

# Technical Support Materials for Pureland Greenhouse Microgreens Production

Feb 05, 2020

## **Summary**

**Pureland Greenhouse** uses organic seeds only based on the research results of several research papers below. Under sufficient light exposure and in a clean environment, very healthy and fresh radish and broccoli microgreens are grown. No pesticides are needed, so there are no contaminants in the roots or the microgreens.

## **Business philosophy**

From the following papers, we reach these conclusions:

- 1) Broccoli microgreens, Chinese rose radish and Daikon radish microgreens are rich in vitamin C, beta carotene, anthocyanins, sulforaphane and polyphenols. Among all of them, radish microgreens have more of these nutrients.
- 2) The use of organic seeds in Pureland Greenhouse is for avoiding pesticide residues. Pureland Greenhouse grows microgreens in a very clean environment without the use of soil and cleaning chemicals, so there are no pesticides or harmful bacteria on the microgreens, making them safe to consume raw.
- 3) Pureland Greenhouse seed selection is determined from the comprehensive considerations of seed availability, nutrient content, taste and price.
- 4) The microgreens at Pureland Greenhouse are grown under specially optimized lighting spectrums, which enhance their growth, producing darker green leaves which contain higher nutrients. These microgreens can contain 20 to 50 times the nutritional content of mature plants, which results in a cost-effective and highly efficient way to attain such vital nutrients.
- 5) Nutrients from the microgreens have a wide range of positive health effects. They contain several cancer fighting and cancer prevention properties, can improve and reverse the state of cardiovascular disease and diabetes 2, alleviate aging diseases in the nervous system, strengthen the immune system, detoxify the body, and more.
- 6) Environmental benefit consideration: Pureland Greenhouse selects locations in city centres without utilizing agriculture land to produce high quality fresh vegetables for local customers come to pick up so as to minimize transportation costs and thereby reduce air-pollution. Also, customers are encouraged to return and reuse containers to avoid plastic waste and unnecessary recycling costs.
- 7) Social benefit consideration: Pureland Greenhouse situates in cities close to where its consumers live, thereby building friendly and healthy social interactions, social networking, neighbourhood food security and a sustainable local economy.

## **References for Pureland Greenhouse**

1. Key point: **anti-cancer, anti-carcinogens**

July 3, 1997 – Johns Hopkins University: Broccoli sprouts: An exceptionally rich source of inducers of enzymes that protect against chemical carcinogens <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC23369/>

- 1) Certain cruciferous vegetables (including green broccoli and white broccoli) contain 3-day-old sprouts containing glucose urea (glucosinolates of sulforaphane) that are 10 to 100 times higher than corresponding mature plants.
- 2) A small number of cruciferous sprouts can effectively prevent the risk of cancer and is as effective as a large number of mature vegetables of the same variety.
- 3) Isothiocyanate sulforaphane was identified as the main and very effective phase 2 enzyme inducer as a chemical protectant, and emphasized the long-established chemical protection characteristics of these compounds. Sulforaphane also has tumor blocking activity. The retardation of tumor development by isothiocyanate was clearly dose-dependent, and 25 mmol of glucosinolate began to take effect.

2. Key point: **anti-cancer, anti-carcinogens**

December, 2014: Published by Texas Tech University Health Science Center - \* Phenethyl Isothiocyanate: A comprehensive review of anti-cancer mechanisms (It's a thorough article of how it is anti-cancer.) [www.ncbi.nlm.nih.gov/pmc/articles/PMC4260992/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4260992/)

- 1) Epidemiological evidence for chemo-preventive effects of dietary intake of cruciferous vegetables.
- 2) Several researchers have demonstrated the anticancer properties of isothiocyanates in various cancer types. Two primary mechanisms that have been identified are cell cycle arrest and induction of apoptosis.
- 3) Phenyl isothiocyanate -mediated generation of reactive oxygen species is known to be a general mechanism of action leading to cytotoxic effects, especially specific to cancer cells. It demonstrates anti-inflammatory effect as one of the anticancer effects and immunomodulatory activities.
- 4) In normal cells, ROS production causes DNA damage that drives cells toward apoptosis. Conversely, in cancer cells, ROS promotes cell survival by inducing several survival pathways responsible for cell proliferation, apoptosis suppression, cell migration and invasion, as well as suppression of the immune system. Cancer cells generate higher ROS levels due to increased oxidative metabolism and shortage of nutrient supply. However, increasingly high ROS levels can be toxic to cancer cells and can induce cell death.

3. Key points: interventions for **prostate cancer and breast cancer**

October 30, 2008: Department of Urology, Stanford University, California - Temporal changes in gene expression induced by sulforaphane in human prostate cancer cells

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2612096/pdf/nihms-75465.pdf>

- 1) Consumption of cruciferous vegetables has been associated with a significantly decreased risk of several malignancies, including prostate cancer, and this reduction has been attributed to the isothiocyanate sulforaphane.
- 2) Sulforaphane produced a distinct, robust change ( $\geq 2$ -fold) in transcript levels for many genes that began within 4 hours of treatment and persisted for at least 24 hours.
- 3) Increasing concentration of sulforaphane was associated with decreased cell number. We observed no increase in the number of apoptotic cells until sulforaphane concentrations in the media exceeded 25  $\mu$ M, implying that the decrease in cell number was due to growth inhibition.
- 4) In prostate cells sulforaphane primarily induces cellular defenses and inhibits cell growth by causing G2/M phase arrest. Furthermore, based on the striking similarities in the gene expression patterns induced across experiments in these cells, sulforaphane appears to be the primary bioactive compound present in broccoli sprouts, suggesting that broccoli sprouts can serve as a suitable source for sulforaphane in intervention trials.

4. Key points: Sulforaphane **helps prostate cancer recurrence** after radical prostatectomy

May 12, 2015: Department of Urology, Institute of Technology, Cedex University of Technology, France -Effect of Sulforaphane in Men with Biochemical Recurrence after Radical Prostatectomy

<https://cancerpreventionresearch.aacrjournals.org/content/canprevres/8/8/712.full.pdf>

The PSA response in non-prostatectomized patients on active surveillance could therefore be related to the demonstrated anti-inflammatory and antioxidant effects of sulphoraphane, pomegranate, turmeric, and green tea. The effectiveness of a biostable sulphoraphane for decreasing the rate of PSA progression in men with prostate cancer and biochemical recurrence after definitive radical prostatectomy appears promising. The compliance and tolerance were very good.

5. Key points: **broccoli sprouts inhibit bladder cancer**

March 2008: Johns Hopkins University - Broccoli Sprouts Inhibition of Urinary Bladder Carcinogenesis by Broccoli Sprouts <https://cancerres.aacrjournals.org/content/68/5/1593.short>

- 1) Lack of glutathione S-transferase (GST) or NAD (P) H: quinone oxidoreductase increases the risk of bladder cancer in humans. These two enzymes are cytoprotective agents that prevent carcinogens and oxidants.
- 2) Sulforaphane (isothiocyanate) is a well-known cancer preventive agent that can transform the nutrients in broccoli sprouts into these two enzymes. Broccoli sprouts are a rich source of several sulforaphane. Cauliflower sprout extract is a very promising substance for the prevention of bladder cancer. The sulforaphane in the extract is selectively transferred to the bladder epithelium through urine excretion.
- 3) The incidence, diversity, size, and progression of all bladder cancers are inhibited by these extracts, and these extracts themselves do not cause changes in bladder tissue.

4) We found that > 70% of sulforaphane in the extract was excreted into the urine within 24 hours. This indicates a high level of bioavailability and a rapid urination process. The concentration of sulforaphane in the urine of test rats was 2 to 3 orders of magnitude higher than that in plasma and liver, indicating that the main site of bladder epithelial cell bladder cancer development is the part most exposed to sulforaphane.

5) Broccoli sprouts extract is a very promising substance for the prevention and prevention of bladder cancer. Sulforaphane extract in dietary broccoli sprouts is a very effective substance in inhibiting bladder cancer in rats. Epidemiological studies have shown that dietary sulforaphane and cruciferous vegetable intakes have opposite risks to human bladder cancer.

#### 6. Key points: **reversing cardiovascular disease**

2003 : University of Saskatchewan - Dietary approach to attenuate oxidative stress, hypertension, and inflammation in the cardiovascular system [www.ncbi.nlm.nih.gov/pmc/articles/PMC406471/pdf/1017094.pdf](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC406471/pdf/1017094.pdf)

1) Our results show that broccoli sprouts are high in sugar urea and its metabolite sulforaphane is an effective phase 2 protein inducer, which can reduce oxidative decline, cardiovascular system and kidney inflammation, and promote cardiovascular Function similar to long-term edible pharmacological antioxidants.

2) Test rats were fed 200 mg / day of broccoli dried sprouts 5 days a week for 14 consecutive weeks, which contained glucosinithiocyanate, which was converted into the phase 2 protein inducer sulforaphane, which was found in cardiovascular and kidney The oxidative decay in the tissues was significantly reduced, and the vascular endothelium-dependent aortic relaxation was better, and blood pressure was significantly reduced (20 mm Hg).

3) The improvement of cardiovascular function by sulforaphane is similar to that seen with long-term pharmacological antioxidants. In this study, two doses were examined, each rat corresponding to 0.5 and 5.5 mol sulforaphane daily. It only affects oxidative stress parameters and blood pressure at high doses, and has some positive effects on endothelial function at low doses. Ingestion of glucosinolate glucosinithiocyanate may have a more profound effect.

4) In 1995, the direct cost of hypertension to the U.S. health care system was nearly \$ 20 billion. Our results suggest that even modest dietary changes can have a significant impact on health and significantly reduce medical costs.

#### 7. Key points: **Daikon radish microgreens high nutrient density**, light is very important for the nutritional content in microgreens

July 18, 2012: University of Maryland, etc . - Assessment of Vitamin and Carotenoid Concentrations of Emerging Food Products: Edible Microgreens <https://www.researchgate.net/publication/267354000>

This study did not include broccoli microgreens, including a detailed study of water-cultivated Chinese rose carrot and Daikon radish microgreens. These data and conclusions serve as the scientific basis for Pureland Greenhouse's pure greenhouse cultivation.

1) Although small in size, Miao vegetable can provide surprisingly obvious taste, bright colors and crunchy texture, and can be used as edible decoration or new salad ingredients. Miao and sprouts are very different in taste, nutrition, and safety.

2) The concentrations of ascorbic acid (vitamin C), vitamin K1, carotenoids, sulforaphane and polyphenols in 25 commercially available microgreens were tested. The results showed that the content of vitamins and carotenoids provided by different microgreens varied greatly. The concentrations of ascorbic acid, carotenoids, sulforaphane and polyphenols in red cabbage, coriander, garnet and ivory turnip microgreens were highest.

3) Compared with the nutrient concentration in mature leaves (US Department of Agriculture National Nutrition Database), cotyledons of microgreens have higher nutrient density than stems and roots. These phytonutrient data can provide a scientific basis for assessing the nutritional value of microgreens, and can also be used as recommendations for health agencies and consumers' choice of fresh vegetables.

4) Vitamin K1 (benzoquinone) is used for blood coagulation, and it is the highest in the photosynthetic tissue of dark green vegetables.

5) Vitamin C (ascorbic acid) is an essential nutrient for the body and can be used as an antioxidant. Chinese rose radish has the second highest vitamin C content, and Daikon radish microgreens also have high vitamin C content.

Provitamin A ( $\beta$ -carotene) is an important fat-soluble antioxidant that can scavenge free radicals to protect cell membranes. Lutein and zeaxanthin are lutein carotenoids. Chinese rose radish microgreens and Daikon radish microgreens are considered excellent sources of these substances. These findings indicate that the green leaves of these microgreens have higher lutein / zeaxanthin concentrations than their fully grown plants and have very good anti-aging effects on vision.

7) Vitamin E, known as fat-soluble antioxidant, has extremely high levels of  $\alpha$ - and  $\gamma$ -vitamin E in Daikon radish microgreens.

8) It should also be noted that the concentration of vitamins and carotenoids processed by golden pea tendrils grown in the absence of light is much lower than that of pea tendrils grown in the light, which indicates that light has nutritional value during the growth of microgreens.

The data generated by this study may provide a scientific basis for evaluating vitamin and carotenoid concentrations in cotyledons of microgreens. Obviously, growth, harvest, and post-harvest processing conditions may have a considerable impact on the synthesis and degradation of phytonutrients, including vitamins and carotenoids, and other studies may be needed to evaluate the effects of these agricultural practices on phytonutrient retention influences.

Therefore, the pure ground greenhouse provides live raw microgreens without any treatment to customers to ensure the original ecology and no loss of nutrients.

8. Key points: **Fighting Helicobacter pylori and treating gastritis**

April 4, 2009: University of Tokyo, etc. - Broccoli sprouts rich in sulforaphane in the diet can reduce colonization and reduce gastritis in mice and humans infected with H. pylori

<https://cancerpreventionresearch.aacrjournals.org/content/2/4/353>

- 1) Sulforaphane has a strong bactericidal effect on Helicobacter pylori infection, and Helicobacter pylori infection is closely related to the global gastric cancer pandemic.
- 2) Forty-eight patients with Helicobacter pylori infection were randomly assigned to feed cauliflower sprouts (70 g / d; containing 420  $\mu\text{mol}$  of sulforaphane precursor) or to consume equal weight alfalfa sprouts (without sulforaphane) as placebo. Return to original level after 2 months of withdrawal. Daily intake of broccoli sprouts rich in sulforaphane for 2 months can reduce the H. pylori value in experimental mice and improve the sequelae of infection in experimental mice and humans.
- 3) In establishing a good animal model of Helicobacter pylori infection, oral broccoli sprouts can reduce gastritis and prevent gastric mucosal inflammation in the body.
- 4) The following conditions were observed in the rats taking sulforaphane: a) After 8 weeks of treatment at a dose of 6.7  $\mu\text{mol}$  / day, or 22 weeks of treatment at a dose of 5  $\mu\text{mol}$  / day, chemically induced lung tumors were observed Decrease; b) Decrease in intestinal tumors and biomarkers was observed after 34 weeks at 10.2  $\mu\text{mol}$  / day; d) Intestinal polyp inhibition and histone deacetylase inhibition were observed after 10 weeks after 6  $\mu\text{mol}$  / day at 34 weeks.

9. Key points: The **value of light on the nutritional content of microgreens**, which have better nutritional advantages

June 15, 2015: Georgetown University, USA - Untargeted Metabolomics Reveals Predominant Alterations in Lipid Metabolism Following Light Exposure in Broccoli Sprouts <https://www.mdpi.com/1422-0067/16/6/13678>

- 1) The molecular composition of this plant is strongly influenced by growth conditions. This study highlights the significant contribution of light to the final metabolic phenotype, which may affect the cellular physiology and nutritional value of broccoli sprouts.
- 2) Ingestion of phytosterols affects endogenous sterol lipid metabolism and is associated with reduced cardiovascular disease and cancer. From these findings, microgreens have better nutritional advantages than sprouts. Therefore, it is necessary to grow microgreens under the light. The sensory characteristics (such as flavor and aroma) of broccoli microgreens, as well as their nutritional value and health characteristics, are very good.
- 3) Interestingly, in addition to chlorophyll and lipid metabolism nutrients (steroids, carotenoids, polyketones, arachidonic acid and unsaturated fatty acid metabolites), we also reported that due to exposure of broccoli microgreens to sunlight Significant changes have occurred in terpenoid metabolism and indole alkaloid

biosynthesis. Exposure to light during growth is a major lipid biochemical pathway that is essential for affecting chlorophyll metabolism and participating in photosynthesis mechanisms.

10. Key points: effect of sulforaphane on the **upper respiratory tract**

November 21, 2008: David Geffen School of Medicine - Oral sulforaphane increases Phase II antioxidant enzymes in the human upper airway <https://www.sciencedirect.com/science/article/abs/pii/S1521661608008620>

Cellular [oxidative stress](#) is an important factor in asthma and is thought to be the principle mechanism by which [oxidant](#) pollutants such as ozone and particulates mediate their pro-inflammatory effects. Endogenous Phase II enzymes abrogate oxidative stress through the scavenging of [reactive oxygen species](#) and metabolism of reactive chemicals.

1) Study subjects consumed oral sulforaphane doses contained in a standardized [broccoli sprout homogenate](#) (BSH). RNA expression for selected Phase II enzymes was measured in [nasal lavage](#) cells by [RT-PCR](#) before and after sulforaphane dosing.

2) All subjects tolerated oral sulforaphane dosing without significant adverse events. Increased Phase II [enzyme expression](#) in nasal lavage cells occurred in a dose-dependent manner with maximal [enzyme induction](#) observed at the highest dose of 200 g broccoli sprouts prepared as BSH. Significant increases were seen in all sentinel Phase II enzymes RNA expression compared to baseline. Phase II enzyme induction was not seen with [ingestion](#) of non-sulforaphane containing [alfalfa](#) sprouts.

Oral sulforaphane safely and effectively induces mucosal Phase II enzyme expression in the upper airway of human subjects. This study demonstrates the potential of antioxidant Phase II enzymes induction in the human airway as a strategy to reduce the inflammatory effects of oxidative stress.

11. Key points: **Detox effect to fight carcinogenesis and mutagenesis**

1999: The Johns Hopkins University - Antioxidant functions of sulforaphane: a potent inducer of Phase II detoxification enzymes. <https://www.sciencedirect.com/science/article/pii/S0278691599000824?via%3Dihub>

OR <https://www.drperlmutter.com/wp-content/uploads/2014/06/antiox-sulforaphane.pdf>

Phase 2 enzymes play an important role in protecting cells from the toxicity of electrophiles and various oxidative decay effects. The induction of these enzymes helps cells defend against reactive oxygen and other forms of toxicity mechanisms and oxidative toxicity.

12. Key points: **Intestinal efficacy of sulforaphane**

September 2009: National Institutes of Health of Taiwan - Protective effect of sulforaphane on doxacin in intestinal Int 407 cells through heme oxygenase-1 expression. Taiwan, National Health Research Institutes:

Protective effect of sulforaphane on in . "Domethacin-induced cytotoxicity via heme oxygenase-1 expression in human intestinal Int 407 cells

<https://onlinelibrary.wiley.com/doi/abs/10.1002/mnfr.200800558>

Sulforaphane is known to be an indirect antioxidant that acts by inducing NF-E2-related factor 2 (Nrf2)-dependent phase II enzymes. In the present study, we investigated the effect of sulforaphane on the expression of heme oxygenase-1 (HO-1) in human intestinal Int 407 cells. RT-PCR and Western blot data revealed that sulforaphane induced an increase in HO-1 expression at the mRNA and protein levels, respectively. This induction was also marked by an increase in HO-1 activity. Actinomycin D (an RNA synthesis inhibitor) and cycloheximide (a protein synthesis inhibitor) inhibited sulforaphane-responsive HO-1 mRNA expression, indicating that sulforaphane is a requirement for transcription and de novo protein synthesis. Moreover, sulforaphane increased the nuclear levels of Nrf2 and increased the binding activity of nuclear proteins to the antioxidant responsive element consensus sequence. We also found that U0126, an ERK kinase inhibitor, suppressed the sulforaphane-induced HO-1 expression and nuclear translocation of Nrf2. Moreover, the cytoprotective effect of sulforaphane on indomethacin-induced cytotoxicity was partially blocked by ERK and HO-1 inhibitors, further demonstrating that sulforaphane attenuated oxidative stress through a pathway that involved ERK and HO-1. Taken together, this study gives additional support to the possible use of sulforaphane as a dietary preventive agent against oxidative stress-induced intestinal injury.

13. Key points: **"Beauty from Within"** comes from broccoli microgreens and radish microgreens

September 2017: Johns Hopkins University-Effects of Orally Delivered Phytochemicals on Aging and Inflammation in the Skin by Johns Hopkins University ("Beauty from Within ")

<https://clinicaltrials.gov/ct2/show/NCT03289832>

The protective effect of UV-induced skin erythema (redness or "sunburn") is determined after oral sulforaphane, curcumin, or a combination of two plant-based (diet) supplements. Based on animal studies and preliminary evidence from human volunteers, oral sulforaphane (sulforaphane) provides systemic protection for a variety of organ systems, and researchers hypothesized that the system would also include skin. Researchers have previously only evaluated the ability of topically applied sulforaphane to protect the skin from UV-induced erythema. The next logical step is to assess the ability of oral administration to affect the skin of healthy volunteers. Curcumin is also an effective anti-inflammatory drug, acting on a different biochemical pathway than sulforaphane, and is also an antioxidant. Discovering these effects more than a century ago has become the subject of more than a hundred clinical studies and has become an ingredient in ordinary foods consumed by millions of people.

14. Key points: **Daikon radish microgreens have more nutrients that the human body can absorb than broccoli microgreens**

July 9, 2019: University of Valencia - Evaluation of the Bioaccessibility of Antioxidant Bioactive, Genotype Antioxidant Bioactive Compounds and Minerals in Four Cruciferous Microgreens, University of Valencia, Spain

## Compounds and Minerals of Four Genotypes of Brassicaceae Microgreens

<https://www.ncbi.nlm.nih.gov/pubmed/31324050>

Microgreens constitute an emerging class of fresh, healthy foods due to their nutritional composition. In this study the content of minerals and antioxidant bioactive compounds, and for the first time bioaccessibility, were evaluated in broccoli, green curly kale, red mustard and radish hydroponic microgreens. Macro- (K, Ca, Mg) and oligo-elements (Fe, Zn), ascorbic acid, total soluble polyphenols, total carotenoids, total anthocyanins, total isothiocyanates and total antioxidant capacity (Trolox Equivalent Antioxidant Capacity and Oxygen Radical Absorbance Capacity) were determined before and after the standardized simulated gastrointestinal digestion process. All microgreens provided relevant amounts of vitamin C (31-56 mg/100 g fresh weight) and total carotenoids (162-224 mg  $\beta$ -carotene/100 g dry weight). Mineral content was comparable to that normally found in hydroponic microgreens and the low potassium levels observed would allow their dietetic recommendation for patients with impaired kidney function. Both total soluble polyphenols and total isothiocyanates were the greatest contributors to the total antioxidant capacity after digestion (43-70% and 31-63% bioaccessibility, respectively) while macroelements showed an important bioaccessibility (34-90%). In general, radish and mustard presented the highest bioaccessibility of bioactive compounds and minerals. Overall, the four hydroponic *Brassicaceae* microgreens present a wide array of antioxidant bioactive compounds.

It can be seen from this table that the Daikon radish microgreens have the highest levels of the five most important nutrients content over broccoli, kale and mustard microgreens. Therefore, while they are all excellent sources, white radish microgreens are the most nutritious. With affordable price and great flavors of broccoli and radish seeds, Pureland Greenhouse currently mainly grows these two microgreens.

It is obvious from the table below that the Daikon radish microgreens have better content than the broccoli microgreens in these five important nutrients, and radish microgreens are better than the kale and mustard seedlings in sulforaphane, beta carotene and polyphenols. Therefore, Pureland Greenhouse strongly recommends eating radish microgreens.

**Table 1.** Antioxidant bioactive compounds content in broccoli, kale, mustard and radish microgreens before and after simulated gastrointestinal digestion.

Microgreen	Total Content mg/100 g	Bioaccessible Fraction mg/100 g	Bioaccessibility (%)	Function
<i>(Vc) Ascorbic Acid</i> <sup>1</sup>				<b>Vc</b> plays an important role in a number of bodily functions including the production of collagen, L-carnitine, and some neurotransmitters. It helps metabolize proteins and its antioxidant activity may reduce the risk of some cancers.
Broccoli	50.99 ± 1.91 <sup>b</sup>	0.56 ± 0.09	1.10 ± 0.17 <sup>d</sup>	
Kale	56.14 ± 1.04 <sup>a</sup>	1.05 ± 0.09 <sup>a</sup>	1.87 ± 0.17 <sup>c</sup>	
Mustard	30.67 ± 1.02 <sup>d</sup>	1.14 ± 0.10 <sup>a</sup>	3.73 ± 0.32 <sup>a</sup>	
Radish	45.43 ± 1.15 <sup>c</sup>	1.19 ± 0.09 <sup>a</sup>	2.61 ± 0.21 <sup>b</sup>	
<i>Total carotenoids (β-carotene)</i> <sup>0</sup>				<b>Beta carotene</b> is an antioxidant that converts to vitamin A and plays a very important role in health. It's responsible for the red, yellow, and orange coloration of some fruits and veggies.
Broccoli	221.80 ± 13.36 <sup>a</sup>	0.18 ± 0.02 <sup>b</sup>	0.08 ± 0.01 <sup>c</sup>	
Kale	217.54 ± 18.74 <sup>a</sup>	0.12 ± 0.02 <sup>c</sup>	0.06 ± 0.01 <sup>d</sup>	
Mustard	224.27 ± 9.35 <sup>a</sup>	0.25 ± 0.02 <sup>a</sup>	0.11 ± 0.01 <sup>b</sup>	
Radish	162.29 ± 5.50 <sup>b</sup>	0.23 ± 0.03 <sup>a</sup>	0.14 ± 0.02 <sup>ab</sup>	
<i>Total isothiocyanates (sulphoraphane)</i> <sup>2</sup>				<b>Sulphoraphane</b> are compounds produced by several plants belonging to the families Brassicaceae, Capparaceae and Caricaceae as a system of defense against pathogen attack, and they arise from the hydrolysis of glucosinolates by the enzyme myrosinase.
Broccoli	633.11 ± 10.69	204.51 ± 47.94 <sup>a</sup>	32.30 ± 7.57 <sup>b</sup>	
Kale	608.23 ± 35.63 <sup>b</sup>	207.18 ± 10.33 <sup>b</sup>	34.06 ± 1.70 <sup>b</sup>	
Mustard	801.07 ± 51.16 <sup>a</sup>	248.90 ± 25.75 <sup>b</sup>	31.07 ± 3.21 <sup>b</sup>	
Radish	809.62 ± 27.83 <sup>a</sup>	512.99 ± 33.97 <sup>a</sup>	63.36 ± 4.20 <sup>a</sup>	
<i>Total anthocyanins (cyanidin-3-glucose)</i> <sup>2</sup>				<b>Anthocyanins</b> are the pigments that give red, purple, and blue plants their rich coloring. In addition to acting as antioxidants and fighting free radicals, anthocyanins may offer anti-inflammatory, anti-viral, and anti-cancer benefits.
Broccoli	12.66 ± 1.53 <sup>b</sup>	ND	-	
Kale	1.39 ± 0.43 <sup>d</sup>	ND	-	
Mustard	36.40 ± 0.46 <sup>a</sup>	ND	-	
Radish	5.57 ± 0.86 <sup>c</sup>	ND	-	
<i>Total soluble polyphenols (GAE)</i>				<b>Polyphenols</b> are micronutrients that we get through certain plant-based foods. They're packed with antioxidants and potential health benefits. It's thought that polyphenols can improve or help treat digestion issues, weight management difficulties, diabetes, neurodegenerative disease, and cardiovascular diseases.
Broccoli	2037.38 ± 103.10	1427.98 ± 175.00	70.09 ± 8.59 <sup>a</sup>	
Kale	2415.95 ± 109.34 <sup>a</sup>	1447.72 ± 140.10 <sup>a</sup>	59.92 ± 5.80 <sup>a</sup>	
Mustard	1889.76 ± 64.81 <sup>bc</sup>	820.57 ± 31.00 <sup>b</sup>	43.42 ± 1.64 <sup>b</sup>	
Radish	2111.19 ± 132.79 <sup>b</sup>	1434.82 ± 62.34 <sup>a</sup>	67.96 ± 2.95 <sup>a</sup>	

15. Key point: Be sure to **eat broccoli and radish microgreens raw**

Received August 15, 2003, Shinshu University, Japan - Broccoli's Phenolics, ascorbic acid, carotenoids and antioxidant activity of broccoli and their changes during conventional and microwave cooking

<https://www.sciencedirect.com/science/article/pii/S0308814604001517>

Antioxidant components, including phenolics, ascorbic acid and carotenoids, of broccoli floret and stem, antioxidant activity, and their changes during conventional and microwave cooking, were investigated.

Broccoli florets and stem were cooked by conventional boiling or by microwave over up to 300 s. Total phenolics were retained by up to 28.1–28.4% in the cooked florets and 55.6–57.8% in the cooked stems, and ascorbic acid by 34.1–34.4% and 29.1–29.5%, respectively. Total carotenoids were retained better compared to total phenolics and ascorbic acid. Total antioxidant activity was retained at 34.7–35.0% in the cooked florets and 34.6–34.7% in the cooked stems and phenolic antioxidant activity was retained at 37.4% and 64.7%, respectively. The results showed that antioxidant components and antioxidant activity in broccoli were lost heavily during the cooking. These losses need to be taken into account when calculating the dietary intake of these compounds from the cooked broccoli.

16. Key points: Potential benefits of sulforaphane for prenatal **prevention of autism**

September 4, 2014: Contributed by Paul Talalay at Johns Hopkins University School of Medicine - The potential benefits of sulforaphane for prenatal prevention of ASD and early treatment of young children with this disease. <https://www.pnas.org/content/111/43/15550.short>

Autism spectrum disorder (ASD) covers impaired communication and social interactions, as well as repetitive stereotypes and language, affecting 1-2% of male-dominated diseases. This is a huge medical and economic problem. Currently, there are no documented mechanism-based therapies. In a placebo-controlled, randomized, double-blind clinical trial, phytochemical sulforaphane (derived from broccoli sprouts) was orally administered daily to 29 men with ASD for 18 weeks compared to 15 placebo recipients ).

Parents / caregivers and physicians use three widely accepted behavioral measures to quantify the daily oral dose of sulforaphane (50-150  $\mu\text{mol}$ ) for 18 weeks, followed by untreated behavioral effects for 4 weeks: Abnormal Behavior Checklist (ABC), Social Response Scale (SRS), and Clinical Overall Impression Improvement Scale (CGI-I). After sulforaphane was discontinued, the total score for all grades rose to pre-treatment levels. Choose diet sulforaphane with lower toxicity because of its ability to reverse ASD-related abnormalities, including oxidative stress and lower antioxidant capacity, reduced glutathione synthesis, decreased mitochondrial function and oxidative phosphorylation, increased lipid peroxidation and neuroinflammation.

17. Key points: sulforaphane may improve cognitive function in patients with **schizophrenia**

October 2, 2014: Chiba University Hospital, Japan - Study of Sulforaphane - rich Broccoli Sprout Extract in Patients with Schizophrenia by Chiba University Hospital, Japan  
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4423155/pdf/cpn-13-62.pdf>

Schizophrenia is a mental disorder characterized by severe cognitive impairment and bipolar symptoms. Cognitive deficits in schizophrenia are thought to be related to impaired dorsolateral prefrontal cortex function and its interaction with other brain regions. Our preliminary research suggests that supplementation therapy with broccoli sprouts rich in sulforaphane and sulforaphane may have the potential to improve cognitive impairment in patients with schizophrenia.

18. Key points: **Reduce hepatic glucose, prevent complications of diabetes, neuropathy, renal failure and atherosclerosis**

June 14, 2017: Sweden and the United States - Sulforaphane reduces hepatic glucose production and improves glucose control in patients with type 2 diabetes <https://stm.sciencemag.org/content/9/394/eaah4477.full>

- 1) Another reason to eat broccoli: Type 2 diabetes is becoming more common worldwide and not all patients can be successfully treated with existing medicines. The main candidate for this analysis is sulforaphane, a natural compound found in broccoli and other vegetables. Sulforaphane can inhibit glucose production and increase glucose tolerance in rodents on high-fat or high-fructose diets. In a clinical trial, human patients with obesity and type 2 diabetes disorders were well tolerated with broccoli sprout extract containing sulforaphane and improved fasting blood glucose.
- 2) Sulforaphane reduces glucose production in hepatocellular carcinoma cells. The effect of sulforaphane on glucose production is not mainly exerted by changing insulin signaling. Sulforaphane reduces glucose production in part through NRF2 translocation and reduced expression of key gluconeogenesis enzymes, while high concentrations of sulforaphane in broccoli bud extract can improve fasting blood glucose and HbA1c in obese T2D patients. Broccoli sprouts extract is well tolerated, and sulforaphane reduces glucose production through a different mechanism than metformin. Due to its antioxidant effect, sulforaphane can also prevent diabetic complications such as neuropathy, renal failure and atherosclerosis in animal models.

19. Key points: sulforaphane relieves **eye muscle and retina aging symptoms**

September 25, 2013: Chinese and American universities - Sulforaphane Enhances the Ability of Human Retinal Pigment in human retinal pigment epithelial cells

Epithelial Cell against Oxidative Stress, and Its Effect on Gene Expression Profile Evaluated by Microarray Analysis <https://www.hindawi.com/journals/omcl/2013/413024/>

Sulforaphane increases the ability of RPE 19 cells to resist oxidative decay by up-regulating antioxidant enzymes and down-regulating inflammatory mediators and chemokines. The gene display spectrum analysis in this study showed that the antioxidant effect of sulforaphane on the survival of human RPE cells mainly occurs by inducing the expression of antioxidant genes and inhibiting the anti-inflammatory response genes. Therefore, sulforaphane can be a useful dietary supplement for the prevention of retinal diseases related to photooxidative stress including AMD. Sulforaphane regulates the transcription levels of 69 genes in RPE 19 cells, and the affected genes encode proteins whose activities involve a variety of cellular processes, including antioxidant, detoxification, cell growth regulation, anti-apoptosis, apoptosis, angiogenesis, Immune regulation, inflammatory response and signal transduction. These indicate that sulforaphane strongly stimulates intracellular redox activity, which means that the redox system plays an important role in defending against H<sub>2</sub>O<sub>2</sub>-induced RPE 19 cell apoptosis.

20. Key points: sulforaphane reduces **lung cancer**

2018: University of Pittsburgh - Randomized Clinical Trial of Lung Cancer Chemoprevention with Sulforaphane in Former Smokers

<http://grantome.com/grant/NIH/R01-CA213123-01A1>

Lung cancer is the leading cause of cancer death, and cigarettes smoking is the most important causal relationship. The smoking cessation program and antismoking campaign over the past 50 years has reduced the prevalence of cigarette smoking by two-thirds in the US. Currently there are more former smokers than current smokers. However, former smokers remain at high risk of lung cancer even after quitting smoking for many years. Majority new lung cancer cases occur among former smokers.

Unfortunately preventive intervention for lung cancer among former smokers is still lacking. This proposed proof-of-principal study is to evaluate the chemopreventive potentials of sulforaphane, a natural product formed from glucoraphanin in certain cruciferous vegetables, on reducing the cellular and molecular risk biomarkers of lung cancer pathogenesis. Sulforaphane and other isothiocyanates derived from cruciferous vegetables have shown promising chemopreventive properties in preclinical animal experiments. The sulforaphane and other isothiocyanates in cruciferous vegetables have shown promising chemopreventive properties in preclinical animal experiments, epidemiological studies, and short-term randomized clinical trials in humans.

The intake of sulforaphane in the diet significantly reduced the incidence of tobacco carcinogen-induced lung adenocarcinoma in an animal model that mimics a pre-smoker scenario, while reducing the cell proliferation marker Ki-67 and the apoptosis marker caspase-3 and TUNEL. In short-term clinical trials in humans, intake of sulforaphane enhanced the detoxification of environmental carcinogens and reduced the Ki-67 index. Epidemiological studies have shown that large intakes of cruciferous vegetables or isothiocyanates are significantly associated with a reduced risk of lung cancer in humans. However, there is a lack of clinical trials for relatively long-term treatment of sulforaphane to regulate lung cancer pathogenesis biomarkers.

In short-term clinical trials in humans, intake of sulforaphane enhanced the detoxification of environmental carcinogens and reduced Ki-67 index. Epidemiological studies demonstrated that high intake of cruciferous vegetables or isothiocyanates was associated significantly with reduced risk of lung cancer in humans. However, clinical trials with a relatively long-term treatment of sulforaphane on the modulation of lung cancer pathogenesis biomarkers are lacking. This proposed randomized, double-blinded, placebo-controlled, phase 2 clinical trial will enroll 72 former smokers at high risk for lung cancer. All subjects will be randomly assigned to either treatment (daily minimal dose of 120 mol sulforaphane for 12 months) or placebo. Bronchoscopy-guided bronchial biopsy and brushing, bronchoalveolar lavage, and nasal brushing, blood and urine samples will be collected pre- and post- intervention.

## 21. Key points: **Suppression of tumor and oncogene activation**

June 6, 2018: China, United States and Taiwan - Anticancer Activity of Sulforaphane: Epigenetic Mechanism and Nrf2 Signaling Pathway Anticancer Activity of Sulforaphane: The Epigenetic Mechanisms and the Nrf2 Signaling Pathway <http://downloads.hindawi.com/journals/omcl/2018/5438179.pdf>

In the classic view, cancer is caused by genetic changes including mutations, insertions, deletions, copy number acquisition, recombination, genomic instability and single nucleotide polymorphisms. Sulforaphane, a compound derived from cruciferous vegetables, has been proven to be safe and non-toxic, and has been

studied extensively due to the absence of side effects due to myriad biological activities such as anti-cancer and antioxidant activities. The single frequency network exerts its anti-cancer effect by regulating key signal pathways and inducing apoptosis and cell cycle genes to block and inhibit angiogenesis. Carbothione also up-regulates a series of cytoprotective genes erythroid-2- (NF-E2-) related factor 2 (Nrf2) by activating nuclear factors, which is a key transcription factor that is activated in response to oxidative stress; Of cancer prevention effect. Increasing evidence supports that epigenetic modification is an important factor in cancerization and cancer progression, as epigenetic changes often help to suppress the stress of tumors and oncogenes.

Measurement of sulforaphane and its metabolite sulforaphane-GSH showed that concentrations of 3 to 30 nmol / g were required to prevent or delay the formation of adenomas in the gastrointestinal tract of ApcMin / + test mice.

## 22. Key points: Soybean products and microgreens combined diet to suppress breast tumors

June 13, 2018: University of Alabama - The Effects of combinatorial Genistein and Sulforaphane in Breast Tumor Inhibition: Role in Epigenetic Regulation <https://www.mdpi.com/1422-0067/19/6/1754>

- 1) Genistein (GEN), found in soy, has been extensively studied for its role as an epigenetic modifier especially as a DNA methyltransferase (DNMT) inhibitor and sulforaphane (SFN), found in cruciferous vegetables, is known as a histone deacetylase (HDAC) inhibitor.
- 2) At certain doses, the compounds have synergistic effects in decreasing cellular viability of breast cancer cell lines. Our results indicate that the combination of GEN and SFN is much more effective than their single doses in increasing the rate of apoptosis and lowering the colony forming potential of these cells.
- 3) The combination is more effective in preventing or treating mammary cancer via extending tumor latency and reducing tumor volumes/sizes than either of these dietary components administered alone. These results are consistent with our in vitro study suggesting potential preventive and therapeutic effects of this novel dietary combinatorial approach against breast cancer.

## 23. Key points: Broccoli sprouts are detoxifying

November 1, 2011: Johns Hopkins University, USA - Modulation of the metabolism of airborne pollutants by glucoraphanin-rich and sulforaphane-rich broccoli sprout beverages in Qidong, China <https://academic.oup.com/carcin/article/33/1/101/2463507>

The study protocol was as follows: a 5 days run-in period, a 7 days administration of beverage, a 5 days washout period and a 7 days administration of the opposite beverage. Urinary excretion of the mercapturic acids of acrolein, crotonaldehyde, ethylene oxide and benzene were measured both pre- and post-interventions using liquid chromatography tandem mass spectrometry. Statistically significant increases of 20–50% in the levels of excretion of glutathione-derived conjugates of acrolein, crotonaldehyde and benzene were seen in individuals receiving SFR, GRR or both compared with their pre-intervention baseline values. No significant differences were seen between the effects of SFR versus GRR. Intervention with broccoli sprouts may enhance detoxication of airborne pollutants and attenuate their associated health risks.

24. Key points: sulforaphane is a potent inhibitor of **intestinal polyposis**

May 4, 2006: University of New Jersey - Cancer chemoprevention of intestinal polyposis in ApcMin / + mice by sulforaphane, a natural product derived from cruciferous vegetable

<https://www.ncbi.nlm.nih.gov/pubmed/16675473>

Sulforaphane is widely found in cruciferous vegetables and is particularly high in broccoli and broccoli. It has been shown to be an effective inhibitor of certain carcinogen-induced cancers in rodents. Here, we investigated the chemopreventive efficacy of sulforaphane in the ApcMin / + experimental mouse model. ApcMin / + test mice were fed a diet supplemented with two different dose levels of sulforaphane (300 and 600 p.p.m.) for 3 weeks. Our results clearly show that ApcMin / + test rats fed a diet of sulforaphane in a dose-dependent manner of sulforaphane formed significantly less, smaller, and higher apoptotic and proliferation indices in the small intestine. . In addition, immunohistochemical (IHC) staining of adenomas showed that sulforaphane significantly inhibited phosphorylated c-Jun N-terminal kinase (p-JNK), phosphorylated extracellular signal-regulated kinase (p-ERK), and phosphate Akt (p-Akt) was found to be highly expressed in adenomas of ApcMin / + test mice. In contrast, sulforaphane treatment did not affect the expression of two Key pointbiomarkers  $\beta$ -catenin and cyclin-D1 in the Wnt signaling pathway. Using LC-MS in the small intestine Measurement of sulforaphane and its metabolite sulforaphane-GSH showed that concentrations of 3 to 30 nmol / g were required to prevent or delay the formation of adenomas in the gastrointestinal tract of ApcMin / + test mice.

25. Key points: **sulforaphane reduces joint inflammation and damage**

April 24, 2018: University of Unikuma, Brazil - Sulforaphane Modulates Joint Inflammation in a Murine Model of Complete Freund's Adjuvant-Induced Mono -Arthritis

<https://www.mdpi.com/1420-3049/23/5/988>

Rheumatoid arthritis (RA) is characterized by inflammation of one or more joints, and affects ~1% of the adult population worldwide. Sulforaphane (SFN) is a natural compound that has been suggested as an antioxidant. Here, SFN's effects were evaluated in a murine mono-arthritis model. Mono-arthritis was induced in mice by a single intra-articular injection of Complete Freund's Adjuvant (CFA-10 \_g/joint, in 10 \_L) into the ipsilateral joint. The contralateral joint received an equal volume of PBS. On the 4th day post-joint inflammation induction, animals received either SFN (10 mg/kg) or vehicle (3% DMSO in saline), intraperitoneally (i.p.), twice a day for 3 days. Joint swelling and secondary mechanical allodynia and hyperalgesia were evaluated over 7 days post-CFA. After this period, animals were culled and their blood and synovial fluid samples were collected for analysis of cell populations, cytokine release and thioredoxin reductase (TrxR) activity. Knee joint samples were also collected for histology. SFN reduced joint swelling and damage whilst increasing the recruitment of Ly6C+ and Ly6G+ cells to CFA-injected joints. SFN-treated animals presented down-regulation of CD11b and CD62L on synovial fluid Ly6G+ cells. Rheumatoid arthritis (RA) the repeated treatment with SFN reduces knee joint inflammation / damage (denoted by data on knee joint thickness and histology) in animals with CFA-induced mono-arthritis, without affecting their nociceptive thresholds. Other studies have also reported the anti-oedematogenic and anti-nociceptive effect of Sulforaphane (1-isothiocyanato-4-(methylsulfinyl) butane,

SFN is one of the most extensively studied isothiocyanates, and is found in cruciferous vegetables such as broccoli and Brussels sprouts.

## 26. Key points: help normalize **bowel habits**

November 3, 2017: University Hospital of Tsukuba, Japan - Daily intake of broccoli sprouts normalizes bowel habits in human healthy subjects. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5773831/>

We evaluated that daily intake of sulforaphane-rich broccoli sprouts can improve bowel movements in humans. Forty-eight subjects with a constipation scoring system (CSS) > 2 points were assigned to the broccoli bud group (n = 24) or the Alfalfa bud group (n = 24) and were asked to eat 20 g of raw broccoli sprouts or Alfalfa shoots for 4 weeks. Broccoli sprouts contain 4.4 mg / g sulforaphane glucosinolate (SGS), while Alfalfa sprouts do not contain SGS. Bowel habits were assessed based on a CSS-based questionnaire. Stool samples were collected to evaluate the intestinal flora using terminal restriction fragment length polymorphisms. Intervention in broccoli sprouts instead of Alfalfa sprouts caused significant impacts that did not reduce the time to attempt a bowel movement, and the overall CSS score. Sulforaphane inhibits the excessive growth of anaerobic flora and promotes protection of the small intestine from oxidative damage.

- 1) A recent study conducted after the great earthquake hit eastern Japan on March 2011 showed that chronic constipation was strongly associated with an unbalanced daily diet due to the increased psychological stress caused by the disaster.<sup>(2)</sup> The persistence of chronic constipation frequently impairs the quality of life; therefore, it is important to resolve these issues by implementing lifestyle changes.
- 2) Sulforaphane exhibits anti-bacterial activity against gastric *Helicobacter pylori* (*H. pylori*) and anaerobic bacteria in the small intestinal mucosa.

In addition, recent studies have shown that certain intestinal flora, such as bifidobacteria, can improve defecation. We observed a slight increase in the constipation score in the BS group after 2 weeks of dietary restriction in the pre-intervention period. The present study demonstrates that intake of 20 g of broccoli sprouts, but not Alfalfa sprouts, significantly enhances defecation with no side effects in healthy human subjects, and these beneficial effects appear to be induced by the protective effects of SFN in the BS on GI function against chronic oxidative stress from daily life.

## 27. Key points: help with **stroke, brain trauma, Alzheimer, and Parkinson's disease**

July 3, 2013: University of Bologna, Italy - Sulforaphane as a Potential Protective Phytochemical against Neurodegenerative Diseases <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3745957/>

- 1) Acute and chronic neurodegenerative diseases, including stroke, traumatic brain injury (TBI), Alzheimer's disease (AD), and Parkinson's disease (PD), are illnesses associated with high morbidity and mortality, and few or no effective options are available for their treatment. These diseases result in acute, as well as gradual and progressive neurodegeneration, leading to brain dysfunction and neuronal death.

- 2) Various Brassica vegetables and especially broccoli contain glucoraphanin. Following cutting or chewing, it is hydrolyzed into the corresponding isothiocyanate Sulforaphane either by the plant thioglucosidase myrosinase or by bacterial thioglucosidases in the colon. These phytochemicals have long been recognized as exerting different biological effects, antioxidant, antiallergic, antiinflammatory, antiviral, antiproliferative, and anticarcinogenic effects.
- 3) Considering that these age-related neurological disorders are multifactorial and that no drugs are available to stop their progression, intervention strategies using phytochemicals have been proposed as an alternative form of treatment for their prevention.
- 4) Both plasma and tissue levels of these SF metabolites are rapidly eliminated through urinary excretion within 12–24 h reflecting the rapid elimination of SF. These data suggest the hypothesis that repeated consumption of SF or cruciferous vegetables is required to maintain the SF metabolite concentration in tissues.
- 5) Protective Effects of Sulforaphane against Chronic Neurodegeneration Sulforaphane: presents many advantages, such as good pharmacokinetics and safety after oral administration as well as the potential ability to penetrate the brain blood barrier and deliver its neuroprotective effects in the central nervous system. Based on these considerations, sulforaphane appears to be a promising compound with neuroprotective properties that may play an important role in preventing neurodegenerative diseases.

28. Key points: **metal detoxification** and prevention of **liver cancer**

March 14, 2013: Children's Hospital of the Institute of Eastern Ontario, Canada - Chelation: Utilizing and Enhancing the Effects of Heavy Metal Detox

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3654245/pdf/TSWJ2013-219840.pdf>

A living body is full of chelates, metals that can bind to two or more coordination bonds. Modern exposure to mercury and cadmium is usually done orally, which has prompted people to ask questions about the consumption of fish, seafood and wildlife, as well as cigarette smoke. Toxic metals such as arsenic, cadmium, lead, and mercury are ubiquitous, have no beneficial effect on human homeostasis, and cause non-infectious chronic diseases. Although people are eagerly searching for new drug targets for chronic diseases, the potentially useful drugs that contribute to toxic elements and chelator detoxification have been largely limited to apparent acute poisoning.

Given that toxic metals have great affinity for sulphur-containing peptides, diets rich in sulphur-containing foods such as alliums (e.g. garlic ) and brassicas (e.g., broccoli) have been suggested for effects on glutathione, with hopes for symptomatic improvement and enhanced excretion. Garlic prevented cadmium-induced kidney damage and decreased the oxidative damage due to lead in rats.

29. Key points: **Detox effect to fight carcinogenesis and mutagenesis**

1999: Johns Hopkins University - Antioxidant function of sulforaphane: a potent inducer of phase II detoxifying enzymes.

<https://www.ncbi.nlm.nih.gov/pubmed/10541453>

or <https://www.drperlmutter.com/wp-content/uploads/2014/06/antiox-sulforaphane.pdf>

Phase 2 enzymes play an important role in protecting cells from the toxicity of electrophiles and various oxidative stress. The induction of these enzymes helps cells defend against reactive oxygen species and other forms of toxicity mechanisms.

Indirect antioxidants, such as sulforaphane and other phase 2 enzyme inducers, are actually very effective and versatile antioxidants for the following reasons: 1) Unlike direct antioxidants, they do not chemically act as antioxidants Metered consumption; 2) they have a longer duration of action, and because induced enzymes have a half-life measured in days, there is no need to continuously maintain high cell concentrations; 3) they support the important naturally-occurring direct-acting resistance The functions of oxidants such as tocopherol and coenzyme Q; 4) they enhance the synthesis of glutathione, glutathione is one of the most abundant direct antioxidants in cells, and (5) they improve the ability to cope with many types Oxidant enzyme.

### 30. Key points: **Enhance immune system**

October 8, 2008-Amala Cancer Research Center in India: – India Amala Cancer Research Center: Modulation of Cell-Mediated Immune Response in B16F-10 Melanoma-Induced Metastatic Tumor-Bearing C57BL/6 Mice by Sulforaphane <https://www.tandfonline.com/doi/full/10.1080/08923970701511728>

Effect of sulforaphane on cell-mediated immune response (CMI) was studied in B16F-10 melanoma-induced metastasis-bearing C57BL/6 mice. Administration of sulforaphane significantly enhanced natural killer (NK) cell activity in metastatic tumor-bearing animals (43.17% cell lysis, on day 5) and the activity was observed earlier than in tumor-bearing control animals (maximum of 9.76% cell lysis, on day 9). Antibody-dependent cellular cytotoxicity also was enhanced significantly in metastatic tumor-bearing animals (41.20% cell lysis on day 9) after sulforaphane administration compared with untreated control tumor-bearing animals (maximum of 12.62% cell lysis on day 15). An early antibody-dependent complement-mediated cytotoxicity also was observed in sulforaphane-treated tumor-bearing animals (26% cell lysis, on day 15). Administration of sulforaphane significantly enhanced the production of IL-2 and IFN- $\gamma$  in metastatic tumor-bearing animals. In addition, sulforaphane significantly downregulated the serum levels of proinflammatory cytokines such as IL-1 $\beta$ , IL-6, TNF- $\alpha$ , and GM-CSF during metastasis.

### 31. Key points: **Anti-depression and anti-anxiety**

22 December 2015: Hebei Medical University, China - Sulforaphane produces antidepressant- and anxiolytic-like effects in adult mice

<https://www.sciencedirect.com/science/article/pii/S0166432815303399>

- Sulforaphane works as an antidepressant and anxiolytic in mice.
- Sulforaphane exerts anxiolytic-like activity in stress-induced depression mice.
- Sulforaphane inhibits HPA axis activity in stress-induced depression mice.
- Sulforaphane inhibits the inflammatory response in stress-induced depressive mice.

Increasing evidence suggests that depression is accompanied by dysregulation of neuroimmune system. Sulforaphane (SFN) is a natural compound with antioxidative, anti-inflammatory and neuroprotective activities. The present study aims to investigate the effects of SFN on depressive- and anxiety-like behaviors as well as potential neuroimmune mechanisms in mice. Repeated SFN administration (10 mg/kg, i.p.) significantly decreased the immobility time in the forced swimming test (FST), tail suspension test (TST), and latency time to feeding in the novelty suppressed feeding test (NSF), and increased the time in the central zone in the open field test (OPT). Using the chronic mild stress (CMS) paradigm, we confirmed that repeated SFN (10 mg/kg, i.p.) administration significantly increased sucrose preference in the sucrose preference test (SPT), and immobility time in the FST and TST of mice subjected to CMS. Also, SFN treatment significantly reversed anxiety-like behaviors (assessed by the OPT and NSF) of chronically stressed mice.

Finally, ELISA analysis showed that SFN administration blocked the increase in the serum levels of corticosterone (CORT), adrenocorticotropic hormone (ACTH), interleukin-6 (IL-6) and tumor necrosis factor- $\alpha$  (TNF- $\alpha$ ) in chronically stressed mice. In summary, these findings demonstrated that SFN has antidepressant- and anxiolytic-like activities in stressed mice model of depression, which likely occurs by inhibiting the hypothalamic-pituitary-adrenal (HPA) axis and inflammatory response to stress. These data support further exploration for developing SFN as a novel agent to treat depression and anxiety disorders.

### 32. Key points: **Absolute therapeutic effect of sulforaphane**

July 21, 2017: Spain, Italy, and Poland - Nrf2 targeting by sulforaphane: A potential therapy for cancer treatment <https://www.tandfonline.com/doi/abs/10.1080/10408398.2016.1259983>

In the past decades, extensive studies have reported the potential chemopreventive activity of sulforaphane, an isothiocyanate derived from glucoraphanin, occurring in large amounts in Brassica genus plants. Sulforaphane was found to be active against several forms of cancer. A growing body of data shows that sulforaphane acts against cancer at different levels, from development to progression, through pleiotropic effects. Sulforaphane remains a good candidate in the adjuvant therapy based on natural molecules against several types of cancer.

### 33. Key points: a **dose-dependent induction of apoptosis** in blasts from patients diagnosed with acute lymphoblastic or myeloid leukemia.

2014 Jul 14: Universities in Italy - Antileukemic Activity of Sulforaphane in Primary Blasts from Patients Affected by Myelo- and Lympho-Proliferative Disorders and in Hypoxic Conditions

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4096754/>

- 1) The efficacy of the chemotherapy still is unsatisfactory in Leukemia treatments, since the rate of complete remission ranges 30– 60%, depending on age, and the survival rate has not changed significantly in years. Thus, leukemia remains a formidable therapeutic challenge that requires the identification and the development of novel agents for the treatment of this disease.
- 2) Sulforaphane caused a **dose-dependent** induction of apoptosis in blasts from patients diagnosed with acute lymphoblastic or myeloid leukemia. Sulforaphane seems not to have any activity on samples from patients with chronic lymphocytic leukemia.
- 3) Survival of cancer cells is influenced by the interactions between pro- and anti-apoptotic proteins. The antileukemic effect of Sulforaphane is strengthened by the inhibition of cell proliferation. As to the mechanism through which Sulforaphane induces apoptosis, an important trigger is likely to reside in its ability of damaging nuclear DNA.
- 4) Sulforaphane could represent an interesting therapeutic approach for patients affected by acute proliferative disorders and might set the stage for a novel therapeutic principle complementing our growing armature against malignancies. Large clinical trials will be necessary to confirm this attractive perspective.

#### Nutrition knowledge:

1. **Polyphenols** are beneficial compounds in many plant foods that can be grouped into flavonoids, phenolic acid, polyphenolic amides, and other polyphenols. They may improve digestion, brain function, and blood sugar levels, as well as protect against blood clots, heart disease, and certain cancers.

2. **Anthocyanin** may offer anti-inflammatory, anti-viral, and anti-cancer benefits. In herbal medicine, anthocyanin-rich substances have long been used to treat a number of conditions (including high blood pressure, colds, and urinary tract infections), in addition to acting as antioxidants and fighting free radicals.

3. **Vitamin C** is being used in many different ways in human body. Vitamin C is needed by the body to form collagen. According to the NIH, the body also uses vitamin C to make skin, tendons, ligaments and blood vessels. It also uses this vitamin to repair and maintain cartilage, bones and teeth, to heal wounds and to form scar tissue.

4. If you eat broccoli raw, you will get 3 times nutrients than the cooked broccoli. Broccoli microgreens have more than 50 times the nutritional content of broccoli heads. So be sure to eat broccoli microgreens, Chinese rose carrots and Daikon radish **microgreens raw for the best nutrition.**