World Journal of Pharmaceutical Sciences
ISSN (Print): 2321-3310; ISSN (Online): 2321-3086
Published by Atom and Cell Publishers
Available online at: http://www.wjpsonline.org/
Review Article

Broccoli: the powerhouse of nutrition in flowering crest like a cabbage

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Received: 17-06-2015 / Revised: 23-07-2015 / Accepted: 26-07-2015

ABSTRACT

Broccoli belongs to the cruciferous vegetable family, which includes kale, cauliflower, Brussels sprouts, bok choy, cabbage, collard greens, rutabaga and turnips. These nutrition powerhouses supply loads of nutrients for little calories. If you are trying to eat healthier, cruciferous vegetables like broccoli should be at the very top of your grocery list. If you or your kids are not big fans of broccoli, be sure to read the how to incorporate more broccoli into your diet section for tips and delicious recipes. According to the USDA National Nutrient Database6, one cup of chopped raw broccoli (approximately 91 grams) contains 31 calories, 0 grams of fat, 6 grams of carbohydrate (including 2 grams of sugar and 2 grams of fiber) and 3 grams of protein. Just one cup of broccoli provides over 100% of your daily need for vitamin C and vitamin K and is also a good source of vitamin A, folate and potassium. Broccoli ranks among the top 20 foods in regards to ANDI score (Aggregate Nutrient Density Index), which measures vitamin, mineral and phytonutrient content in relation to caloric content. To earn high rank, a food must provide a high amount of nutrients for a small amount of calories. Consuming fruits and vegetables of all kinds has long been associated with a reduced risk of many lifestyle-related health conditions. Many studies have suggested that increasing consumption of plant foods like broccoli decreases the risk of obesity, diabetes, heart disease and overall mortality while promoting a healthy complexion and hair, increased energy and overall lower weight. Eating a high amount of cruciferous vegetables has been associated with a lower risk of cancer; namely lung and colon cancer. Studies have suggested that sulforaphane, the sulfur-containing compound that gives cruciferous vegetables their bitter bite, is also what gives them their cancer-fighting power. Researchers have found that sulforaphane can inhibit the enzyme histone deacetylase (HDAC), known to be involved in the progression of cancer cells. The ability to stop HDAC enzymes could make sulforaphane-containing foods a potentially powerful part of cancer treatment in the future. Sulforaphane is now being studied for its ability to delay or impede cancer with promising results shown in melanoma, esophageal, prostate and pancreatic cancers. Other easily recognized cruciferous vegetables include cauliflower, Brussels sprouts, kale, turnips and cabbage, as well as the lesser-known arugula, broccolini, daikon, kohlrabi and watercress. Another important vitamin that broccoli contains, folate, has been shown to decrease the risk of breast cancer in women. Adequate intake of dietary folate (in food) has also shown promise in protecting against colon, stomach, pancreatic and cervical cancers. Although the mechanism of protection is currently unknown, researchers believe that folate's protective effects have something to do with its role in DNA and RNA production and the prevention of unwanted mutations. There is no evidence that folate in supplement form provides the same anti-cancer benefits.

Keywords: Broccoli, HDAC, Sulforaphane, calabrese, chou broccoli, common broccoli, cruciferous vegetable, sprouting broccoli, indole-3-carbinol (I3C), di-indolylmethane (DIM), BioResponse, NF-κB, Indolplex

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INTRODUCTION

Scientific Name(s): *Brassica oleracea* L. var. botrytis L. Family: Brassicaceae (mustard)

Uses: Cruciferous vegetables, including broccoli, are being investigated for a potential role in the prevention and treatment of cancer, but no recommendations can be made. Broccoli is a useful natural source of selenium.

Dosing: Broccoli 500 g daily and broccoli sprouts 50 g daily have been used in clinical trials. Preparation methods affect bioavailability of active chemical compounds and relevant endogenous enzymes.

Contraindications: None established.

Pregnancy/Lactation: Information regarding safety and efficacy in pregnancy and lactation is lacking.

Interactions: Reports of clinically important interactions are lacking. High consumption of broccoli may interfere with international normalized ratio (INR) values, antagonizing the effect of warfarin, but bioavailability of vitamin K is poor.

Figure-1: Broccoli

Adverse Reactions: Few reported in clinical trials.

Toxicology: Effects on thyroid function have been suggested. Tumor-promoting effects of DIM have been shown in some animal models, especially at higher dosages.

Botany: The Brassica L. (mustard) genus includes cabbages, turnips and pak choi; broccoli was derived from a species of wild cabbage. With extensive cultivation and selection, the *B. oleracea* species has become diverse, with many different varieties divided into several groups, including brussels sprouts (var. gemmifera), kohlrabi (var. gongylodes), sprouting broccoli (var. italica) and tronchuda cabbage (var. costata). Common broccoli (var. botrytis) has been developed to have a dense, central flowering head (10-20 cm) on a thick stem, with the head surrounded by petiolate leaves. Both green and purple broccoli varieties exist. Sprouting broccoli, also known as Italian or asparagus broccoli (var. italica), has loose, leafy stems and edible flower shoots, with no central head. Broccoli is a cool weather crop and is grown mostly in California and Arizona in the United States.

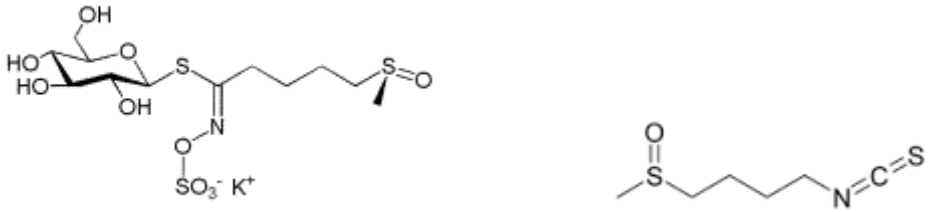
History: Broccoli has its roots in Italy. In ancient Roman times, it was developed from wild cabbage, a plant that more resembles collards than broccoli. It spread throughout the Near East where it was appreciated for its edible flower heads and was subsequently brought back to Italy where it was further cultivated. Broccoli was introduced to the United States in colonial times, popularized by Italian immigrants who brought this prized vegetable with them to the New World. Broccoli is thought to have been domesticated in ancient Rome from wild cabbage, and it was introduced to the United States by Italian immigrants in the early 20th century. Usually boiled or steamed, broccoli is popular as a quick frozen vegetable and it is recognized as a functional food, having health benefits beyond its nutritive value. Extracts have been used in skin disorders and to treat warts.[1]

Chemistry: Raw, green broccoli is a source of multiple vitamins and minerals, including calcium, magnesium, potassium, iron, zinc and selenium, as well as carotene, thiamine, riboflavin, niacin, folate and vitamins C and K; however, content varies widely and the bioavailability of compounds may be low. Flavonoids (eg., quercetin, kaempferol), hydroxycinnamoyl compounds and glucosinolates (primarily glucoraphanin and glucobrassican) have been described. Broccoli sprouts are consumed for their higher glucosinolate content. The glucosinolates give the species its characteristic taste and are influenced by cultivation methods. Glucosinolates have been extensively studied; approximately 120 compounds have been identified. The compounds are inactive after ingestion until hydrolyzed by the myrosinase enzyme endogenous to the plant. The respective isothiocyanates (particularly sulforaphane, I3C and 3,3-DIM) are excreted via the urine as the corresponding mercapturic acids. **Sulforaphane** is a molecule within the isothiocyanate group of organosulfur compounds. It is obtained from cruciferous vegetables such as broccoli, Brussels sprouts or cabbages. It is produced when the enzyme myrosinase transforms glucoraphanin, a glucosinolate, into sulforaphane upon damage to the plant (such as from chewing), which allows the two compounds to mix and react. Young sprouts of broccoli and cauliflower are particularly rich in

glucoraphanin. Levels of glucosinolates are affected by food processing; chopping broccoli increases the activity of myrosinase, while pulping broccoli in a blender will result in complete breakdown by autolysis. Cooking decreases glucosinolate levels up to 60%, depending on the method employed and deactivates endogenous myrosinase, leaving the bacterial enzymes in the distal gut responsible for hydrolysis.

Uses and Pharmacology:

Cancer: Multiple mechanisms of action for broccoli and its constituents (especially sulforaphane, DIM, and I3C) have been proposed based largely on cell culture studies. Mechanisms include the induction of phase 1, 2, and 3 enzyme and transporter systems, phase 2 detoxification, inhibition of histone deacetylation, cell cycle arrest, apoptosis and the inhibition of cell growth. Histone deacetylases (EC 3.5.1.98, HDAC) are a class of enzymes that remove acetyl groups ($O=C-CH_3$) from an ε-N-acetyl lysine amino acid on a histone, allowing the histones to wrap the DNA more tightly. This is important because DNA is wrapped around histones and DNA expression is regulated by acetylation and de-acetylation.



Glucoraphanin, Glucosinolate precursor to Sulforaphane

Figure-2: Sulforaphane biogenesis

Its action is opposite to that of histone acetyltransferase. HDAC proteins are now also called lysine deacetylases (KDAC), to describe their function rather than their target, which also includes non-histone proteins. Histone tails are normally positively charged due to amine groups present on their lysine and arginine amino acids. These positive charges help the histone tails to interact with and bind to the negatively charged phosphate groups on the DNA backbone. Acetylation, which occurs normally in a cell, neutralizes the positive charges on the histone by changing amines into amides and decreases the ability of the histones to bind to DNA. This decreased binding allows chromatin expansion, permitting genetic transcription to take place. Histone deacetylases remove those acetyl groups, increasing the positive charge of histone tails and encouraging high-affinity binding between the histones and DNA backbone. The increased DNA binding condenses DNA structure, preventing transcription.[2]

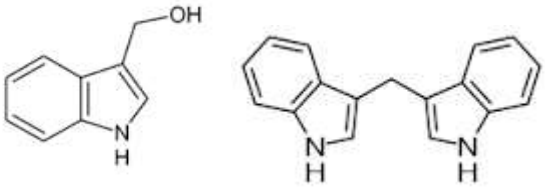


Figure-3: Indole-3-carbinol and Di-indolyl methane

Histone deacetylase is involved in a series of pathways within the living system. According to the Kyoto Encyclopedia of Genes and Genomes (KEGG), these are:

Environmental information processing; signal transduction; notch signaling pathway PATH: ko04330

Cellular processes; cell growth and death; cell cycle PATH: ko04110

Human diseases; cancers; chronic myeloid leukemia PATH: ko05220

Histone acetylation plays an important role in the regulation of gene expression. Hyperacetylated chromatin is transcriptionally active, and hypoacetylated chromatin is silent. A study on mice found that a specific subset of mouse genes (7%) was deregulated in the absence of HDAC1. Their study also found a regulatory crosstalk between HDAC1 and HDAC2 and suggest a novel function for HDAC1 as a transcriptional coactivator. HDAC1 expression was found to be increased in the prefrontal cortex of schizophrenia subjects, negatively correlating with the expression of GAD67 mRNA.

Non-histone effects: It is a mistake to regard HDACs solely in the context of regulating gene transcription by modifying histones and chromatin structure, although that appears to be the predominant function. The function, activity, and stability of proteins can be controlled by post-translational modifications. Protein phosphorylation is perhaps the most widely studied and understood modification in which certain amino acid residues are phosphorylated by the action of protein kinases or dephosphorylated by the action of phosphatases.

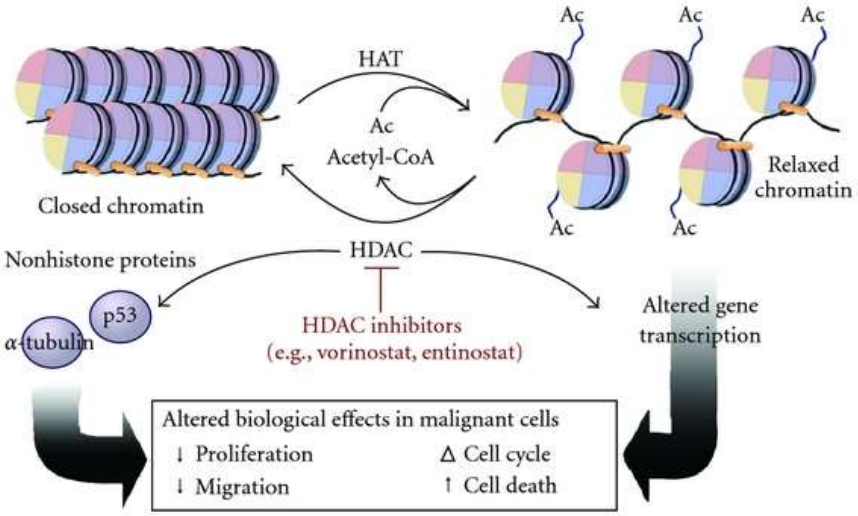


Figure-4: HDAC biochemical pathway

The acetylation of lysine residues is emerging as an analogous mechanism, in which non-histone proteins are acted on by acetylases and deacetylases. It is in this context that HDACs are being found to interact with a variety of non-histone proteins—some of these are transcription factors and co-regulators, some are not. Note the following four examples:

HDAC6 is associated with aggresomes. Misfolded protein aggregates are tagged by ubiquitination and removed from the cytoplasm by dynein motors via the microtubule network to an organelle termed the aggresome. HDAC 6 binds polyubiquitinated misfolded proteins and links to dynein motors, thereby allowing the misfolded protein cargo to be physically transported to chaperones and proteasomes for subsequent destruction.[3]

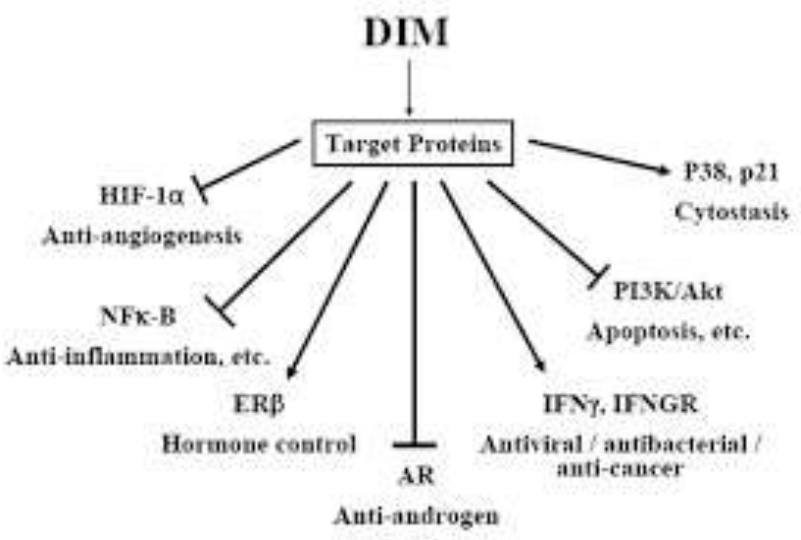


Figure-5: DIM pathway

PTEN is an important phosphatase involved in cell signaling via phosphoinositols and the AKT/PI3 kinase pathway. PTEN is subject to complex regulatory control via phosphorylation, ubiquitination, oxidation and acetylation. Acetylation of PTEN by the histone acetyltransferase p300/CBP-associated factor (PCAF) can repress its activity; on the converse, deacetylation of PTEN by SIRT1 deacetylase and, by HDAC1, can stimulate its activity. APE1/Ref-1 (APEX1) is a multifunctional protein possessing both DNA repair activity (on abasic and single-strand break sites) and transcriptional regulatory activity associated with oxidative stress. APE1/Ref-1 is acetylated by PCAF; on the converse, it is stably associated with and deacetylated by Class I HDACs. The acetylation state of APE1/Ref-1 does not appear to affect its DNA repair activity, but it does regulate its transcriptional activity such as its ability to bind to the PTH promoter and initiate transcription of the parathyroid hormone gene.

NF-κB is a key transcription factor and effector molecule involved in responses to cell stress, consisting of a p50/p65 heterodimer. The p65 subunit is controlled by acetylation via PCAF and by deacetylation via HDAC3 and HDAC6. NF-κB (nuclear factor kappa-light-chain-enhancer of activated B cells) is a protein complex that controls transcription of DNA, cytokine production and cell survival. NF-κB is found in almost all animal cell types and is involved in cellular responses to stimuli such as stress, cytokines, free radicals, ultraviolet irradiation, oxidized LDL, and bacterial or viral antigens. NF-κB plays a key role in regulating the immune response to infection (κ light chains are critical components of immunoglobulins). Incorrect regulation of NF-κB has been linked to cancer, inflammatory, and autoimmune diseases, septic shock, viral infection, and improper immune development. NF-κB has also been implicated in processes of synaptic plasticity and memory. These are just some examples of constantly emerging non-histone, non-chromatin roles for HDACs.Of particular interest is the effect of I3C and DIM on estrogen metabolism. Both compounds appear to affect the concentrations of 2-, 4- and 16-hydroxyestrone (-OHE) estrogen metabolites. Studies have shown that I3C and DIM are capable of increasing levels of 2-OHE and decreasing 16-OHE, suggesting a decreased cancer risk. Changes in the physiological levels of 4-OHE are considered to be too small to be of relevance; however, the metabolite is considered potentially mutagenic. Antiandrogenic properties have also been demonstrated for DIM.[4] Published reviews of epidemiological data investigating the role of broccoli in cancer prevention have not all demonstrated a positive protective effect, but harm was not demonstrated. No association was found for flavonoid-rich foods or broccoli with the incidence of total and site-specific cancers among middle-aged and older women in the Women's Health Study. Likewise, no association was demonstrated for flavonoids and the incidence of ovarian cancer; however, an inverse association with broccoli intake, attributed to kaempferol, was found. In the Prostate, Lung, Colorectal and Ovarian Cancer Screening Trial, vegetable and fruit consumption was not related to prostate cancer risk overall, but broccoli appeared to be protective for risk of aggressive, extraprostatic prostate cancer. The European Prospective Investigation into Cancer and Nutrition study found no association between cruciferous vegetable consumption and the risk of prostate cancer. In the Health Professionals Follow-Up Study, 5 or more servings of broccoli per week showed a protective effect for bladder cancer, while 2 further reviews showed 3-5 servings per week to be protective for prostate cancer. A review of epidemiological data for prostate cancer found modest support for a protective effect of Brassica vegetables, with 4 of 12 studies demonstrating statistically significant protection but noting bias to be a particular problem.

Animal studies: Broccoli, sulforaphane and various glucosinolates/isothiocyanates have been used in experiments in mice and rats with induced prostate, small intestine, skin and mammary cancers. Limited animal studies have shown an increase in carcinogenic activity, such as increased liver cancer in trout fed DIM and apoptosis in splenic cells in mice.

Clinical studies: Prospective clinical trials are limited. A clinical phase 1 study has been undertaken to research the safety, tolerance, and metabolism of broccoli sprouts. Variations in human genotypes have been suggested to influence response to the protective effects of cruciferous vegetables. Two trials evaluated the effect of broccoli on biomarkers for breast cancer and found a protective effect suggesting a protective role in hormone-dependent cancers. Results from a trial evaluating the effect of broccoli on breast cancer recurrence among breast cancer survivors are not available. A 12-month trial of a broccoli-rich diet showed a protective effect for prostate cancer biomarkers.

Although the majority of clinical studies have investigated the effect of I3C (Indole-3-carbinol) in cancer, especially in breast and prostate cancers, I3C is rapidly transformed into DIM in the stomach and is considered by some researchers to be a

prodrug of DIM. **Indole-3-carbinol** (C_9H_9NO) is produced by the breakdown of the glucosinolate glucobrassicin, which can be found at relatively high levels in cruciferous vegetables such as broccoli, cabbage, cauliflower, brussels sprouts, collard greens and kale. I3C is also available in a dietary supplement. Indole-3-carbinol is the subject of on-going Biomedical research into its possible anticarcinogenic, antioxidant and anti-atherogenic effects. Research on indole-3-carbinol has been conducted primarily using laboratory animals and cultured cells. Limited and inconclusive human studies have been reported. A recent review of the biomedical research literature found that "evidence of an inverse association between cruciferous vegetable intake and breast or prostate cancer in humans is limited and inconsistent" and "larger randomized controlled trials are needed" to determine if supplemental indole-3-carbinol has health benefits. Poor oral bioavailability of naturally derived DIM has led to development of synthetic analogs. At least 8 registered clinical trials are being conducted using DIM and phase 1 dose escalation and safety trials have been conducted. Preliminary results from clinical trials are encouraging, although not all studies have produced positive findings.

Other effects: Broccoli has been evaluated for its potential to eradicate *Helicobacter pylori*, but results have varied. The antioxidant potential of broccoli has also been investigated.

Dosage: Broccoli 500 g daily has been used in clinical trials evaluating the protective effect on cancer biomarkers. Preparation methods affect bioavailability of active chemical compounds and relevant endogenous enzymes.

Broccoli sprouts were given in dosages of up to 50 g/day (approximately glucosinolate 300 mcg) in 3 divided doses in a phase 1 clinical trial. 29 The most effective dosages for DIM in cancer treatment/prevention have yet to be determined. Some pharmacokinetic studies have been conducted in healthy adults and DIM has been used in clinical studies in children. In clinical trials, DIM has been used at doses of 2-5 mg/kg/day for short periods of time (up to 6 months). DIM has been delivered via an aerosol in a study in lung cancer.[5]

Pregnancy/Lactation: Information regarding safety and efficacy in pregnancy and lactation is lacking. Due to the potential effect on estrogen and androgen metabolism, as well as antiproliferative effects, DIM should not be taken during pregnancy.
Interactions: Information on clinical interactions is lacking. Broccoli may antagonize the effect of warfarin; however, the effect of the vitamin K content in broccoli on INR fluctuations has been challenged because bioavailability is poor. Sulforaphane is a potent phase 2 enzyme inducer, impacting the cytochrome P450 system and has been observed to inhibit CYP3A4, an isozyme commonly involved in drug-drug interactions. Sulforaphane restored chemosensitivity in doxorubicin-tolerant cell lines; therefore, an interaction with broccoli may present an advantage. Theoretically, consumption of DIM as a supplement might interfere with oral contraception.

Adverse Reactions: Clinical trials investigating consumption of broccoli 500 g daily did not report serious adverse reactions. Minor GI complaints were recorded. Clinical studies with I3C and DIM report mild GI adverse events and, rarely, rash and increases in liver enzymes.

Toxicology: The breakdown of certain glucosinolates has been demonstrated to have negative effects on the thyroid in animals, with goiters reported. In a phase 1 safety trial, notable changes were observed for thyroid-stimulating hormone levels that exceeded upper limits of normal, but these did not reach statistical significance. Changes in plasma ALT were also noted in placebo and active arms, but the effect was attributed to elevations usually observed by participants in such trials.

At 3 times the human therapeutic dose of DIM 2 mg/kg/day, no changes in serum chemistry or histology of the liver, kidney and bone were found in immature rats 48; however, a study conducted in neonatal mice found toxic effects on the immune system, including the spleen. Tumor-promoting effects of DIM have been shown in some animal models, especially at higher dosages. Toxicity of DIM has been shown in dogs at 450 mg/kg/day.

Improving bone health: Poor vitamin K intake is linked with a high risk of bone fracture. Just one cup of chopped broccoli provides 92 micrograms of vitamin K, well over 100% of your daily need. Consuming an adequate amount of vitamin K daily, improves bone health by improving calcium absorption and reducing urinary excretion of calcium. Broccoli also contributes to your daily need for calcium, providing 43 milligrams in one cup.

Looking younger: The antioxidant vitamin C, when eaten in its natural form (in fresh produce as opposed to supplement form) can help to fight skin damage caused by the sun and pollution, reduce wrinkles and improve overall skin texture. Many people automatically think of citrus fruit when they

think of vitamin C, but did you know that broccoli provides 81 milligrams in just one cup? That is more than what you need in an entire day.

Vitamin C plays a vital role in the formation of collagen, the main support system of the skin. Vitamin A and vitamin E are also crucial for healthy looking skin, both of which broccoli provides.[6]

Improved digestion and natural detoxification: Eating foods with a natural fiber like broccoli can prevent constipation, maintain a healthy digestive tract and lower the risk of colon cancer. Adequate fiber promotes regularity, which is crucial for the daily excretion of toxins through the bile and stool. Recent studies have shown that dietary fiber may also play a role in regulating the immune system and inflammation.

Protection from chronic disease: According to the Department of Internal Medicine and Nutritional Sciences Program of the University of Kentucky, high fiber intakes are associated with significantly lower risks of developing coronary heart disease, stroke, hypertension, diabetes, obesity and certain gastrointestinal diseases. Increased fiber intake has also been shown to lower blood pressure and cholesterol levels improve insulin sensitivity and enhance weight loss for obese individuals.

How to incorporate more broccoli into your diet: Broccoli is famously one of the least favorite vegetables of many, along with its cruciferous cousin, Brussels sprouts. But what if you have just been storing and preparing it wrong?

Fresh, young broccoli should not taste fibrous, woody or sulfurous. To make sure you get the best tasting broccoli, store the unwashed vegetable in loose or perforated plastic bags in the crisper drawer of the refrigerator. Only wash broccoli right before eating, as wet broccoli can develop mold and become limp. Broccoli left at room temperature becomes fibrous and woody. You may not be able to tell by looking, but the flavor of broccoli continues to diminish the older it gets.

Broccoli soup: Broccoli can be added to wraps, pasta, pizza or even made into a soup with onion and garlic.
Quick tips to enjoy more broccoli:
Keep it simple and sauté chopped broccoli drizzled with olive oil, cracked black pepper and minced garlic
Chop raw broccoli and add to your next wrap
Top your flatbread or pizza with chopped broccoli before roasting
Make your own pesto or pasta sauce and add broccoli.

Potential health risks of consuming broccoli: If you are taking blood-thinners such as Coumadin (warfarin), it is important that you do not suddenly begin to eat more or less foods containing vitamin K, which plays a large role in blood clotting.

It is the total diet or overall eating pattern that is most important in disease prevention and achieving good health. It is better to eat a diet with a variety than to concentrate on individual foods as the key to good health.[7]

Broccoli is known to be hearty and tasty vegetable which is rich in dozens of nutrients. It is said to pack the most nutritional punch of any vegetable.
Here are some of the benefits of broccoli:
1. Cancer prevention: Broccoli shares these cancer fighting, immune boosting properties with other cruciferous vegetables such as cauliflower, Brussels sprouts and cabbage.
2. Cholesterol reduction: Like many whole foods, broccoli is packed with soluble fiber that draws cholesterol out of your body.
3. Reducing allergic reaction and inflammation: Research has shown the ability of kaempferol to lessen the impact of allergy-related substances on our body. Broccoli even has significant amounts of ω-3 fatty acids, which are well known as an anti-inflammatory.
4. Powerful antioxidant: Of all the cruciferous vegetables, broccoli stands out as the most concentrated source of vitamin C, plus the flavonoids necessary for vitamin C to recycle effectively. Also concentrated in broccoli are the carotenoids lutein, zeaxanthin and β-carotene, other powerful antioxidants.
5. Bone health: Broccoli contains high levels of both calcium and vitamin K, both of which are important for bone health and prevention of osteoporosis.
6. Heart health: The anti-inflammatory properties of sulforaphane, one of the isothiocyanates (ITCs) in broccoli, may be able to prevent (or even reverse) some of the damage to blood vessel linings that can be caused by inflammation due to chronic blood sugar problems.
7. Diet aid: Broccoli is a good carb and is high in fiber, which aids in digestion, prevents constipation, maintains low blood sugar, and curbs overeating. Broccoli is an edible green plant in the cabbage family whose large, flowering head is eaten as a vegetable. The word broccoli comes from the Italian plural of broccolo, which means "the flowering crest of a cabbage", and is the diminutive form of brocco, meaning "small nail" or "sprout". Broccoli is often boiled or steamed but

may be eaten raw. Broccoli is classified in the Italica cultivar group of the species *Brassica oleracea*.

Broccoli has large flower heads, usually green in color, arranged in a tree-like structure branching out from a thick, edible stalk. The mass of flower heads is surrounded by leaves. Broccoli resembles cauliflower, which is a different cultivar group of the same species.

Furthermore, a cup of broccoli has as much protein as a cup of rice or corn with half the calories.
Broccoli can provide you with some special cholesterol-lowering benefits if you will cook it by steaming. The fiber-related components in broccoli do a better job of binding together with bile acids in your digestive tract when they've been steamed. When this binding process takes place, it's easier for bile acids to be excreted, and the result is a lowering of your cholesterol levels. Raw broccoli still has cholesterol-lowering ability—just not as much.

- Broccoli has a strong, positive impact on our body's detoxification system, and researchers have recently identified one of the key reasons for this detox benefit. Glucoraphanin, gluconasturtiian and glucobrassicin are 3 glucosinolate phytonutrients found in a special combination in broccoli. This dynamic trio is able to support all steps in body's detox process, including activation, neutralization, and elimination of unwanted contaminants. Isothiocyanates (ITCs) are the detox-regulating molecules made from broccoli's glucosinolates, and they help control the detox process at a genetic level.
- Broccoli may help us solve our vitamin D deficiency epidemic. When large supplemental doses of vitamin D are needed to offset deficiency, ample supplies of vitamin K and vitamin A help keep our vitamin D metabolism in balance. Broccoli has an unusually strong combination of both vitamin A (in the form of β-carotene) and vitamin K. For people faced with the need to rebuild vitamin D stores through vitamin D supplements, broccoli may be an ideal food to include in the diet.
- Broccoli is a particularly rich source of a flavonoid called kaempferol. Recent research has shown the ability of kaempferol to lessen the impact of allergy-related substances on our body. This kaempferol connection helps to explain the unique anti-inflammatory benefits of broccoli, and it should also open the door to future research on the benefits of broccoli for a hypoallergenic diet.[8]

World's Healthiest Foods Recommendations

Studies have shown that even kids like broccoli and one way to ensure that they enjoy it is to cook it properly by using our Healthy Steaming method. Overcooked broccoli becomes soft and mushy, an indication that it has lost both nutrients and flavor. Begin by cutting broccoli florets into quarters and let sit for several minutes before cooking to enhance its health-promoting benefits. Steam for 5 minutes. You'll want to include broccoli as one of the cruciferous vegetables you eat on a regular basis if you want to receive the fantastic health benefits provided by the cruciferous vegetable family. At a minimum, include cruciferous vegetables as part of your diet 2-3 times per week, and make the serving size at least 1-1/2 cups. Even better from a health standpoint, enjoy broccoli and other vegetables from the cruciferous vegetable group 4-5 times per week, and increase your serving size to 2 cups.

This chart graphically details the %DV that a serving of Broccoli provides for each of the nutrients of which it is a good, very good, or excellent source according to our Food Rating System. Additional information about the amount of these nutrients provided by Broccoli can be found in the Food Rating System Chart. A link that takes you to the In-Depth Nutritional Profile for Broccoli, featuring information over 80 nutrients, can be found under the Food Rating System Chart.

Health Benefits

It's no coincidence that more than 300 research studies on broccoli have converged in one unique area of health science—the development of cancer—and its relationship to three metabolic problems in the body. Those three problems are (1) chronic inflammation (2) oxidative stress and (3) inadequate detoxification. While these types of problems have yet to become part of the public health spotlight, they are essential to understanding broccoli's unique health benefits. Over the past 5 years, research has made it clear that our risk of cancer in several different organ systems is related to the combination of these three problems.[9]

Nutrient	Amount	%	Nutrient Density	Ratings	**Nutrient**	Amount	%	Nutrient Density	Ratings
vitamin K	220.12 µg	245	80.6	excellent	vitamin A	120.74 µg	13	4.4	very good
vitamin C	101.24 mg	135	44.5	excellent	potassium	457.08 mg	13	4.3	very good
chromium	18.55 µg	53	17.5	excellent	copper	0.10 mg	11	3.7	very good
folate	168.48 µg	42	13.9	excellent	vitamin B	0.10 mg	18	2.7	good
fiber	5.15 g	21	6.8	very good	ω-3 fats	0.19 g	8	2.6	good
pantothenic acid	0.96 mg	19	6.3	very good	magnesium	32.76 mg	8	2.7	good
vitamin B6	0.31 mg	18	18	6.0	protein	3.71 g	7	2.4	good
vitamin E	2.26 mg	15	15	5.0	zinc	0.70 mg	6	2.1	good
phosphorus	104.52 mg	15	4.9	very good	iron	1.05 mg	6	1.9	good
manganese	0.30 mg	15	4.9	very good	calcium	62.40 mg	6	2.1	good
choline	62.56 mg	15	4.9	very good	selenium	2.50 µg	5	1.5	good
vitamin B2	0.19 mg	15	4.8	very good	vitamin B3	0.86 mg	5	1.8	good

Table-1: Powerhouse of nutrition in broccoli

The Cancer/Inflammation/Oxidative Stress/ Detox Connection: Exposure to potentially toxic substances in our food and water, or in the air we breathe both indoors and outdoors, exposure to allergy-triggering substances, poor general health, dietary deficiencies, use of prescription and over-the-counter medications, and other lifestyle practices can result in a level of danger to our bodies that prompts our inflammatory system to work in overdrive on a 24/7 basis. Researchers often refer to this phenomenon as "chronic inflammation." Often contributing to this level of danger is weakened detox ability in our body. If our liver, skin, and other organ systems cannot keep up with and detoxify the number of potential toxins that we encounter, too many potential toxins remain at large throughout our body. Once again, the result is a level of risk that prompts chronic inflammation.

On a more temporary, short-term basis, inflammation is part of good health. Whether physical or chemical in nature, whenever our body detects a wound, it typically responds by trying to heal with an inflammatory response. That process is healthy, so long as it is not constant and uninterrupted. But unlike the helpful inflammation that takes place we get a simple cut or bruise, chronic inflammation—when it becomes a standard feature of our metabolism—is incompatible with good health. When our bodies are overwhelmed day in and day out with chronic inflammation, many other metabolic balances can get thrown out of kilter, including the balance in our oxygen metabolism. An unwanted imbalance starts to occur in which too many overly reactive, oxygen-containing molecules are formed. This condition is called oxidative stress. The increased presence of these overly reactive molecules can do damage to many parts of our cells, including their genetic material (and especially their deoxyribonucleic acid, or DNA). Over time, the constant and cumulative DNA damage inside our cells can pose a major risk factor for conversion of healthy cells into cancerous ones.

It's equally possible for this sequence of events to start not with chronic, excessive inflammation, but with chronic oxidative stress. Over time, when overly reactive oxygen-containing molecules cause damage to DNA and other cell structures, our body reads this situation as being highly dangerous and it initiates an inflammatory response to try and reduce the threat posed by the oxidative stress. In either case, we end up with a combination of inadequate detoxification of toxic substances, chronic inflammation and oxidative stress that puts us at greater risk for developing cancer.

In a way that might be unique among foods, the nutrients found in broccoli are able to change this set of connections between inflammation, oxidative stress, detox and cancer. In fact, it would be fair to describe broccoli as containing anti-inflammatory nutrients, antioxidant nutrients, detox-support nutrients, and anti-cancer nutrients as well!

Broccoli's Anti-Inflammatory Benefits: When threatened with dangerous levels of potential toxins, or dangerous numbers of overly-reactive, oxygen-containing molecules, signals are sent within our body to our inflammatory system, directing it to "kick in" and help protect our body from potential damage. One key signaling device is a molecule called Nf-κB. When faced with the type of dangers described above, the NF-B signaling system is used to "rev up" our inflammatory response and increase production of inflammatory components (for example, IL-6, IL-1β, TNF-α, iNOS and COX-2). This process works beautifully in temporary, short-term circumstances when healing from injury is required. When it continues indefinitely at a constant pace, however, it can put us at risk for serious health problems, including the development of cancer.[10]

Research studies have made it clear that the NF-κB signaling system that is used to "rev up" our inflammatory response can be significantly suppressed by isothiocyanates (ITCs). ITCs—the compounds made from glucosinolates found in broccoli and other cruciferous vegetables—actually help to shut down the genetic machinery used to produce NF-κB and other components of the inflammatory system. These anti-inflammatory benefits of ITCs have been demonstrated in the laboratory, and with consumption of the ITCs themselves. While they have yet to be demonstrated on consumption of broccoli in an everyday diet, we fully expect future research to show anti-inflammatory benefits from the routine consumption of broccoli (and its glucosinolates), not just from consumption of ITCs.

Lack of ω-3 fat is dietary problem that can cause over-activation of the inflammatory system. The reason is simple: many key anti-inflammatory messaging molecules (like PGH3, TXA3, PGI3, and LTE5) are made from ω-3 fats. We are not accustomed to thinking about non-fatty vegetables as sources of ω-3 fats, but we need to change our thinking in this area. While it is true that there are limited amounts of ω-3s in vegetables like broccoli, it is equally true that their levels of ω-3s can still play an important role in balancing our inflammatory system activity. In 100 calories' worth of broccoli (about 2 cups) there are approximately 400 milligrams of ω-3s (in the form of α-linolenic acid, or ALA). That amount of ALA falls into the same general ballpark as the amount provided by one soft gel capsule of flax oil. While we would not want to depend on broccoli as our sole source of dietary ω-3s, we still get important anti-inflammatory benefits from the ω-3s it provides.

As mentioned earlier in this section, chronic inflammation can sometimes get triggered by overexposure to allergy-related substances. In this context, broccoli has yet another anti-inflammatory trick up its sleeve, because it is a rich source of one particular phytonutrient (a flavonol) called kaempferol. Especially inside of our digestive tract, kaempferol has the ability to lessen the impact of allergy-related substances (by lowering the immune system's production of IgE-antibodies). By lessening the impact of allergy-related substances, the kaempferol in broccoli can help lower our risk of chronic inflammation.

Broccoli's Antioxidant Benefits: Amongst all of the commonly consumed cruciferous vegetables, broccoli stands out as the most concentrated source of a premiere antioxidant nutrient—vitamin C. This central antioxidant vitamin can provide longer-term support of oxygen metabolism in the body if it is accompanied by flavonoids that allow it to recycle. Broccoli provides many such flavonoids in significant amounts, including the flavonoids kaempferol and quercitin. Also concentrated in broccoli are the carotenoids lutein, zeaxanthin, and beta-carotene. All three of these carotenoids function as key antioxidants. In the case of lutein and β-carotene, broccoli has been shown not only to provide significant amounts of these antioxidants but to significantly increase their blood levels when consumed in the amount of three cups. Other antioxidants provided by broccoli in beneficial amounts include vitamin E and the minerals manganese and zinc.

Considered as a group, the vitamins, minerals, flavonoids and carotenoids contained in broccoli work to lower risk of oxidative stress in the body. The ability of these nutrients to support oxygen metabolism and avoid excess formation of overly reactive, oxygen-containing molecules makes them equally helpful in lowering risk of chronic inflammation and risk of cancer. If cancer development is compared to a 3-legged stool, the antioxidant benefits of broccoli can be viewed as weakening one leg of the stool, namely the leg called "oxidative stress." We've already seen how the glucosinolates and ω-3 fats in broccoli can be viewed as helping to weaken a second leg of the stool (chronic inflammation). In the next section, we'll look at a third leg of the stool (inadequate detoxification) and see how the nutrients found in broccoli can serve to weaken this leg as well.[11]

Broccoli Can Enhance Detoxification: Most toxins that pose a risk to our cells must be detoxified in our body by a 2-step process. What's remarkable about broccoli is its ability to alter activity in both of these two detox steps.

Isothiocyanates (ITCs) made from the glucosinolates in broccoli are well-documented modifiers of the first step in detoxification (called Phase I). In fact, some ITCs like sulforaphane can actually help shut down the genetic machinery that produces certain Phase I enzymes. ITCs are equally capable of altering the activity of enzymes involved in the second step of detoxification (called Phase II). From research in the field of genetics, we know that ITCs can help bridge gaps in Phase II activity when it is insufficient. Taken in combination, the impact of ITCs on Phase I and II detox events is unique—and equally unique is the presence of glucosinolate compounds in broccoli that can be used to make ITCs. Glucosinolates like glucoraphanin, gluconasturtiian, and glucobrassicin are simply not found in other foods in the same combination and concentration that is offered by broccoli. By helping to promote as well as regulate detox activity in our cells, the ITCs made from broccoli can help prevent insufficient detoxification of dangerous substances that threaten our cells.

Broccoli and Cancer Prevention: The unique combination of antioxidant, anti-inflammatory, and pro-detoxification components in broccoli make it a unique food in terms of cancer prevention. Connections between cancer development and oxidative stress, chronic inflammation, and inadequate detoxification are so well-documented in the research that any food improving all three of these metabolic problems would be highly likely to lower our risk of cancer. In the case of broccoli, the research is strongest in showing decreased risk of prostate cancer, colon cancer, breast cancer, bladder cancer, and ovarian cancer. We expect that risk of other cancer types will also eventually be shown to undergo reduction from regular consumption of broccoli.

How Much Broccoli Is Needed for Cancer Prevention?

Recent studies have also provided us with a much better idea about the amount of broccoli that we need to lower our cancer risk. At the lower end of the spectrum, it looks like an average of 1/2 cup of broccoli per day—only 22 calories' worth of broccoli!—is enough to provide some measurable benefits. Few people have broccoli on a daily basis. But a 2-cup serving twice a week would still meet this minimum average amount. It's important to remember how little this amount actually in within the context of one week's food. A person eating 2,000 calories per day would be consuming 14,000 calories per week. A 2-cup serving of broccoli twice a week would provide about 178 calories—only 1% of the total weekly calories! At the higher end of the spectrum, studies show that more broccoli might be needed to accomplish other cancer-preventing tasks. For example, one study showed significantly higher urinary excretion of potential carcinogens from well-done, grilled meats given daily consumption of broccoli in the range of 9 ounces (250 grams) per day. That gram amount corresponds to approximately 1.6 cups of broccoli on a daily basis. We've also seen a study showing that "generous" amounts of broccoli can help optimize levels of antioxidants in the blood, especially beta-carotene and lutein. (Optimal antioxidant levels can help lower the risk of oxidative stress in healthy cells, which also helps lower their risk of becoming cancerous.) In this study, the term "generous" was used to describe consumption of broccoli in the amount of 3 cups daily. Once again, that amount would not be ridiculously high in terms of calories—3 cups would provide about 132 calories, or 6-7% of a 2,000-calorie diet. But it might be a greater amount that many people would want to consume on a regular basis.

For us, the bottom line here is not to treat broccoli like garnish. In recipes like our Asian-Flavored Broccoli with Tofu or 5-Minute Broccoli with Feta Cheese and Kalamata Olives recipes, we use 1 pound of broccoli to provide two servings. That's approximately 1.5 cups of broccoli per serving. There is no reason to shy away from 2-3 cup servings of broccoli when enjoying this cruciferous vegetable, especially if you want to optimize its cancer-preventing benefits. But make sure you're not simply "decorating" your plate with single broccoli stalk and floret.[12]

Broccoli and Digestive Support: The digestive support provided by broccoli falls into two basic categories: fiber support, and ITC (isothiocyanate) support. At approximately 1 gram of dietary fiber for every 10 calories, you don't have to eat much broccoli to get a large amount of your daily requirement! For 100 calories—only 5% of a 2,000-calorie diet—you get about 10 grams of fiber, or 40% of the Daily Value (DV). And, 250 calories of broccoli (about 12% of a 2,000-calorie diet) will give you the full daily requirement for this important nutrient! Few components of food support our digestive system as well as fiber. The speed that food travels through us, the consistency of food as it moves through our intestine, and bacterial populations in our intestine are all supported as well as regulated by dietary fiber.

Alongside of broccoli's dietary fibers are its glucosinolates. These phytonutrients are converted by our bodies into isothiocyanates (ITCs). ITCs—and particularly sulforaphane—help protect the health of our stomach lining by helping prevent bacterial overgrowth of Helicobacter pylori or too

much clinging by this bacterium to our stomach wall. Broccoli sprouts appear to have especially strong stomach support properties in this regard.

Broccoli and Cardiovascular Support: Although research in this area is still in the early stages, anti-inflammatory substances found in cruciferous vegetables are becoming the topic of increasing interest with respect to heart disease. One particular focus here involves the anti-inflammatory properties of sulforaphane, one of the isothiocyanates (ITCs) derived from the glucoraphanin in broccoli. In some individuals susceptible to high blood sugar, sulforaphane may be able to prevent (or even reverse) some of the damage to blood vessel linings that can be cause by chronic blood sugar problems. Decreased risk of heart attacks and strokes may also eventually be linked in a statistically significant way to intake of broccoli and its glucoraphanin.

A second area you can count on broccoli for cardiovascular support involves its cholesterol-lowering ability. Our liver uses cholesterol as a basic building block to product bile acids. Bile acids are specialized molecules that aid in the digestion and absorption of fat through a process called emulsification. These molecules are typically stored in fluid form in our gall bladder, and when we eat a fat-containing meal, they get released into the intestine where they help ready the fat for interaction with enzymes and eventual absorption up into the body. When we eat broccoli, fiber-related nutrients in this cruciferous vegetable bind together with some of the bile acids in the intestine in such a way that they simply stay inside the intestine and pass out of our body in a bowel movement, rather than getting absorbed along with the fat they have emulsified. When this happens, our liver needs to replace the lost bile acids by drawing upon our existing supply of cholesterol, and as a result, our cholesterol level drops down. Broccoli provides us with this cholesterol-lowering benefit whether it is raw or cooked. However, a recent study has shown that the cholesterol-lowering ability of raw broccoli improves significantly when it is steamed. In fact, when the cholesterol-lowering ability of steamed broccoli was compared with the cholesterol-lowering ability of the prescription drug cholestyramine (a medication that is taken for the purpose of lowering cholesterol), broccoli bound 33% as many bile acids (based on a standard of comparison involving total dietary fiber).[13]

The B-complex vitamins in broccoli can also make a major contribution to our cardiovascular health. Especially with respect to excessive formation of homocysteine—an event which raises our risk of atherosclerosis, stroke, and heart attack—B-complex vitamin deficiency intake can pose a major risk. Three B vitamins especially important for lowering our risk of hyperhomocysteinemia (excessive formation of homocysteine) are vitamin B6, vitamin B12, and folate. By making an important contribution to our B6 and folate intake, broccoli can help us lower our risk of excessive homocysteine formation and cardiovascular problems that are related to excess homocysteine.

World's Healthiest Foods Rating	Rule
Excellent	DRI/DV>=75% OR Density>=7.6 AND DRI/DV>=10%
very good	DRI/DV>=50% OR Density>=3.4 AND DRI/DV>=5%
Good	DRI/DV>=25% OR Density>=1.5 AND DRI/DV>=2.5%

Dietary Reference Intake/Daily Value, In-Depth Nutritional Profile for Broccoli

Table-2: DRI/DV of broccoli

Other Health Benefits Provided by Broccoli: Three other areas of health benefits are important to mention when considering broccoli and its unique combination of nutrients. The first area is eye health. Two carotenoids found in significant concentrations in broccoli—lutein and zeaxanthin—play an especially important role in the health of the eye. In fact, no tissue in the body is more concentrated with lutein than the area in the outer portion of the retina (called the peripheral retina). Similarly, in the macula near the central portion of the retina, zeaxanthin is uniquely concentrated. Risk of problems involving the macula of the eye (for example, macular degeneration) and problems involving the lens area of the eye (for example, cataracts) have both been show to lessen with intake of foods (including broccoli) that provide significant amounts of the lutein and zeaxanthin carotenonids. A second area is skin support, including support of sun-damaged skin. Here it is the glucoraphanin found in broccoli—converted into sulforaphane by the body—that has received the most research attention. Since skin cells can carry out the process of detoxification, it may be detox-related benefits of sulforaphane that are especially important in helping to counteract sun damage.[14] A third area of increasing research interest involves the metabolism of vitamin D. Broccoli is not a source of this vitamin, but it is an excellent source of

vitamin K and also of vitamin A (in one of its precursor forms, β-carotene). Many individuals have large vitamin D deficiencies that cannot be remedied through diet alone, and these deficiencies require sizable amounts of vitamin D to be provided through dietary supplementation. When large supplemental doses of vitamin D are needed to offset deficiency, ample supplies of vitamin K and vitamin A appear to help keep our vitamin D metabolism in the proper balance. Assuring adequate intake of vitamins K and A alongside of vitamin D supplementation may turn out to be important in achieving optimal vitamin D supplementation results and avoiding potential problems related to supplementation. Broccoli may turn out to play a particularly helpful role in balancing this set of events by providing its unusually strong combination of both vitamin A and vitamin K.

Description: Broccoli is a member of the cabbage family, and is closely related to cauliflower. Its cultivation originated in Italy. *Broccolo*, its Italian name, means "cabbage sprout." Broccoli's name is derived from the Latin word brachium, which means branch or arm, a reflection of its tree-like shape that features a compact head of florets attached by small stems to a larger stalk. Because of its different components, this vegetable provides a complex of tastes and textures, ranging from soft and flowery (the florets) to fibrous and crunchy (the stem and stalk). Its color can range from deep sage to dark green to purplish-green, depending upon the variety. One of the most popular types of broccoli sold in North America is known as Italian green, or Calabrese, named after the Italian province of Calabria where it first grew. Other vegetables related to broccoli are broccolini, a mix between broccoli and *gai-lin* (Chinese broccoli), and broccoflower, a cross between broccoli and cauliflower. Broccoli sprouts have also recently become popular as a result of research uncovering their high concentration of the anti-cancer phytonutrient, sulforaphane.

How to Select and Store: Choose broccoli with floret clusters that are compact and not bruised. They should be uniformly colored, either dark green, sage or purple-green, depending upon variety, and with no yellowing. In addition, they should not have any yellow flowers blossoming through, as this is a sign of over maturity. The stalk and stems should be firm with no slimy spots appearing either there or on the florets. If leaves are attached, they should be vibrant in color and not wilted. Place broccoli in a plastic bag, removing as much of the air from the bag as possible. Store in the refrigerator where it will keep for 10 days. Do not wash broccoli before storing because exposure to water encourages spoilage. Partial heads of broccoli should be placed in a well-sealed container or plastic bag and refrigerated. Since the vitamin C content starts to quickly degrade once broccoli has been cut, it is best to use it within a couple of days. Broccoli that has been blanched and then frozen can stay up to a year. Leftover cooked broccoli should be placed in tightly covered container and stored in the refrigerator where it will keep for a few days.

Tips for Preparing and Cooking

Rinse broccoli under cold running water. Cut florets into quarters for quick and even cooking. Be sure to enjoy the stems and leaves of broccoli; they provide a good balance of flavors. Peel the broccoli stem and cut the stem into 1/2" slices To get unique health benefits from broccoli, let it sit for several minutes before cooking.[15]

The Healthiest Way of Cooking Broccoli

If you're cooking broccoli, make sure to support your nourishment by sticking with a low cooking temperature in a range that includes the steaming temperature of 212°F (100°C), with a cooking times of 5 minutes at the most. Since the fibrous stems take longer to cook, they can be prepared separately for a few minutes before adding the florets. For quicker cooking, make lengthwise slits in the stems. While people do not generally eat the leaves, they are perfectly edible and contain concentrated amounts of nutrients. We recommend Healthy Steaming broccoli for maximum nutrition and flavor. Fill the bottom of a steamer pot with 2 inches of water. While waiting for the water to come to a rapid boil prepare broccoli florets and stems. Steam stems for 2 minutes before adding the florets and leaves. Steam for 5 more minutes. Toss with our Mediterranean Dressing and top with your favorite optional ingredients.

Healthy Steaming versus Microwaving Broccoli

The principle of a 212°F (100°C) or lower cooking temperature leaves you with several cooking options for your broccoli. Our cooking method of choice for this cruciferous vegetable is steaming. We've seen studies on flavonoids in broccoli, B complex vitamins in broccoli, vitamin C in broccoli, as well as carotenoids and chlorophyll and glucosinolates in broccoli, and in all cases, steaming has been shown to do a better job of preserving nutrients than other cooking methods. You'll find some websites encouraging you to microwave your vegetables, including broccoli. We don't believe that this recommendation is supported by the research. But in addition, we believe that it's important for you to understand why. Many nutrients can be lost from food when the food surface comes into direct contact with water. Hotter

water temperatures leech more nutrients from food, as will longer cooking times. Most research on microwaved broccoli has involved the placement of broccoli in a microwave container that has been partially or completely filled with water. That practice means direct water contact with all or part of the broccoli surfaces. Steaming, by comparison, leaves the broccoli in contact with steam only and can reduce nutrient loss for this reason. It's possible to steam broccoli in a microwave, but since metal containers (like stainless steel) cannot be used in a microwave oven, plastic microwave steamers are the only widely available option here, and we generally try to avoid the heating of foods in plastic in the microwave due to risk of plastic migration into the food. All of the factors described above makes it difficult to microwave broccoli with as little direct water contact or as shortened cooking times as steaming. We also like the more uniform exposure to heat that occurs with steaming.[16]

Stir-Frying Broccoli

In general, we try to avoid the stir-frying of foods in oil due to risk of nutrient damage in the oil from high heat. That being said, we have seen a study of broccoli stir-frying that produced some fairly encouraging results with respect to nutrient retention in the broccoli. (The study did not measure nutrient damage in the oil.) The stir-frying took place for 3-1/2 minutes in a frying pan heated to 248°-284°F (120°-140°C). Approximately two-thirds or more of the nutrients examined (including vitamins, minerals, phenols, and glucosinolates) were retained after stir-frying. Given these results, if you are planning to stir-fry your broccoli, we'd recommend a lower-heat skillet (at approximately 250°F/121°C) and a relatively short stir-frying time of about 3 minutes or less.

Raw Broccoli and Broccoli Sprouts

Both cooked and raw broccoli can make excellent additions to your meal plan. If you enjoy raw broccoli, by all means include it in your diet! There may be some special advantages for your digestive tract when broccoli is eaten in uncooked form. And if you're concerned about issues involving enzymes and sulfur compounds in broccoli—don't be! With fresh raw broccoli, simple slicing a few minutes prior to eating or thorough chewing of unsliced pieces will help activate sulfur-metabolizing enzymes. Another form of broccoli you may also want to try in you enjoy raw broccoli is broccoli sprouts. Some of the nutrients found in broccoli—like vitamin C—are especially concentrated in broccoli sprouts. Remember that all raw broccoli requires more thorough chewing than cooked broccoli, so take your time enjoying the textures and flavors of this amazing vegetable.[17]

Nutrient and Health Benefits of Raw Broccoli:

We've been especially impressed in the most recent research by the impact of uncooked broccoli—as well as uncooked broccoli sprouts—on the health of the stomach and stomach lining. Many stomach problems have been linked in research studies with overgrowth of a bacterium called *Helicobacter pylori* and also with excessive attachment of this bacterium to the inner stomach lining. Raw broccoli sprouts appear to provide special stomach support with respect to these unwanted overgrowth and over-attachment circumstances. It's not that steamed broccoli provides no support in this regard, because it does provide support. It's just that uncooked broccoli and broccoli sprouts may be especially helpful in providing these benefits. We've seen several research studies using what's called "HG broccoli," or high glucosinolate broccoli, to investigate genetic activities in the stomach lining cells. The glucosinolates in broccoli are clearly a key part of broccoli's ability to support stomach health, and they are very likely to alter gene expression in cells that provide the stomach with its inner lining. HG broccoli is not a commercially marketed form of broccoli that you can find in the grocery store, but ordinary broccoli will still provide you with plenty of glucosinolate phytonutrients.

Individual Concerns

Broccoli as a "Goitrogenic" Food

Broccoli is sometimes referred to as a "goitrogenic" food. Yet, contrary to popular belief, according to the latest studies, foods themselves—broccoli included—are not "goitrogenic" in the sense of causing goiter whenever they are consumed, or even when they are consumed in excess. In fact, most foods that are commonly called "goitrogenic"—such as the cruciferous vegetables (including broccoli, kale, and cauliflower) and soyfoods—do not interfere with thyroid function in healthy persons even when they are consumed on a daily basis. Nor is it scientifically correct to say that foods "contain goitrogens," at least not if you are thinking about goitrogens as a category of substances like proteins, carbohydrates, or vitamins. With respect to the health of our thyroid gland, all that can be contained in a food are nutrients that provide us with a variety of health benefits but which, under certain circumstances, can also interfere with thyroid function. The term "goitrogenic food" makes it sound as if something is wrong with the food, but that is simply not the case. What causes problems for certain individuals is not the food itself but the mismatched nature of certain substances within the food to their unique health circumstances. For more, see an An Up-to-Date Look at Goitrogenic Substances in Food.

Nutritional Profile: Broccoli is an excellent source of vitamin K, vitamin C, chromium and folate. It is a very good source of dietary fiber, pantothenic acid, vitamin B6, vitamin E, manganese, phosphorus, choline, vitamin B1, vitamin A (in the form of carotenoids), potassium and copper. Broccoli is also a good source of vitamin B1, magnesium, ω-3 fatty acids, protein, zinc, calcium, iron, niacin, and selenium. Broccoli is also concentrated in phytonutrients. In one particular phytonutrient category—glucosinolates—broccoli is simply outstanding. The isothiocyanates (ITCs) made from broccoli's glucosinolates are the key to broccoli's cancer-preventive benefits.[18]

CONCLUSION

In addition to the nutrients highlighted in ratings chart, an in-depth nutritional profile for Broccoli is also available. This profile includes information on a full array of nutrients, including carbohydrates, sugar, soluble and insoluble fiber, sodium, vitamins, minerals, fatty acids, amino acids and more. In order to better help you identify foods that feature a high concentration of nutrients for the calories they contain, we created a Food Rating System. This system allows us to highlight the foods that are especially rich in particular nutrients. The following chart shows the nutrients for which this food is either an excellent, very good, or good source (below the chart you will find a table that explains these qualifications). If a nutrient is not listed in the chart, it does not necessarily mean that the food doesn't contain it. It simply means that the nutrient is not provided in a sufficient amount or concentration to meet our rating criteria. (To view this food's in-depth nutritional profile that includes values for dozens of nutrients - not just the ones rated as excellent, very good, or good - please use the link below the chart.) To read this chart accurately, you'll need to glance up in the top left corner where you will find the name of the food and the serving size we used to calculate the food's nutrient composition. This serving size will tell you how much of the food you need to eat to obtain the amount of nutrients found in the chart. Now, returning to the chart itself, you can look next to the nutrient name in order to find the nutrient amount it offers, the percent Daily Value (DV%) that this amount represents, the nutrient density that we calculated for this food and nutrient, and the rating we established in our rating system. For most of our nutrient ratings, we adopted the government standards for food labeling that are found in the U.S. Food and Drug Administration's "Reference Values for Nutrition Labeling."Read more background information and details of our rating system.

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