been shown to pass the [twin test](#)! No diet approach is richer in phytonutrients in fruits and vegetables than the Mediterranean Diet. In the case of identical twins who share the exact same genetic inheritance, close adherence to the Mediterranean Diet has been shown to provide health benefits that outweigh the influence of genetics. These health benefits include antioxidant protection from the amazing variety of phytonutrients found in the World's Healthiest fruits and vegetables.

## **Conclusion**



The array of phytochemicals offered by plant-based foods such as fruits, vegetables, whole grains and legumes further supports the fact that these foods can make important contributions to our health. Although they are officially considered "non-essential nutrients," meaning that their intake is not necessary for survival, phytochemicals seem to truly be essential for the sustenance of a good life, one full of health and abundant energy. Hopefully, one day as the accepted nutrition paradigm changes from preventing outright deficiencies to one that emphasizes that foods can help prevent disease and promote longevity, the true importance of these phytonutrients will be recognized.

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