

# *Fundamentals of Phytonutrition*

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**Phytonutrient**, within the context of natural health and nutrition, has come to refer to certain bio-active plant chemicals that humans eat and have or may well have significant positive effects on human metabolism. Most *phytonutrients* are not essential for life, but more and more they appear to be essential for optimal health and longevity! They therefore may properly be classified as micro-nutrients, along with vitamins and minerals. The technical classification of the major groups of phytonutrients found in our diets includes: *terpenes, amines, organosulfurs, phenols, polysaccharides, and organic acids.*

One food can contain several classifications of phytonutrients. For example, an orange contains terpenes (*carotenoids and limonoids*) and phenols (*bioflavonoids*). In this introductory article, we will briefly examine the major groups and sub-groups of *phytonutrients* and how they may contribute towards optimal biological function.

## **The Terpenes - Carotenoids, Limonoids, Saponins and Chromonals: Powerful Antioxidants for Cancer Prevention, Optimizing Cardio-Vascular Dynamics, Protecting Vision**

**Terpenes** are any of various unsaturated hydrocarbons,  $C_{10}H_{16}$ , found in essential oils and resins of plants. **Carotenoids**, a fat soluble group of naturally occurring plant pigments of the yellow, orange, red spectrum, are perhaps the most familiar of phytonutrients. Carotenoids function as powerful antioxidants and immunopotentiators. Carotenoids are considered potent membrane antioxidants due to their reactivity with singlet oxygen. Diets rich in carotenoids are linked with a decreased risk of heart disease, cancer, and degenerative eye diseases such as macular degeneration and cataracts. 1

*Alpha-carotene, beta-carotene, and cryptoxanthin, as found in* Carrots, oranges, sweet potatoes and squash, are the main vitamin A precursors. Leafy green vegetables contain mostly *lutein and zeaxanthin*. *Lycopene* is most abundant in tomatoes with smaller amounts in pink grapefruit, watermelon, guava, and rose hips. *Astaxanthin*, found mostly in red yeasts and red algae, is now fed to salmon, trout, crabs, krill and shrimp in “fish farms”.

Of note, some carotenoid rich foods like carrots and tomatoes yield more *beta-carotene and lycopene*, respectively, when cooked. *Lutein and lycopene* require fat for optimal uptake of carotenoids whereas dietary fiber inhibits absorption of lutein, *lycopene, and beta-carotene* by 40% to 75 %. 2, 3

**Limonoids** are found in yellow/orange citrus fruit peels. Limonoids may be chemo-preventive agents, especially directed toward protection of the lungs. 4, 5, 6 Eight ounces of OJ would usually contain approximately 19 mg of d-limonene.

**Saponins** are found abundantly in many beans, alfalfa, aloe and quinoa (keen-wah) seed. Saponin containing plants tend to have a soapy texture, and are often called “natural detergents” due to the foam that develops when heated, as when heating beans. Saponins form a complex with cholesterol, which is then excreted from the body. Saponins also inhibit the multiplication of cancer cells by interfering with their DNA. 7

The most familiar **Chromonols** are the vitamin E complex *tocotrienols* and the *tocopherols*. These two naturally occur in palm oils and whole grain germ and/or bran, yet research has shown that the biologic functions of tocopherols and tocotrienols are unrelated. Tocotrienols appear to inhibit breast cancer cell growth, whereas tocopherols have been most studied for their cardiovascular health effects. 8

## **The Phenol Group- Flavonoids, Anthocyanidins, Catechins, and Lignans: Anti-inflammatory, Anticlotting, Antioxidant, Immune Enhancers and Hormone Modulators**

**Phenols** are a class of chemical compounds consisting of a hydroxyl group (-OH) attached to an aromatic hydrocarbon group. The simplest of the class is phenol ( $C_6H_5OH$ ). They create the blue, blue-red and violet colorations seen in berries, grapes and purple eggplant. Phenols protect plants and humans from oxidative damage. They block specific enzymes that cause inflammation and allergies, and modify the prostaglandin pathways and thereby protect platelets from clumping. 9 They help the liver detoxify and inhibit specific enzymes such as the angiotensin-converting enzyme (ACE) that raises blood pressure. 10

Once lumped together as **vitamin P**, science has now discovered well over 1,500 phenol **flavonoids!** They are perhaps best known for their ability to enhance the effects of ascorbic acid. Along with Vitamin C, flavonoids are well known for their ability to protect the vascular system by strengthening, maintaining and repairing

capillaries. 11 Flavonoids, including the isoflavones, may reduce the risk of cancers, either by enhanced detoxication, or as in the case for isoflavones, by occupying estrogen receptor sites. 12

**Anthocyanidins** are phenols that provide cross-links that connect and strengthen intertwined strands of collagen protein. Collagen protein is the most abundant protein in the body as it makes up a large proportion of muscle sheaths, skin, tendon, ligament, and bone matrix. Their blue pigment, as in blueberries, help protect the retina from macular degeneration. 13 Anthocyanidins are also powerful water-soluble antioxidants. Larger doses are often useful in conditions wherein there is a profuse free radical cascade, such as trauma, inflammation, allergic reactions, and heavy exercise.

**Catechins**, are the polyphenolic compounds that provide the antioxidant activity of black, green and white tea. The most common catechins are gallic esters. The most potent is epigallocatechin gallate (EGCG), Protective benefits are thought to include promotion of apoptosis of cancer cells in prostate, stomach, skin, lung, breast and colorectal tissues. 14

**Lignans** are found in seeds and grains, especially flaxseed. The lignan found in flaxseed is called *secoisolariciresinol glucoside (SDG)*. Lignans are weak phytoestrogens that also have anti-viral, anti-bacteria, anti-fungal, antioxidant, and immune enhancing properties. 15

Lignans are not to be confused with *lignins* which are a non-carbohydrate dietary fiber that, along with polysaccharides, occur in the cell walls of plants.

### **Polysaccharides - Fiber, Glyco-Nutrients and Phytosterols: Modulate Cholesterol Absorption, Alimentary Transit Time, Glycemic Response, Hormone Metabolism, Immune Function, and Inflammatory Physiology**

**Polysaccharides** are complex carbohydrates, made up of chains of multiple sugar molecules. Examples of polysaccharides include cellulose, starch, and dextrin. Both **soluble and insoluble fibers** are made from polysaccharides. The former absorb cholesterol and lower glycemic response, while the later promote bowel movements. The immune enhancing effects of ginseng, aloe vera or beta glucan from oats or mushrooms comes in large part from sugar-protein-receptor complexes on their cell wall, now called **glyco-nutrients**.

**Phytosterols** are polysaccharide-lipid complexes known particularly for their cholesterol lowering abilities. Nuts and seeds are the richest source of *phytosterols* in the Western diet. Phytosterols are poorly absorbed. They lower cholesterol by interfering with its absorption in the small intestine. Just three gram of phytosterols daily shows significant lipid lowering effects. 16 Phytosterols can also mimic hormone precursors or modulate hormones. For example, Swedish tree pollen, pumpkin seeds, pygeum, and saw palmetto are all used in cases of benign hyper-trophic prostate disease (BHP) and prostatitis. These phytosterols inhibit the conversion of testosterone to dehydroxytestosterone (DHT). 17

### **The Organosulfur Group- Indoles, Isothiocyanates, and Thiosulfonates: Detoxifiers, Cardiovascular Risk Reducers, and Non-Specific Immunity Supporters**

**Organosulfurs** are organic compounds containing sulfur (-SH). As phytonutrients, they provide sulfur vital for phase II enzymes activities. Specifically, organosulfurs provide *glucosinolates* which are converted into several bio-transformation products in the human body, particularly *indole-3-carbinol*, *isothiocyanates*, and *thiosulfonates*.

The **indoles** and **isothiocyanates** are most especially found in the *cruciferae family* of brassica and mustard plants. These includes horse radish, cabbage, broccoli, Brussels sprouts, kale, arugula, bok choy, cauliflower, mustard seeds and greens, watercress, turnip greens, daikon, wasabi, and kohlrabi. These help the liver break down toxins and potential carcinogens, especially toxic estrogen metabolites.

The thiosulfonates are predominant in the *allium family* where garlic, onion, leek, asparagus, shallots, chive and scallion are representative. 18 Though the **thiosulfonates** are also able to assist Phase II detoxication, and thereby enhance protection against carcinogenesis, they are perhaps better known for their ability to promote a more favorable HDL- LDL ratio, lower blood pressure and stimulate non-specific immunity.

### **Organic Acids: Antioxidant Cancer Preventives, Liver Protectors, and Inflammatory Mediators.**

An **organic acid** is an organic compound that is an acid. Perhaps the most common example is the carboxylic acids whose acidity derives from a carboxyl group -COOH. Phytochemicals in this group are commonly found in grains, herbs, teas, a few vegetables and some fruits. 13 They include *oxalic acid* found in spinach, rhubarb, tea and coffee; *tartaric acid* in apricots and apples; *cinnamic acid* in aloe and cinnamon; *caffeic acid* in burdock and

hawthorn; *ferulic acid* in oats and rice; *gallic acid* in tea, *coumaric acid* in turmeric; *salicylic acid* in spearmint; and *tannic acid* in nettles, tea, and berries. They are powerful antioxidants, anti-inflammatories, and support liver detoxification.<sup>19</sup>

Perhaps of most current interest is **ellagic acid**, which is found in guava, currants, apples, grapes, strawberries, and most particularly in red raspberries and wild cherry cherries. According to the Hollings Cancer Institute at the University of South Carolina, ellagic acid is a proven anti-carcinogen, anti-mutagen, and anti-cancer initiator!<sup>20</sup>

## The Amines: Carcinogen Deactivators and Enzymatic Therapy

**Amines** are organic compounds that contain nitrogen (- NH) as the key atom of the functional group. The amines include both **chlorophyll** (as in *chlorella*, *spirulina*, *hydrilla*, and *the leafy greens and grasses*) and **plant enzymes** (as in *papain* and *bromelain*). Chlorophyll is well known to detoxify carcinogens found in cooked muscle meats (*heterocyclic amines*), smoked or barbecued foods (polycyclic hydrocarbons), and peanut mold (*aflatoxin*).<sup>21</sup> Chlorophyll has also been recognized for its anti-inflammatory, anti-mutagenic, and antioxidant properties.<sup>22, 23</sup>

*Chlorophyll* has been cited as strengthening the immune response, therapeutic for inflammation of the ear and the mucous membrane of the nose and sinuses, supportive of normal kidney function, accelerating wound and ulcer healing, and reducing fecal, urinary, and body odor in geriatric patients.<sup>24, 25</sup>

*Plant enzymes* are well accepted as useful in assisting digestion, having the advantage of being active in a wide PH range.<sup>26</sup> Taken in between meals, they assist in injury resolution by increasing the blood enzymes available to digest proteins related to fibrolytic and inflammatory process and immune responses.<sup>27</sup>

## In Conclusion

We have made a very cursory review of the major phytonutrient compounds, namely the *terpenes*, *polysaccharides*, *phenols*, *organosulfurs*, *organic acids*, and *amines*. These can be grouped into families based on their chemical structures. Phytonutrients have many salubrious physiological effects. These effects are likely a major factor in the well documented reduction in the incidence of the common diseases of aging in those who consume a largely plant based diet, abundant in fruits, vegetables and greens, as the USDA recommends.<sup>28</sup>

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