Sprouting Guide + Q&A with Dr. Jed Fahey

Found My Fitness

A note from Rhonda...

I became an avid sprouter several years ago after coming across the fascinating research of Dr. Jed Fahey, a nutritional biochemist with a broad, extensive background in plant physiology, human nutrition, and phytochemistry.

The bulk of Dr. Fahey's work has focused on glucosinolates and their byproducts – isothiocyanates. Of particular interest is sulforaphane, an isothiocyanate derived from cruciferous vegetables such as broccoli. Sulforaphane is a potent inducer of key enzymes that promote detoxification of carcinogens in humans, but it also shows promise as a therapeutic agent against a wide range of other diseases, including autism, cardiovascular disease, and diabetes, among others. Dr. Fahey discovered that broccoli sprouts are an exceptionally rich and consistent source of sulforaphane.

We get lots of questions about sprouting here at FMF, so we sat down with Dr. Fahey and got the lowdown on how it's done. And now we're sharing that information with you!

Everything you've ever wanted to know about sprouting broccoli seeds: A Q&A with Dr. Jed W. Fahey and illustrated how-to guide

About this guide:

This guide is a one-stop "best practice" document for home sprouters. It provides practical tips and resources on how to sprout broccoli seeds and answers common questions. Here's what you'll find:

Key Terms

Glucosinolate: A compound found in the leaves, stems, and flowers of moringa and cruciferous plants such as broccoli, broccoli sprouts, kale, and others. Glucosinolates react with myrosinase, a type of enzyme, to produce isothiocyanates.

Glucoraphanin: The glucosinolate present in broccoli and broccoli sprouts. Glucoraphanin reacts with myrosinase to produce sulforaphane, a potent activator of the Nrf2 genetic pathway.

Isothiocyanate: The byproduct of a reaction between two compounds (glucosinolates and myrosinases) found in the leaves and stems of cruciferous vegetables. Isothiocyanates inhibit the formation of carcinogens in the body by activating detoxication enzymes.

Myrosinase: An enzyme found in the leaves, stems, and flowers of moringa and cruciferous plants such as broccoli, broccoli sprouts, kale, and others. Chopping, chewing, or otherwise damaging the plants causes a reaction between myrosinase and other plant chemicals called glucosinolates. The end products of the reaction are compounds called isothiocyanates. Myrosinase is also produced by bacteria in the human gut.

Sulforaphane: An isothiocyanate phytochemical derived from broccoli and broccoli sprouts. Sulforaphane is produced when the plant is damaged when attacked by insects or eaten by humans. It switches on a vast array of proteins via activation of the Nrf2 pathway that protects cells from damage.

The Science of Sprouting

1 Glucoraphanin in the sprouts is converted to sulforaphane (SF) via the myrosinase enzyme.

glucoraphanin

broccoli sprouts

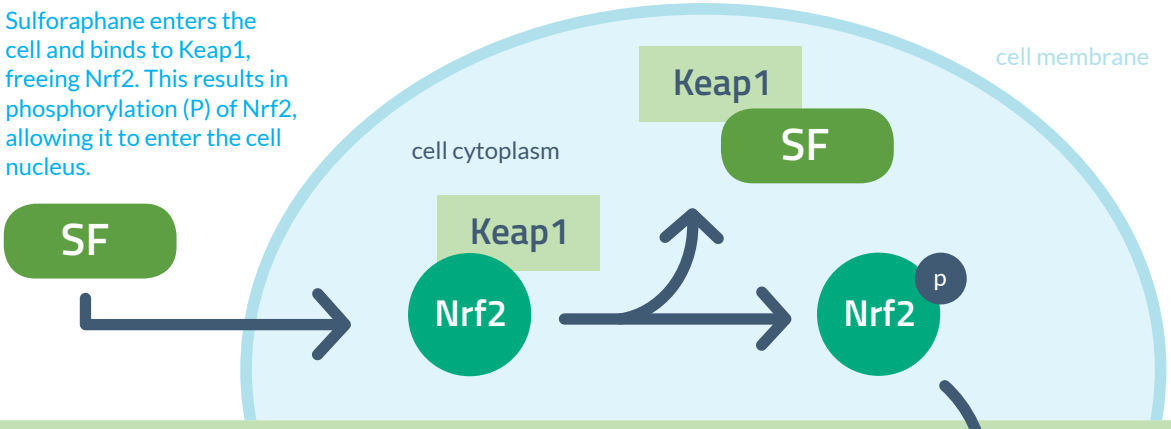
myrosinase

- chewing
- freezing
- gut bacteria

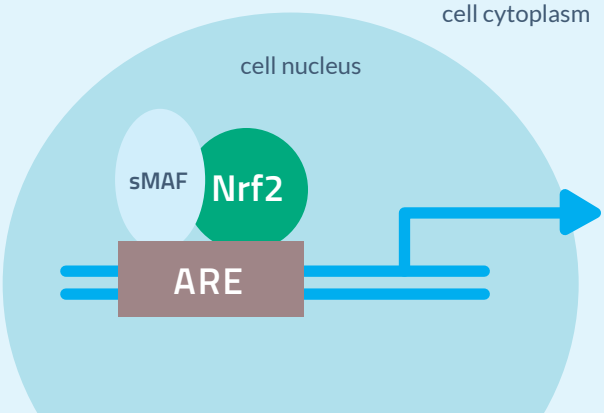
SF

sulforaphane

2 Sulforaphane enters the cell and binds to Keap1, freeing Nrf2. This results in phosphorylation (P) of Nrf2, allowing it to enter the cell nucleus.



3 Nrf2, along with a small MAF (sMAF) protein, binds with the antioxidant response element (ARE), to influence gene expression.



- Increased phase 2 enzymes
- Increased antioxidant defense enzymes
- Decreased inflammation

Sprouting step-by-step

1 sort

Inspect seeds and throw out any rocks or other weird stuff. Add **3-7 tablespoons** of seeds to a quart-sized sprouting jar.

4 tablespoons yields about 4 cups of sprouts

2 clean

Fill the jar with water plus a bacteria killing solution* (apple cider vinegar [plus a drop of liquid dish soap] or bleach, for example) in a **1:10 ratio**. Let sit for **10 minutes**, then **rinse very very well** with fresh water.

Soap reduces the surface tension of the vinegar to make it more effective at killing bacteria. *For more information about seed sterilization, please see Dr. Fahey's recommendations on pages 11 & 12.

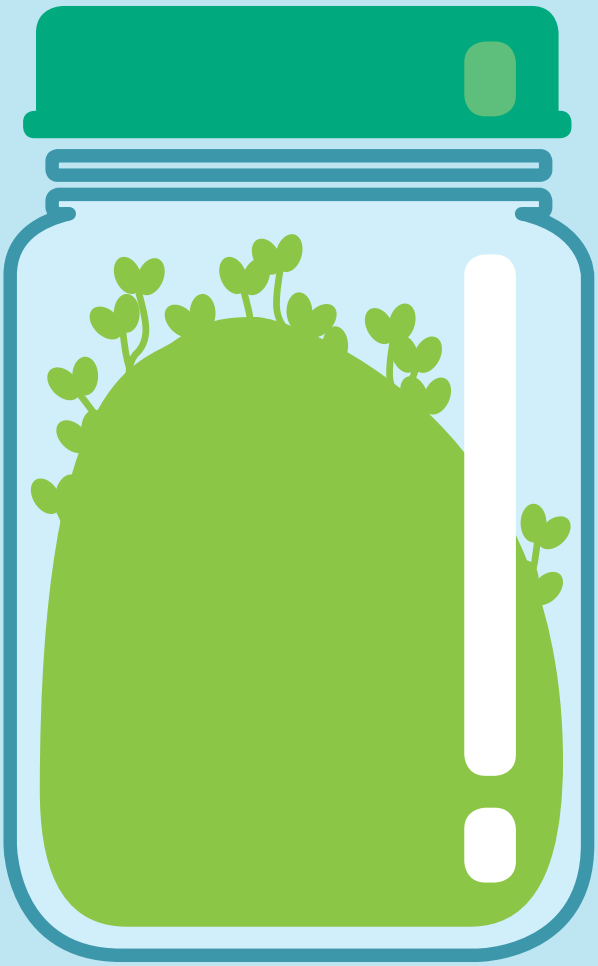
3 soak

Add enough fresh water to cover the seeds completely, with at least an inch of water above them. Soak for **8 hours** or **overnight**.

4 rinse

Drain the water from the jar. Add fresh water through the lid and swirl the seeds around to rinse them. Completely drain the water & rest the jar at an angle, so any remaining water can drain out. Rinse the seeds **twice a day**, for **3-5 days**.

At FMF we tend to harvest ours on the early side, at 2-3 days. See page 10 for photos.



Store your sprouts in the fridge or freeze them and add to salads or smoothies! We like them on avocado toast or as an addition to Rhonda's micronutrient smoothie.

Q&A with Dr. Jed Fahey JWF

FMF **The big question has to be this: Why sprouts?**

JWF Simply put, broccoli sprouts and other kinds of sprouts are wonderful sources of vitamins, minerals, fiber, and, perhaps more importantly, phytochemicals.

FMF **Can you explain for our readers what phytochemicals are and why they're important?**

JWF Phytochemicals are compounds such as scents, pigments, and even toxins that are produced by plants for their own protection or to give them a survival advantage in their environment. Sprouts contain high levels of phytochemicals. They are, in essence, a microcosm of the plants they will grow up to become. But they're fresh, they're inexpensive, and incredibly fast-growing.

FMF **Tell me about the phytochemicals in broccoli sprouts.**

JWF Well, there are lots of phytochemicals in broccoli sprouts, but the ones of greatest interest to the research community and to me are glucoraphanin, myrosinase, and sulforaphane. Glucoraphanin is a glucosinolate – a compound found in the leaves, stems, and flowers of moringa and cruciferous plants such as broccoli, broccoli sprouts, kale, and others. Myrosinase is an enzyme. It's strategically sequestered in tiny vesicles in the same list of plants. Chopping, chewing, or otherwise breaking open the plants' cells causes a reaction between glucosinolates and myrosinase. The glucoraphanin in broccoli sprouts reacts with myrosinase to produce sulforaphane, an isothiocyanate compound and a powerful indirect antioxidant.

Direct/Indirect antioxidants

Many classic antioxidants – such as vitamin C, vitamin E, and beta carotene –work by terminating the molecular chain reactions initiated by free radicals or by directly quenching oxidants or reactive oxygen species. These are considered "direct" antioxidants because they directly inhibit oxidation.

Other compounds – such as sulforaphane – don't directly inhibit oxidation because they don't have redox activity, the alternating chemical processes of reduction (gain of electrons) and oxidation (loss of electrons). Rather, these compounds enhance and increase many antioxidant genetic pathways that, in turn, robustly protect cells from oxidative stress. Compounds that act in this way are known as "indirect" antioxidants.

FMF **How did you get involved in sprouting?**

JWF My work with broccoli sprouts began in 1993 when physician and cancer researcher Dr. Paul Talalay hired me at the Johns Hopkins School of Medicine to run a brand-new lab – the Brassica Chemoprotection Laboratory. My initial responsibility was to develop "better broccoli." What we were after was something

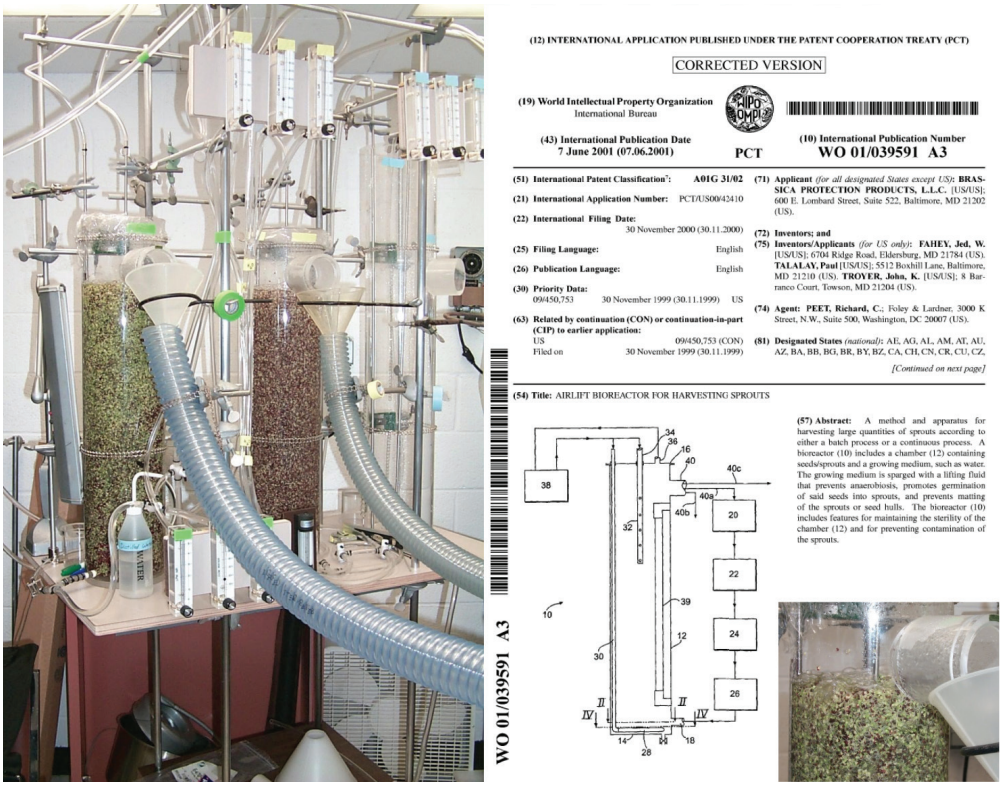
with more sulforaphane – a cancer-preventive phytochemical that Talalay and Yuesheng Zhang had discovered the previous year. I started growing broccoli in the field on the eastern shore of Maryland and bringing it back to Baltimore to the lab to analyze. Unfortunately, when winter came, I was unable to harvest broccoli from the farms or even from the greenhouse where we had been growing young plants. So, I started surface-sterilizing seeds – a process called "disinfesting" – and growing small seedlings on agar in an incubator on the 13th floor of the Johns Hopkins Hospital in Baltimore.

FMF **What did you learn in your analysis?**

JWF I rapidly discovered that the highest concentrations of glucoraphanin were in the seeds and sprouts of broccoli and that you could grow high-glucoraphanin sprouts from high-glucoraphanin seeds. As the sprouts matured, the concentration of glucoraphanin decreased as the biomass – proteins, sugars, and other content – increased. We published our first paper on broccoli sprouts in 1997 in the Proceedings of the National Academy of Sciences and, subsequent to that, many other research papers dealing with broccoli sprouts, glucoraphanin, sulforaphane, myrosinase, and animal and clinical studies utilizing this potent phytochemical. Much of the data are still unpublished.

FMF **Did you use any special technology to grow your sprouts in the lab?**

JWF Commercial green sprouts are typically produced in one of two ways – either in inclined trays or in 5- to 7-foot diameter rotating drums, where water is sprayed on them and then allowed to drain away. But in the early days of our research, I was looking for alternative ways to grow sprouts. I developed what we called a "hydrosprouter" or "airlift reactor." Essentially, we used long, clear, vertical glass or plastic tubes and bubbled in huge amounts of air at the bottom to stir and agitate an expanding column of sprouts.



(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

CORRECTED VERSION

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
7 June 2001 (07.06.2001)

PCT

(10) International Publication Number
WO 01/039591 A3

(51) International Patent Classification⁷: A01G 31/02

(21) International Application Number: PCT/US00/42410

(22) International Filing Date: 30 November 2000 (30.11.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data: 09/450,753 30 November 1999 (30.11.1999) US

(63) Related by continuation (CON) or continuation-in-part (CIP) to earlier application: US 09/450,753 (CON) Filed on 30 November 1999 (30.11.1999)

(71) Applicant (*for all designated States except US*): BRASSICA PROTECTION PRODUCTS, L.L.C. [US/US]; 600 E. Lombard Street, Suite 522, Baltimore, MD 21202 (US).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): FAHEY, Jed, W. [US/US]; 6704 Ridge Road, Eldersburg, MD 21784 (US). TALALAY, Paul [US/US]; 5512 Boxhill Lane, Baltimore, MD 21210 (US). TROYER, John, K. [US/US]; 8 Barranco Court, Towson, MD 21204 (US).

(74) Agent: PEET, Richard, C.; Foley & Lardner, 3000 K Street, N.W., Suite 500, Washington, DC 20007 (US).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ,

[Continued on next page]

(54) Title: AIRLIFT BIOREACTOR FOR HARVESTING SPROUTS

(57) Abstract: A method and apparatus for harvesting large quantities of sprouts according to either a batch process or a continuous process. A bioreactor (10) includes a chamber (12) containing seeds/sprouts and a growing medium, such as water. The growing medium is sparged with a lifting fluid that prevents anaerobiosis, promotes germination of said seeds into sprouts, and prevents matting of the sprouts or seed hulls. The bioreactor (10) includes features for maintaining the sterility of the chamber (12) and for preventing contamination of the sprouts.

WO 01/039591 A3

The hydrosprouter that Dr. Fahey invented as a result of trying to optimize sprouting in his lab.

The idea behind the hydrosprouter was that it provided a way to:

- visualize the sprouts as they grew;
- expose them to light;
- introduce sterilizing, growth regulating, nutrients, bacteria-suppressing, or other compounds;
- grow them longer than they typically would be grown;
- harvest them more easily;
- recycle water;
- have ready access to their growing medium in order to regularly assess bacterial contamination;
- sparge – or "bubble" – them with any sort of gas, at any concentration.

We even applied for patents here in the U.S. and elsewhere, although ultimately, we didn't pursue them due to cost and other issues. I can provide more information to anybody who is interested in learning more about the hydrosprouter. I'd love to see someone play around with this methodology again, because I thought it was pretty cool!

FMF **How can a home sprouter grow broccoli sprouts?**

JWF You can grow sprouts on a window ledge, in a kitchen cabinet, or anywhere there's a square foot or so of free space, for that matter. All you need is a source of clean, fresh water and a few minutes, three or four times a day, to attend to them. Attending to them simply means rinsing them with fresh water. Do this again and again for **three to five days**, and you've got fresh sprouts.

FMF **Are there any concerns with eating fresh sprouts?**

JWF Yes. Several years ago, the FDA put out a warning that very young, very old, or immunocompromised people should avoid fresh sprouts. This has been updated at various points over the years – most recently in 2017. That's because sprouts are, like it or not, a potential source of foodborne illnesses. This comes from improperly sanitizing or surface-disinfecting the seeds that go into the sprouting process, and/or sprouting seeds and growing sprouts in an unsanitary environment. Sprouts – germinated seeds – are bathed in a variety of nutrients that leach from the seeds during the germination process. These nutrients are ideal for the growth of bacteria, including *Listeria*, *Salmonella*, and *E. coli*, and these bacteria, if present at the onset of the sprouting process, can multiply rapidly and cause serious illness to people who consume them. There are no known cases of foodborne illnesses arising from broccoli sprouts that I'm aware of, but certainly there have been outbreaks in alfalfa and daikon and other sprouts in the past.

FMF **What supplies does the home sprouter need?**

JWF You can use anything that's convenient. You need a jar with a screened or slotted lid. My go-to is Mason jars or Ball jars, which have lids that you can fit screening in yourself, but there are all sorts of screened or slotted lids (stainless steel or plastic) that you can buy specifically for sprouting. They are made for either the wide mouth or the narrow mouth canning jars. I prefer glass vessels for sprouting, which is why I suggest Mason jars, but there's certainly nothing to say you can't use plastic. I just prefer not to have too much plastic in contact with my food. So that's a personal preference thing.

FMF **What kind of lids do you use?**

JWF The lids I prefer have a stainless-steel screen embedded in a plastic cap, and they have little feet on which you can stand the jar to let the seeds drain more readily. Those are the only things I ever purchased for sprouting (other than seeds of course) and they are available from many online vendors. [See "Resources," below.] If you use Mason jars with 2-piece lids, you can even use cheesecloth as your screen, but it's more cumbersome and drains a little less easily than dishwasher-safe stainless-steel screens. So, the equipment for sprouting is really cheap or free and readily available. You can improvise very easily.

A note from Rhonda: One extra benefit of using metal rather than plastic is that metal lids seem to drain faster and are heat tolerant, which is helpful if you use hot water to sterilize the jar ahead of time, like I do.

Examples of metal sprouting lids that can be purchased online.

Any other tips?

FMF

JWF The most important thing is that you need to be able to rinse and drain your seeds and sprouts at least three times a day, to invert your vessel and have it open for circulation so air can get in relatively easily, and you need all of the sprouts in the vessel to see light by the end of the process so that they will green up. For this reason, you wouldn't want to use something configured like a soda or drink bottle.

"Green up"?

FMF

JWF Yes – the process of chlorophyll synthesis. This isn't as critical as some would make it out to be. You can start the sprouts in the dark or the light, and even the short time that you expose them to light when you are rinsing them is enough to allow the final step in chlorophyll synthesis. Greening up is mostly for aesthetic reasons so you're not eating a white or beige plant, but it also has some nutritional aspects. The best bet for nice rich green sprouts is to make sure that the last few hours or half-day of growth takes place in daylight (or artificial light) [see next page]. I do the whole process on my kitchen counter.

Broccoli seeds on days 0, 1, 2, 3 and 4

FMF **Where can sprouters get good quality seeds?**

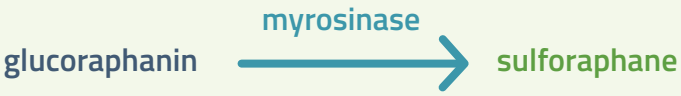
JWF Sourcing quality seeds is relatively straightforward. There are many good and conscientious vendors of seeds. [See "Resources," below.] The main thing you want to be cautious of when buying broccoli seeds or any other seeds for sprouting is that they have not been treated with pesticides. Insecticides and fungicides are almost always applied to seeds that are going to be planted in the ground to make a crop. Most people that are growing sprouts like to start with organic seeds, but that's a personal preference. Just make sure that they have not been treated with pesticides. Another factor to consider is germination rate. If you're growing seeds for sprouts you want the vast majority of them to actually sprout. With most seeds sold for sprouting you don't have to worry about that, but if they've been stored for a long, long time – such as those sold online through third party vendors – this may be a concern. A 90 to 95 percent or higher germination rate is desirable. Otherwise you'll be left with a bunch of non-germinated seeds. A final consideration is that you need the seeds to be clean and free of debris.

FMF **Does anyone "certify" how much glucoraphanin is in their seeds?**

JWF As far as I'm aware, nobody who is selling seeds for sprouting will certify the level of the glucoraphanin in broccoli seeds. But starting out with seeds that have a high level of glucoraphanin compared to other broccoli seeds is important, if what you're after is delivery of sulforaphane to your body. After all, this is likely the main reason one would want to grow broccoli sprouts. Determining how much glucoraphanin is present is a huge problem.

Now that I have retired from academia, one of my urgent objectives is to develop a directory of seeds and supplements that we've tested for glucoraphanin levels. This will involve going to a commercial lab to have the products analyzed. This is costly, and frankly there only a few labs around that I would trust to do the analyses or that routinely offer the service. I also know that it's a financial burden that most home sprouters would not want to shoulder because it costs upwards of $150 per test. Nobody wants to spend $20 on a pound of broccoli seed and pay $150 plus shipping to have a sample of that pound tested for glucoraphanin level. However, the glucoraphanin level of the broccoli seeds is absolutely and directly proportional to the level in the resulting sprouts that are eventually grown from them. So, the best I can say at this point is stay tuned and I hope to begin working on this in the very near future.

How much sulforaphane is in broccoli sprouts?



Technically speaking, broccoli sprouts contain ZERO sulforaphane. That's because the two precursors to sulforaphane, glucoraphanin and myrosinase, are sequestered in tiny vesicles within the plant and never come in contact with each other until the plant is damaged by insects, chewing, or some other vicious attack. But even a light breeze over the surface of the sprouts can bend the tiny plants sufficiently to allow glucoraphanin and myrosinase to be released. When that happens, voilà! You get sulforaphane.

FMF **Can I get sulforaphane from other types of sprouts?**

JWF Many people talk about sprouting all sorts of cruciferous vegetables and assume that they will have sulforaphane or its precursor glucoraphanin in them. It ain't so! Unfortunately, it's pretty much only broccoli seeds and their sprouts that contain glucoraphanin. There may be some in some varieties of red kale and perhaps very, very low amounts in a few of the other crucifers. All of the crucifers do indeed have close chemical relatives to glucoraphanin and sulforaphane, but not sulforaphane. In almost all cases that we're aware of except moringa, which by the way is not a crucifer, the potency of the isothiocyanate that's formed is not as good a cytoprotective compound as sulforaphane. That said, all sprouts are good for you because they're loaded with fiber, vitamins, minerals, and phytochemicals. They are living foods, they're non-processed, and if you're eating green sprouts, just about any sprouts that you like the taste of would be good for you. Just don't listen to the self-anointed nutrition experts who try to tell you that all cruciferous vegetables have sulforaphane, because they're wrong, and they don't.

FMF **Okay, so let's get down to basics. How do you sprout?**

JWF Well, the first thing I do is sanitize my seeds. I use bleach. It's inexpensive, readily available, and it works. I've used bleach ever since I discovered broccoli sprouts and started sprouting. I use a 1:10 ratio of bleach to water, with a brand of bleach containing 5 to 6 percent sodium hypochlorite, the active ingredient, and no extra additives. I bleach my seeds for 10 minutes and then I obsess over the rinsing part – meaning that I rinse well and then probably overdo it by rinsing even more. I either fill a jar and empty it 20 to 30 times, or I'll just run tap water into the jar for two or three minutes after pouring off the bleach solution. This isn't a scientific formula, and there are lots of ways you can do it.

I know that some people favor things like grapefruit extract, peracetic acid, hydrogen peroxide, or vinegar, but the experiments that I have done and the published work that I've seen makes me stick with bleach. It will wipe out any bacteria adhering to the surface of the seeds. This is important when you consider that seeds are grown in fields, and birds, deer, mice, raccoons, possums, wildcats – and even the people who are harvesting the seeds – pee and poop in those fields. It's important that you get rid of fecal contamination because this step isn't taken when the seed is harvested due to concerns over having to wet the seeds.

FMF **Wow, bleach. Doesn't that concern you?**

JWF No. Once you've killed the bacteria on the surface of the seeds, you thoroughly rinse the oxidizing agent (the bleach) off the seeds. Once you've done that, you're safe and you won't be drinking or consuming bleach. None of the published work that I've seen highlights anything better than very cheap and very widely available household bleach. So, I recommend this approach, and I think that it is foolhardy not to disinfest seeds in some manner prior to sprouting. If you don't, you're needlessly playing Russian roulette with your health.

FMF **Is there a work-around?**

JWF The only work-around to this that I'm aware of would be to buy seeds that are gamma-irradiated. If they were more widely available, I would use them all the time. However, there are many people who find this offensive and wouldn't dare use irradiated seeds. I maintain that gamma-irradiation is perfectly safe, I endorse it, and wish it were more widely used.

FMF **Sometimes sprouting might be too much trouble for some people. Can't they just take a supplement?**

JWF This question always comes up, and with good reason. I used to always say that eating fresh vegetables or fruits is best, and you shouldn't need to take supplements. Well, I still believe that, if you underline the word "shouldn't." But any of us who survive birth and the first five years of life in good health and disease-free hope that, ultimately, we'll get to a point in life where we outlive our evolutionary utility to be on this planet. In other words, once we pass reproductive age, we are useless from an evolutionary perspective.

That's a scary thought for many people to internalize, but the vast majority of scientists agree with this. Therefore, it's quite rational to assume that in order to maintain optimal health throughout a long and vigorous lifespan, we may indeed need to supplement with a variety of vitamins, minerals, and phytochemicals – underline "phytochemicals" – and perhaps even some of the more traditional macronutrients. Furthermore, as we age, especially in the developed world, we become less active and we eat less. The concept of eating nine servings a day of fresh fruits and vegetables is just about impossible for many people as they become older and less active. We can talk about "Blue Zones" and optimum practices for enhanced healthspan all we want, but the reality of Western life is that many, many people don't live their lives that way. A responsible public health approach needs to embrace the health of those people, too. So, I think we have to very seriously consider the fact that many people will probably thrive and achieve more optimal health only with appropriate dietary supplementation. That said, if you can eat them, fresh sprouts are wonderful.

FMF **How soon should you eat your sprouts after they've germinated?**

JWF Eat them soon! It's best to harvest them in the first two to five days, when their cotyledons – the seed leaves – pop out of the seed. This timing ensures that you have the highest concentration of glucoraphanin and reduces the risk of bacterial growth. I put mine in the refrigerator in the jar in which I sprouted them. In other words, my "harvest" is to stick them in the refrigerator. I generally don't keep them longer than five days. You'll know when they start to go bad because they'll get sloppy looking and smell bad. If they don't smell or look as fresh as they did when you put them in the refrigerator, get rid of them. Seeds are cheap enough that it's not worth risking your health to eat sprouts that have gone funky (very scientific term there).

FMF **Everybody wants to know how an expert like you eats his sprouts!**

JWF My favorite way is to use them fresh – in a salad or as a salad. You can put them on sandwiches, and you can put them in smoothies. You can cook them in soups, casseroles, or anything else that you would put fresh vegetables in, but I suggest that you chop them up a bit first. The texture of cooked whole broccoli sprouts (or alfalfa or radish or clover) is frankly sort of lousy.

FMF **Can you freeze them?**

JWF You can definitely freeze them, but a caution here is that as soon as they're thawed, they will be watery and stringy – much like cooked sprouts. If you do freeze them, I suggest you quick-freeze them by spreading them out on a baking sheet on waxed paper or parchment, then gather them quickly into a container for freezer storage once well-frozen. After they're frozen, you can use them in a smoothie or in cooking, but due to the lousy texture they won't be any fun on a salad or wrap or sandwich anymore.

FMF **How much sulforaphane should a person try to consume for optimal health?**

JWF This question always comes up when I'm talking to people about either sprouts or supplements. If you're talking about taking supplements, it's important, and we've dealt with this topic at some length in a recent scientific paper. But when it comes to eating sprouts, I think it's not really an issue. Let me explain why. If you have chosen to grow and eat fresh sprouts, it's likely you either enjoy their taste or at least tolerate it. However, it's very unlikely you will be able to enjoy or even consume more than between 2 to 4 ounces of them. As a point of reference, 4 ounces is what's in a typical grocery store clamshell package of sprouts. This quantity of sprouts will give you a very reasonable quantity of glucoraphanin, plus you'll be getting myrosinase, the enzyme that converts glucoraphanin to sulforaphane. You won't be able to eat much more than that unless you're the sort of person who engages in hot dog eating contests and that sort of thing, because frankly the taste itself will start to become unappealing and likely will lead to stomach upset or to indigestion or heartburn. I know that that's the case for me – I can't eat more than 3 or 4 ounces of fresh broccoli sprouts without really starting to feel uncomfortable.

Glucosinolate consumption: a matter of taste

Glucosinolates have been described alternately as sharp, pungent, acrid, astringent, or lachrymatory (tear-inducing), but they are most widely regarded – in some cases inaccurately – as bitter. Whereas the glucosinolates are notably bitter in some vegetables (Brussels sprouts, turnips, and rutabaga come to mind) those found in broccoli and broccoli sprouts are much milder.

Humans have an innate aversive reaction to bitterness – a highly conserved protective measure against ingestion of toxic substances. As a result, high consumption of bitter-tasting foods is naturally limited.

The ability to perceive bitterness relies on bitter taste receptors in the mouth, mostly on the tongue. But these receptors are found in some surprising other places, including tissues of the gut, airways, and testes.

Scientists don't fully understand what the receptors are doing in these far-flung places, but they've been implicated in a variety of activities geared toward protecting humans (or their reproductive capacity), including neuroendocrine signaling, airway openness, and sperm production.

Whether bitter-tasting compounds such as some glucosinolates modulate cell signaling pathways regulated by bitter taste receptors to elicit beneficial (or deleterious) health effects remains to be seen.

FMF **Can you eat more if they're cooked?**

JWF In this case you're also going to be limited in the amount you can eat by just getting too full, as well as perhaps not enjoying the taste when you eat too much. Cooked sprouts have all the fiber that fresh sprouts do, and again I guarantee that you won't be able to eat more than something between a half a pound and a pound of them. Frankly I'd be surprised if anybody really wanted to. It's not a pleasant sensation for most people. As with all vegetables, your body is going to limit the amount you eat even if you're trying to eat a lot. With both fresh and cooked sprouts, based on various calculations than I and others have done, you can't get "too much" glucoraphanin. You'll stop eating well before you get to that threshold, and on average you will get a very reasonable amount of sulforaphane – with some variation existing from person to person – as long as you start with seeds that are fairly rich in glucoraphanin.

FMF **Does cooking or freezing affect the amount of sulforaphane you get from your sprouts?**

JWF Yes. This is related to myrosinase, the enzyme that converts glucoraphanin to sulforaphane. Freezing and thawing sprouts activates myrosinase, as does chewing fresh sprouts. But cooking denatures, or irreversibly inactivates, myrosinase. Although a lot of clinical testing along these lines is still in progress, we think **you'd have to eat about three times more sprouts** or supplements that don't contain active myrosinase than those that do to get the same benefits.

*Disclaimer: Dr. Fahey is a researcher and scientist who studies nutrition and other subjects in the lab and the clinic, but he is not a physician. He does not give medical advice – general or personal.

Resources

• General information: Dr. Fahey recommends “The Sprout Book,” by Doug Evans.

• Seed sources: Dr. Fahey recommends Johnny’s Selected Seeds, from whom he regularly bought seeds for his lab (no connection with them in any way). The aforementioned book also lists many seed sources.

• The FAQ section from the Cullman Center for Chemoprotection (Dr. Fahey’s lab) has a lot of great information about the science associatedwith sulforaphane.

Relevant publications

•2020 article reviewing clinical trial evidence for sulforaphane: Broccoli or Sulforaphane: Is It the Source or Dose That Matters?

• 2020 article reviewing evidence for the main mechanism by which sulforaphane acts: Current Landscape of NRF2 Biomarkers in Clinical Trials

• 2016 book chapter reviewing glucosinolates: Glucosinolates from the Brassica Vegetables and Their Health Effects

• 1997 article about broccoli sprouts: Broccoli sprouts: An exceptionally rich source of inducers of enzymes that protect against chemical carcinogens

• 1992 landmark article about the discovery that sulforaphane induces cytoprotective mechanisms: A major inducer of anticarcinogenic protective enzymes from broccoli: isolation and elucidation of structure