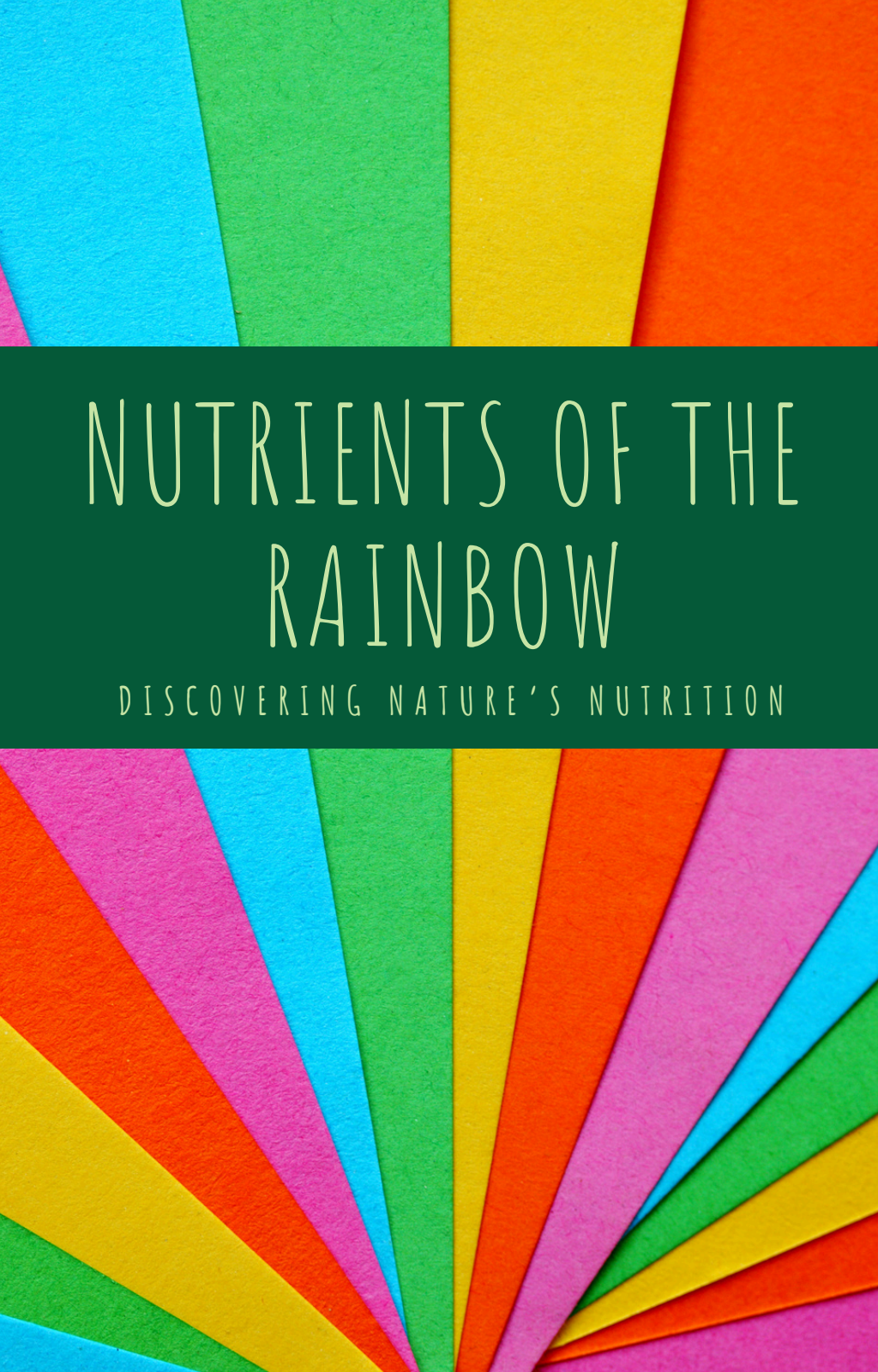

NUTRIENTS OF THE RAINBOW

DISCOVERING NATURE'S NUTRITION

Introduction

Welcome to Nutrients of the Rainbow, a journey through colorful nutrition, where we will explore the vibrant world of nutrients found in the colorful array of foods that grace our plates. As we set off on this journey, we'll look at the rich spectrum of vitamins, minerals, and phytonutrients that give fruits and vegetables their dazzling hues.

We'll be highlighting the significance of incorporating a variety of colors into our diets for optimal health and wellness. From the fiery reds of tomatoes to the deep purples of eggplant, each color represents a unique blend of nutrients that play essential roles in supporting our bodies' functions.

Throughout this ebook, we'll dive into specific color groups, starting with carotenoids, the pigments responsible for the vibrant oranges and yellows found in many fruits and vegetables. We'll then journey through the nutrients of the rainbow, exploring the health benefits of each color group, from the leafy greens packed with chlorophyll to the antioxidant-rich blues and purples found in berries and other produce.

Whether you're a seasoned nutrition enthusiast or just beginning your journey toward a healthier lifestyle, you will be inspired and empowered to make colorful choices that nourish your body and enhance your well-being. So, let's get started on this colorful adventure together and discover the nutritional treasures waiting to be found in the foods of the rainbow.

NUTRIENTS OF THE RAINBOW

You may have heard the advice to eat foods of all the colors of the rainbow, but what nutrients are responsible for the pigments and the benefits of brightly colored fruits and vegetables? In this ebook we'll uncover the phytochemicals that give plants their characteristic colors and highlight a few key nutrients of the rainbow and their benefits.

Why Plants Are Brightly Colored

Before we get into the nutrition of specific colors, let's think about the ecological reasons for colorful plants. Color primarily serves the purpose of plant reproduction, whether by pollination or spreading its seeds. Hummingbirds, for example, learned that brightly colored flowers indicate a rich nectar source, which is why they are attracted to the color red. For this reason, many flowering plants are brightly colored to attract bugs and birds to pollinate them.

Also, colorful phytonutrients may offer protection for the plant in various ways. An example of this is carotenoids, which offer antioxidant protection from damage by UV or visible light, like sunscreen for plants. Sometimes brightly colored nutrients deter herbivorous animals from eating the plant.

Humans have learned to utilize plant pigments as natural dyes, for their medicinal properties, and of course, to eat them. Eating is a sensory experience and color is the way we associate vision with our food.

NUTRIENTS OF THE RAINBOW

Color Wheels and Hue Angles

Determining colors of specific foods is far from a "black and white" distinction, so to speak. There may be many compounds that offer color in a single plant, such as the yellowish carotenoids in leafy greens that are covered up by the presence of chlorophyll.

Scientists use a system called "CIELAB", also known as L*a*b*, to qualify small variations in color based on the four basic colors of human perception: red, yellow, green, and blue.

L* is degree of lightness, where 0 is black and 100 is white
a* is a scale of redness or greenness
b* is a scale of yellowness or blueness

Together, these values help determine the hue angle, as represented by the color wheel below.

NUTRIENTS OF THE RAINBOW

Colors are associated with the following hue angles:

Red: <20˚ or >330˚
Yellow/Orange: 20˚ to 80˚
Green: 80˚ to 160˚
Blue: 160˚ to 270˚
Magenta: 270˚ to 330˚

Hue angles also correlate with antioxidant capacity. Foods with hue angles below 20˚ and greater than 180˚, i.e. in the red, blue, and purple range, typically offer the most antioxidants.

Plant nutrients that are responsible for the colors of the rainbow include:

Anthocyanins (red, blue, purple)
Carotenoids (red, orange, yellow)
Chlorophyll (green)
Betalains (red, violet, and sometimes orange and yellow)

As you can see, there is a great deal of color variety within these nutrient categories, and we'll cover them all in the four parts of this blog series: red, orange/yellow, green, and blue/purple.

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RED FOOD: ANTIOXIDANT POWERHOUSES

Red foods contain a high amount of antioxidant activity, thanks to phytonutrients called anthocyanins and carotenoids. First, we'll get into anthocyanins.

Anthocyanins are water-soluble compounds with multiple aromatic rings and varying degrees of hydroxyl (-OH) groups. Often they are found in glycated forms, which means they are bound to sugar molecules such as glucose, arabinose, or rutinose. The aglycated form (meaning it is not bound to a sugar molecule) is called an anthocyanidin.

Anthocyanins have color because of their conjugated bonds, which means that their single and double bonds alternate. This characteristic gives them the ability to absorb certain wavelengths and also to delocalize and share electrons across its structure, an important feature for an antioxidant.

The most common anthocyanins have a familiar ring to them, as they are named after the flowers they are found in.

RED FOOD

Common Anthocyanins in Flowers and Plants

- Cyanidin – red, reddish purple. Found in berries, red sweet potato, and purple corn.
- Delphinidin – blue, red, purple. Common pigment in blue flowers.
- Pelargonidin – red. Found in strawberries, cranberries, and raspberries.
- Peonidin – magenta. Found in berries, grapes, and red wine.
- Malvidin – purple, red. Common pigment in blue flowers. It is also the major pigment in red wine.
- Petunidin – dark red, purple. Found in black currants and is responsible for purple pigment of flowers.

You may be wondering how an anthocyanin, such as malvidin, contributes the blue pigment of flowers and also the dark red color of wine. That is because anthocyanins express their color differently according to pH. At acidic pH, such as in red wine, anthocyanins take on a more red tone. At neutral pH, they are typically purple and as the solution becomes more basic, they tend to be blue. Notice that red foods with high anthocyanin content, like strawberries, tomatoes, and red wine, are also quite acidic.

RED FOOD

Nutritional Benefits of Anthocyanins

Like many other phytonutrients, anthocyanins are antioxidants. Their conjugated bond system allows them to donate an electron to neutralize free radicals, thanks to the ability of the molecule to distribute electrons evenly amongst itself to retain its own stability.

Furthermore, these molecules offer antimicrobial and anti-inflammatory effects. These traits support overall systemic health and the relationship between anthocyanins and health, including cardiovascular disease, cancer, diabetes, vision, and cognitive function, is well studied.

Anthocyanins aren't the only components of red foods responsible for health benefits. Red fruits and vegetables also tend to be high in vitamin A, vitamin C, potassium, folate, fiber, and other flavonoids, such as pectin or quercetin. Spicy red peppers also contain capsaicin, another anti-inflammatory compound, though this nutrient is colorless.

Carotenoids are brightly colored nutrients that are present in red foods, such as tomatoes, watermelon, and papaya. Most carotenoids are orange and yellow and will be covered more extensively in the next blog of the series. Lycopene, the most potent antioxidant of the carotenoids, is responsible for the red color of these foods.

RED FOOD

Lycopene: An Antioxidant in the Carotenoid Family

Most carotenoids contain 40 carbons and fit into two categories, hydrocarbon carotenoids and xanthophylls. Lycopene is a hydrocarbon carotenoid, meaning it consists solely of carbon and hydrogen atoms. Like anthocyanins, lycopene contains conjugated double bonds, which contributes to its antioxidant activity and produces a vibrant red color. Many carotenoids can be converted to vitamin A, known as provitamin A, though lycopene is not one of them.

Like vitamin A, carotenoids, and hydrocarbons, for that matter, lycopene is fat-soluble. Thus, the bioavailability of lycopene is greatly enhanced when consumed with dietary fat. Fat-solubility is also the reason that tomato products stain plastic containers orange as lycopene sticks in porous surfaces. Cooking also greatly enhances the bioavailability and concentration of lycopene in tomato products due to water loss and heat disrupting the plant's cells to release the nutrient.

Lycopene is a very well-studied nutrient, particularly in relation to cancer and cardiovascular disease, due to its well-known ability to reduce oxidative stress. Epidemiological studies show that higher intakes of lycopene are associated with reduced rates of cancer. In addition, lycopene may protect cells against the free-radical inducing effects of ionizing radiation and UV-induced damage (i.e. sunburn).

RED FOOD

Tomatoes immediately come to mind when thinking about sources of lycopene. Concentrated tomatoes, such as sun-dried tomatoes, pureed tomatoes, and tomato paste, have the highest concentration of lycopene. Ketchup and tomato-based sauces are the primary forms of lycopene in American diets.

Other foods contain lycopene too. These include:

- Watermelon
- Pink grapefruit
- Guava
- Papaya
- Sweet peppers
- Red cabbage
- Asparagus (Yes, even though it's green! Though not nearly as much as in tomatoes...)

RED FOOD

Homemade Ketchup

Here is a homemade ketchup recipe that can be customized to your tastes and preferences.

Ingredients:

12 ounces tomato paste
2-4 tablespoons sweetener of choice (maple syrup, honey, agave, brown sugar, etc.)
1 teaspoon salt
1/8 teaspoon cayenne pepper
½ teaspoon garlic powder
1 teaspoon onion powder
4 tablespoons apple cider vinegar
Water as necessary

Directions:

Combine all ingredients in a bowl, except water. Whisk together adding water in small increments to achieve desired consistency. Store in a glass jar in the refrigerator for up to a month.

Serve with roasted potatoes, eggs, burgers, or however you like your ketchup. Consume with healthy fats for maximum lycopene absorption.

Recipe adapted from Momables.

Next in the rainbow series: More carotenoids of the orange/yellow variety!

ORANGE/YELLOW FOOD

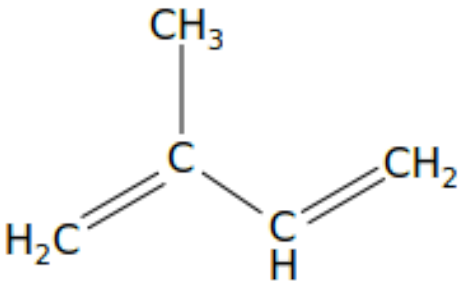
ORANGE/YELLOW FOOD

Moving clockwise along the color wheel we land at nutrients that appear orange or yellow. The nutrients responsible for these colors are primarily carotenoids, of which we learned about the lycopene in the red segment, and is taught in holistic nutrition courses at Nutrition Therapy Institute. Next, we'll explore more carotenoids, such as beta-carotene and xanthophylls, and also the quintessential yellow compound – curcumin.

Before we dive into more carotenoids, let's take a quick detour to learn about the chemical building blocks they are made of.

Isoprene

Isoprene is a unit of 5 carbon atoms arranged in a specific pattern, which includes two carbon to carbon double bonds alternating in a chain with a fifth carbon branching off.



ORANGE/YELLOW FOOD

An isoprenoid compound is one that uses two to thousands of isoprene units attached in sequence. Terpene is a similar term, often used to describe derivatives of isoprenoid structures which may be cyclic or in a straight chain. Isoprenoids commonly found in plants include:

- Monoterpenes – 2 isoprene units (10 carbons)
- Sesquiterpenes – 3 isoprene units (15 carbons)
- Diterpenes – 4 isoprene units (20 carbons)
- Triterpenes – 6 isoprene units (30 carbons)
- Tetraterpenes – 8 isoprene units (40 carbons)

You may recognize these categories of compounds from your favorite herbal constituents, as terpenes are often responsible for the fragrances, flavors, anti-inflammatory and antimicrobial properties of various plants. In fact, many nutrients contain isoprenoid components to some degree, including the fat-soluble vitamins A, D, E, and K, chlorophyll, alkaloids, ubiquinones (like coenzyme Q10), and carotenoids.

Carotenoids are tetraterpenes, containing 8 isoprene units or 40 carbons. Many isoprene units in sequence creates a series of conjugated double bonds, which is the property that allows for the presence of color. Carotenoids appear yellow, orange, or red because these conjugated bonds absorb wavelengths that correspond to violet, blue, and green

ORANGE/YELLOW FOOD

Isoprene building blocks are assembled in many different quantities and configurations. Adding functional groups to the structure, such as double bonded oxygen or hydroxyl groups, produces a seriously wide range of diversity and characteristics of these fascinating nutrients.

One well known characteristic of some carotenoids is that they are a precursor to vitamin A, a nutrient that must be obtained in the diet.

Provitamin A Carotenoids

One way to get vitamin A in the diet is to consume it in its preformed state, retinol, which is obtained from animal foods. The other way to get vitamin A in the diet is to consume its carotenoid precursors, aka provitamin A, and then convert it to retinol on your own (that's how it got in those animal foods, after all).

Provitamin A carotenoids include:

- Beta-carotene (this is the major one)
- Alpha-carotene
- Beta-cryptoxanthin

The conversion of provitamin A to the real deal is accomplished by enzymes in the intestines or the liver. Factors that affect conversion efficiency include individual characteristics, like genetics and vitamin A status, and the type of plant it comes from and whether it was consumed with dietary fat. Dietary fat increases the absorption of carotenoids, as they are fat-soluble nutrients.

ORANGE/YELLOW FOOD

Though there is a high degree of variability surrounding the conversion efficiency of provitamin A carotenoids, the general rule of thumb is that it takes about 12 mcg of beta-carotene or 24 mcg of alpha-carotene or beta-cryptoxanthin to equal 1 mcg of retinol, or 1 retinol activity equivalent (RAE). The RDA for vitamin A is 700 RAE for the average adult.
Food sources of beta-carotene and other provitamin A carotenoids include orange and yellow fruits and vegetables and dark leafy greens, though their presence is masked by chlorophyll in these foods.

Foods Rich in Provitamin A:

- Sweet potato
- Carrot
- Red pepper
- Papaya
- Peach
- Chili powder
- Paprika
- Pumpkin
- Butternut squash
- Spinach
- Kale
- Collard greens

ORANGE/YELLOW FOOD

Carotenoids like these are an important source of vitamin A, which is necessary for eye health and immune function, and they are also antioxidants. Next, we'll dive a little deeper into eye health with a different class of carotenoids with the coolest name ever: xanthophylls.

Xanthophylls

Carotenoids come in two general types: the hydrocarbon variety, which includes the carotenes, and xanthophylls, which include oxygen in their structure.

Like the other carotenoids, xanthophylls contain repeated isoprene units, totaling 40 carbons with lots of conjugated double bonds. The addition of oxygen, typically in a hydroxyl group (-OH), tends to change the wavelength of light they absorb, making xanthophylls appear more yellow in color than the carotenes, which are typically orange.

Examples of xanthophylls include:

- Lutein
- Zeaxanthin
- Astaxanthin
- Neoxanthin
- Violaxanthin
- Flavoxanthin
- Beta-cryptoxanthin (the only xanthophyll that is provitamin A)

Again, thanks to the conjugated double bonds, xanthophylls are antioxidants, which are able to neutralize free radicals. (A major theme among the nutrients of the

rainbow!) In addition, certain xanthophylls, lutein and zeaxanthin, have a particular affinity for the tissues of the eye and they play a major role in vision health.

Lutein and Zeaxanthin and Eye Health

Somehow after being absorbed from the diet, lutein and zeaxanthin set up camp in the retina. Together with meso-zeaxanthin, a metabolite of lutein, they form what is known as macular pigment. Macular pigment protects the eyes from the damaging effects of light by absorbing blue light, which has a short wavelength and high energy.

Too much blue light exposure oxidizes the tissues of the eye and can result in impairments of central or peripheral vision. A common manifestation of vision decline as a result of decreased macular pigment and increased oxidation is age-related macular degeneration (AMD), the leading cause of blindness in older people.

Nutritional sources of lutein and zeaxanthin are similar to the other carotenoids: orange and yellow fruits and vegetables and dark leafy greens. Even though they are green and not orange, leafy green vegetables tend to have a much higher concentration of xanthophylls. For example, kale has about 20 times more lutein per gram than carrots!

Animal foods, such as egg yolks, also contain a good deal of this nutrient. It is important to note that the xanthophyll content of animal foods comes from the inclusion of these nutrients in their diets. For this reason, lutein is often

ORANGE/YELLOW FOOD

added to chicken feed to intensify the yellow-orange color of their yolks.

Foods rich in Lutein and Zeaxanthin:

- Kale
- Spinach
- Parsley
- Peas
- Squash
- Brussels sprouts
- Pistachios
- Egg yolks
- Broccoli
- Pumpkin
- Cantaloupe
- Corn
- Orange

Bioavailability of xanthophylls, like all fat-soluble nutrients, increases in the presence of dietary fat. Egg yolks impart a greater availability of lutein and zeaxanthin as fat naturally occurs with this food.

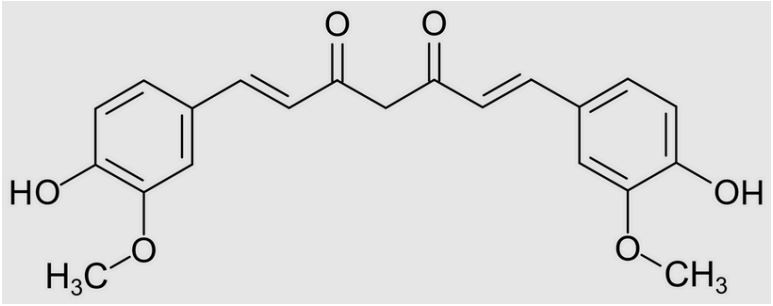
ORANGE/YELLOW FOOD

Cooking with heat tends to decrease carotenoid content of plant foods, yet improves their bioavailability. You win some, you lose some, as they say.

Moving on to a nutrient that leaves its yellow mark (literally) on everything it touches, let's briefly explore the incredible nutritional value of curcumin.

Curcumin

Found in turmeric, curcumin is a potent antioxidant that it extensively studied for a variety of health benefits. Taking a look at its structure, it's not hard to see why it is brightly yellow. It has two phenyl rings joined by alternating double bonds (i.e. a whole lotta conjugation) with plenty of oxygens sprinkled in.



ORANGE/YELLOW FOOD

Curcumin has antioxidant, anti-inflammatory, antimicrobial, and anticancer properties. It has been studied for its nutritional value in many health conditions ranging from metabolic, arthritis, pain, anxiety, and exercise recovery.

This nutrient is notoriously not very bioavailable, owing to its poor absorption coupled with rapid metabolism and excretion. However, its absorption can be increased by consuming it with fat and/or black pepper, which contains piperine, a compound that interferes with the body's system for metabolizing it.

Recipes for More Orange and Yellow in Your Life

The most important thing to remember when consuming the foods on the lists in this section is that they will be better absorbed when they are consumed with dietary fat. That means, drizzle your salads with an olive oil vinaigrette, lightly steam your greens with coconut oil, and douse your sweet potatoes with a healthy dollop of butter. Add avocados, nuts, and seeds to your meals. Or, you can also try the turmeric paste recipe below.

Turmeric Paste

Ingredients:

- ½ cup ground turmeric
- 1 ½ tsp black pepper
- 1 tbsp cinnamon

ORANGE/YELLOW FOOD

- C1 tsp ginger powder
- ½ cup coconut oil
- 1 ¾ cup water
- ¼ cup raw honey

Directions:

Mix all ingredients (except honey) together in a saucepan over medium heat. Whisk together while simmering gently for about 10 to 15 minutes. Remove from heat and allow to cool for another 10 minutes. Whisk in honey. Store in a glass jar in the refrigerator for up to 3 months.

Add a spoonful (or two) to smoothies, lattes, and golden milk. This is delicious when mixed with vanilla ice cream.

Squashed Stuffed with Pears and Wild Rice is another great recipe to work orange and yellow nutrients into your diet!

Next up: green. Until then, get all the colors of the rainbow on your plate!

GREEN FOOD

GREEN FOOD

There aren't many compounds that create the appearance of green in plants. In fact, there's really only one nutrient that is responsible for this color and that is chlorophyll.

Chlorophyll is of the utmost importance to plants, and consequently to all animal and human life. We'll learn about how this molecule's role in harvesting energy from the sun, making life on Earth possible by producing food for the plant and the animals who eat them, while emitting a waste product with major biological significance – oxygen. Then, we'll cover what happens when chlorophyll breaks down, other nutrients associated with green foods, and ways to get more green on your plate.

Chlorophyll: A Pigment Suited for Plant Energy

Plants, especially their leaves, appear green because of the pigment inside them named chlorophyll. A pigment is a molecule that has a particular color because it absorbs light at wavelengths of its complementary, or opposite, colors.

Basic Complementary Colors:

- Red and Green
- Orange and Blue
- Yellow and Purple

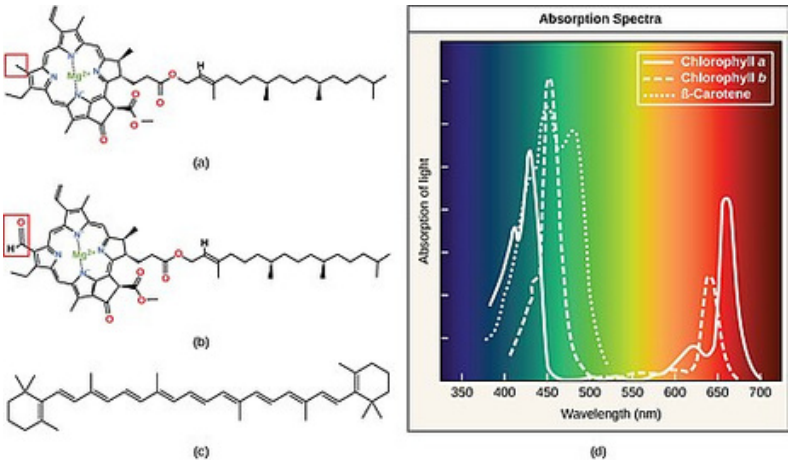
We've seen the benefits of this phenomenon in the ability of the orange-pigmented compounds, lutein and zeaxanthin, to absorb blue light to protect our eyes.

GREEN FOOD

Similarly, chlorophyll absorbs red wavelengths, so it appears green.

Sunlight, of course, contains all the wavelengths of the rainbow blended together. The various forms of chlorophyll, with some help from carotenoids, absorb light at wavelengths that correspond to red, but also blue. This helps the plant to balance its energy intake so it gets enough energy in times of low light and protects it from energy overload in times of too much light.

The following diagram illustrates the structures and wavelength absorption spectra of the two main types of chlorophyll and beta-carotene.



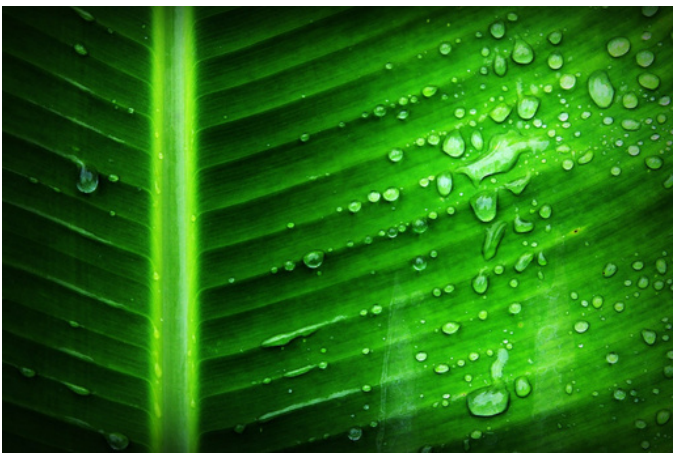
Notice that wavelengths corresponding to green and yellow are not absorbed. Reflecting these wavelengths is the reason plants are green.

GREEN FOOD

Chlorophyll's Structure

Chlorophyll contains two main chemical features. The first is a porphyrin ring, the circular portion of the chlorophyll structure in the diagram above. In the center of the porphyrin ring is a magnesium ion. Another well-known porphyrin structure is the heme unit of hemoglobin, which contains an iron atom at its center. Cobalamin, also known as vitamin B12, is another example with cobalt occupying the center of the ring.

Porphyrin rings have conjugated bonds that, as we learned in the previous rainbow blogs, give these molecules the energetic ability to absorb certain wavelengths to produce color. The metal ion in the center adds another dimension to the molecule's light absorption capacity. Heme is red, chlorophyll is green – the electron interactions between conjugated bonds and the metal center determines which color is seen.



GREEN FOOD

The other structural feature of chlorophyll is the long carbon chain attached, known as a phytyl chain. This feature stabilizes the chlorophyll molecule and makes it soluble in fat. The porphyrin part of chlorophyll is soluble in water.

In plants, chlorophyll is bound to protein structures used in photosynthesis. Once these bonds are broken, chlorophyll loses a lot of stability. This molecule is very sensitive to all kinds of environmental stimuli, like light, acidity, high temperature, enzyme degradation, and oxygen. Think about the discoloration of cucumbers as they are pickled in vinegar, for example.

Chlorophyllin, a common supplemental form of chlorophyll, derives from the natural structure above minus the phytyl chain, making this somewhat synthetic version soluble in water. The magnesium ion at the center is often replaced with copper or zinc, which protects it from degradation and loss of its vibrant green color.

There are 5 main forms of chlorophyll: a, b, c, d, and f. Chlorophyll a is the most abundant variety. It is present in any organism that performs photosynthesis.

Chlorophyll's Function

There are two main benefits of chlorophyll to plants and the rest of the ecosystem on planet Earth. The first is photosynthesis, which gives plants the ability to provide food from themselves using carbon dioxide, water, and sunlight.

Chlorophyll is found in the chloroplasts, the cells of a plant

GREEN FOOD

where photosynthesis takes place. In photosynthesis, the plant uses light from the sun and translates it into energy. Chlorophyll's role is to absorb light for this purpose. The energy is then used to make food for the plant.

The second benefit is the byproduct of photosynthesis, oxygen, which is essential for animal life.

In a nutshell, all life is dependent on chlorophyll. It is essential for the nutrition of plants, the animals who eat plants, and the animals who eat other animals who eat plants. Furthermore, without oxygen, we would perish pretty quickly. One could say this special green molecule is a pretty big deal.

Degrading Chlorophyll Reveals the Unseen Colors of Leaves

Few, if any, organisms can be energy makers all of the time, and plants eventually shut down their photosynthetic machinery to succumb to the cycle of life and death. As a result, chlorophyll naturally degrades.

There is no better display of this phenomenon than the coloring of leaves in the fall. As sunlight wanes, plants shut down chlorophyll production and the action of an enzyme, chlorophyllase, begins to take over.

Chlorophyllase breaks the bond between the porphyrin ring and the phytyl chain and the chlorophyll molecule degrades and loses its function. This gives the unseen nutrients of the rainbow, carotenoids and anthocyanins, the opportunity to shine their brilliant yellow, orange, and red hues, as they are no longer masked by the power of chlorophyll.

GREEN FOOD

Not only are decomposing leaves the result of degrading chlorophyll, ripening fruit is another example. When fruit is ready for ripening, the plant begins to emit a gas called ethylene. Ethylene stimulates the production of chlorophyllase, which degrades chlorophyll and allows the true color of the fruit to shine. This is happening when your bananas turn from green to yellow and tomatoes from green to red.

We now know that chlorophyll makes energy and oxygen production possible in plants, but what about its nutritive value?

Nutritional Benefits of Chlorophyll

Chlorophyll supplementation is one of the latest trends in holistic nutrition, claiming benefits including antioxidant activity, binding to carcinogenic substances, and increasing energy. Many supplements contain the semi-synthetic, water-soluble version discussed earlier, chlorophyllin.

Preparations of chlorophyllin are used topically on wounds and acne. It has also been used for many decades as an "internal deodorant", often for colostomy patients, to improve the odor of urine and feces.

More research is definitely needed to ascertain the purported metabolic and anticancer benefits of chlorophyll supplements, as the bioavailability and mechanisms of this nutrient are not well known.

Though the nutritive benefits of chlorophyll supplementation are unclear, consuming plenty of green vegetables and fruits

GREEN FOOD

has plenty of other benefits, especially in support of metabolic, cardiovascular, and cognitive health.

Other Nutrients in Green Plants

- Magnesium
- Potassium
- Folate
- Fiber
- Vitamin C
- Vitamin K
- Iron
- Carotenoids
- Nitrates

GREEN FOOD

How to Get More Green on Your Plate

Eat your veggies! Here are some suggestions that are especially high in chlorophyll.

- Spinach
- Kale
- Parsley
- Cress
- Green beans
- Arugula
- Leek
- Endive
- Sugar snap peas
- Green cabbage
- Celery
- Broccoli
-

Enjoy them in salads, smoothies, lightly steamed, or in soups. Add a side of my favorite green treat – homemade pickles!

Pickles Recipe

I've included two recipes for pickles. One is a basic dill pickle, and the other is a sweet variety. Normally I'm not a fan of sweet pickles, but I discovered this recipe as I was researching a cultivar that I grew in my garden last year, Boothby Blonde, and fell in love.

Boothby Blonde is actually a yellow variety of cucumber that is particularly suited for sweet pickling, though I've tried this recipe with green pickling cucumbers with great success. They are so delicious alongside pretty much any meal.

GREEN FOOD

Basic Dill Pickle

Ingredients:

- 4-5 pickling cucumbers – about 5 cups thinly sliced
- ½ onion of your choice, thinly sliced (about one cup)
- 5 tbsp sea salt or pickling salt
- 2 garlic cloves, sliced
- 1 tsp mustard seeds
- Dill sprigs
- 1 tsp black peppercorns
- 1 cup water
- 1 cup white vinegar
- 2 tbsp sugar

Directions:

1. Cover cucumbers and onion with salt and let sit for 1-2 hours.
2. Meanwhile, bring water, vinegar, sugar, and peppercorns to boil. Simmer for 5 min, then remove from heat.
3. Add garlic, mustard seeds, and dill to the pickle mixture and divide in glass jars. The seasonings can be customized to your preference as well.
4. Strain liquid mixture and pour over jars evenly. Refrigerate and enjoy in 1-2 days.

GREEN FOOD

Sweet Pickles

Ingredients:

- 4-5 pickling cucumbers, about 5 cups thinly sliced
- ½ onion of choice, thinly sliced (about one cup)
- 1 ½ tbsp sea salt or pickling salt
- 1/2 cup granulated sugar
- ¼ cup brown sugar
- 1 cup white vinegar
- ½ cup apple cider vinegar
- 2 tsp mustard seed
- 1 tsp celery seed
- ½ tsp turmeric

Directions:

1. Cover cucumbers and onion with salt and let sit for 1-2 hours.
2. Combine remaining ingredients, except apple cider vinegar, over medium heat and simmer to dissolve sugar – about 10 min. Remove from heat and add apple cider vinegar.
3. Divide cucumber mixture among two quart sized glass jars. Pour liquid mixture evenly into the jars. Refrigerate and enjoy in 1-2 days.

Up Next, blue/purple food. And remember, no matter what's on your plate, be thankful for chlorophyll, the green molecule that makes the food we eat and the air we breathe possible.

BLUE/PURPLE FOOD

BLUE/PURPLE FOOD

For the last segment – blue and purple – we will revisit anthocyanins and introduce betalains, a similar category of chemicals in plants that produce color. We'll learn about the similarities and differences between these molecules, highlight two superfoods – blueberries and beets, and provide a recipe for beet kvass.

Anthocyanins Revisited

Recall from the red segment of the rainbow series that water-soluble antioxidant molecules called anthocyanins are responsible for the red pigment of strawberries, raspberries, cranberries, and grapes. Anthocyanins can also be blue or purple, depending on which anthocyanins are present and the pH of their environment.

Take purple cabbage, for example. Its purple color results from a combination of anthocyanins present in the plant, mostly cyanidins. If you chop the cabbage and boil it in water for a few minutes, a purplish liquid appears. Add baking soda, and the solution turns blue. Add acid and the solution turns pink.

This is why sauerkraut made with purple cabbage turns a bright magenta pink. As bacteria present on the cabbage leaves ferment the natural sugars, the pH of the solution lowers and changes the appearance of the anthocyanin's color.

RECIPE ››› Tangy Probiotic Sauerkraut

BLUE/PURPLE FOOD

Solutions made from purple cabbage work well as natural dyes for Easter eggs or fabrics. Here's a fun experiment to introduce the concept of pH changes to kids using purple cabbage.

Purple cabbage, purple sweet potato, blackberries, currants, and blueberries are the most common foods rich in blue and purple anthocyanins.

Naturally blue foods are actually pretty hard to come by, as blue is the rarest naturally occurring color in the plant world. Next let's highlight a super special blue food.

Blueberries

One of the richest sources of antioxidants per gram, blueberries are truly a superfood. Not only are they high in anthocyanins, which contribute to their color, they also contain numerous other phytochemicals, including quercetin, a polyphenol that is found on their skins, and resveratrol. In addition, blueberries are a good source of vitamin C, vitamin K, manganese, copper, and fiber.

The antioxidant and anti-inflammatory properties of blueberries make this fruit an ideal candidate for the study of its potential therapeutic benefits for chronic health issues that plague the world today. As a result, a large body of research is devoted to the effects of regular blueberry consumption or supplementation with blueberry products on cardiovascular disease, type 2 diabetes, cognitive function, aging, and weight management.

BLUE/PURPLE FOOD

Though research of this sort is inconclusive and unlikely to draw a direct connection between blueberries and health outcomes, recommending moderate blueberry intake is a no brainer because of their likely health benefits, safety, and of course, their delicious taste.

Blueberries are native to North America, and if you're lucky enough to live in or visit an area where they grow wild, take advantage of picking them fresh. As the berries form, they are a bright green (hello chlorophyll!). As they ripen, the chlorophyll degrades and the berries turn white to pink to red, then finally blue as anthocyanin and sugar production increases.

Anthocyanins aren't the only molecules that give plants purple hues. Betalains are another class of compounds that impart this color. Let's take a look at how they compare.

BLUE/PURPLE FOOD

Anthocyanins vs Betalains

The function of these two sets of molecules in plants is the same – to provide color to attract pollinators and to protect them from environmental stress. Interestingly, you won't find both molecules in the same plant, and scientists haven't figured out exactly why.

It appears that plants use either the synthesis pathway to anthocyanins or to betalains, but not both. Most plants produce anthocyanins, as that seems to be the most energetically favorable route for antioxidant protection. However, many plants of the order Caryophyllales produce betalains instead.

Ornamental plants with betalains include:

- Cacti
- Four O'clocks
- Ice Plant
- Globe Amaranth
- Bougainvillea

BLUE/PURPLE FOOD

Many Caryophyllales are adapted to life in harsh conditions, such as drought and high salt conditions, so it is speculated that betalains evolved to help plants manage in these environments.

Structurally, anthocyanins and betalains contain conjugated double bonds that allow them to absorb certain wavelengths and reflect others, which gives them their color, and they are both water-soluble. The main difference between them, however, is that betalains contain nitrogen while anthocyanins do not.

In addition, betalains' color is more stable, which is why these molecules are often used as food colorants. Let's take a closer look at these compounds.

All about the Betalains

Tyrosine, an amino acid and source of nitrogen, is the precursor to the production of betalains. Betalains come in two types and colors:

- Betacyanins – red/violet
- Betaxanthins – yellow/orange

Like anthocyanins, betalains are named after the species where they were discovered so their names, such as betanin, amaranthin, gomphrenin, and bougainvillein, are recognizable.

BLUE/PURPLE FOOD

Foods containing betalains include:

- Beets
- Amaranth
- Rhubarb
- Swiss Chard
- Quinoa
- Spinach
- Prickly pear
- Dragonfruit

Like the other nutrients of the rainbow, betalains are great antioxidants, perhaps even stronger in this ability than the anthocyanins. This feature, plus their anti-inflammatory nature, also makes them an ideal research subject for potential therapeutic application for a variety of conditions such as cardiovascular disease, cancer, and diabetes.

Furthermore, betalains exhibit antimicrobial properties. Scientists propose that betalains may interfere with the cell membranes of microbes, ultimately leading to their demise. Amaranth, for example, is particularly effective against malaria.

Although betalains are pretty amazing molecules, it's important to consider the presence of other nutrients and phytochemicals in these plants, such as polyphenols, for their antimicrobial contributions as well.

BLUE/PURPLE FOOD

Beets

When I think of purple foods, beets immediately come to mind, thanks to the high betalain concentration, particularly betacyanins. The nutritional profile of beets is also impressive. Beets are a great source of:

- Fiber
- Folate
- Manganese
- Copper
- Potassium
- Iron
- Vitamin C
- Nitrates

In addition, beet greens are a great source of carotenoids, such as lutein, so seek out the entire plant when you can.

BLUE/PURPLE FOOD

Nitrates are particularly interesting nutrients found abundantly in beets, as well as dark leafy greens. In the body, they convert to nitric oxide, which dilates blood vessels and improves blood flow, with potential benefits that include lowering blood pressure and improving muscle function.

Peeling and chopping beets stains my fingers and cutting board a beautiful magenta purple. For some people, beet consumption can also cause discoloration of urine and feces, an alarming, yet harmless phenomenon called beeturia.

Beeturia

Beeturia, or more technically, betacyaniuria, is the condition of pink or red urine or feces following consumption of foods rich in betalains, particularly betacyanins found in beets. It affects roughly 10-15% of the population, with increased prevalence among those with iron deficiency or malabsorption issues.

If iron deficiency is suspected, ask your doctor to order simple blood tests to confirm the condition.

Though the condition may be disconcerting, it is considered harmless. Check out this hilarious Portlandia sketch, and don't worry, it's just beets.

Beet Kvass

There are many ways to enjoy beets – roasted, steamed, pickled, eaten raw like carrot sticks, or in salads and soups. I really like this lightly fermented beet drink, taken from Sally Fallon's Nourishing Traditions.

BLUE/PURPLE FOOD

Ingredients:

- 2-3 cups of peeled and diced beets – about ½ inch cubes (about 2-3 medium to large beets)
- ¼ cup whey (liquid remaining from strained, plain yogurt)
- 1 tablespoon sea salt
- Water
- Additional flavorings such as ginger or lemon zest can be added if desired

Directions:

Combine all ingredients in a two-quart glass jar, or divide it equally into quart-sized jars. Fill with water leaving an inch of headspace. Cover and leave at room temperature for about two days, then transfer to the refrigerator. Strain a portion to drink (Ms. Fallon recommends 4 ounces in the morning and at night) or use in salad dressing or soup.

When a small amount of liquid remains, you can refill the jar with water once more and leave it at room temperature an additional two days to make a more diluted tonic. Discard the beets after the second brewing.

If whey is unavailable or you desire to make this recipe vegan, simply omit the whey. You may need to leave the mixture at room temperature for longer to achieve desired fermentation. The mixture should be dark purple and slightly effervescent.

BLUE/PURPLE FOOD

The Colors of the Rainbow are Everywhere

I hope you enjoyed learning about the molecules responsible for the colors of the flowers, leaves, and foods around you. The variety and beauty of these colors is not only a delight to the senses, but nourishment and antioxidant protection for ourselves, animals, pollinators, and plants. Get creative and include a variety of colors on your plate every day!

About the Author:

Karyn Lane is a current student of NTI's Nutrition Therapist Master Program. She finds her chemistry degree a useful tool in her study of nutrition and loves to treat herself as a laboratory for new recipes and cooking techniques. You can follow her on Instagram @feel.alive.nourishment.

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The Nutrition Therapist Master Certification is science-based and the most comprehensive holistic nutrition training program available today. The program can be completed fully online or in person in Arvada, Colorado. Sign up for an informational webinar hosted by the Director of NTI to learn more.

Gain confidence in the kitchen and learn to create nourishing and delicious recipes by becoming a Natural Food Chef! Attend a live cooking demonstration in person or virtually to hear from one of the chef instructors and learn more about the in-person, 15-week Natural Food chef program.

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