Living With Phytic Acid

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Phytic acid is one of a number of "anti-nutrients" in grains and legumes. For an introduction to this subject, please see this article. Proper preparation of whole grains will neutralize a large portion of these problematic compounds.

Studies on phytic acid reveal that for some people, the phytic acid in whole grains blocks calcium, zinc, magnesium, iron and copper; others seem immune to these adverse consequences, probably because of favorable gut flora, which in some cases can break down phytic acid. In addition, when animal fats providing vitamins A and D accompany dietary whole grains, the effects of phytic acid are mitigated.

The author of the following article found that eliminating phytic acid in his diet and the diet of his family helped reverse serious tooth decay; not everyone will need to take such drastic steps. However, proper preparation of whole grains is a good idea for everyone as it is a practice found almost universally among nonindustrialized peoples.

Preparing Grains, Nuts, Seeds and Beans for Maximum Nutrition

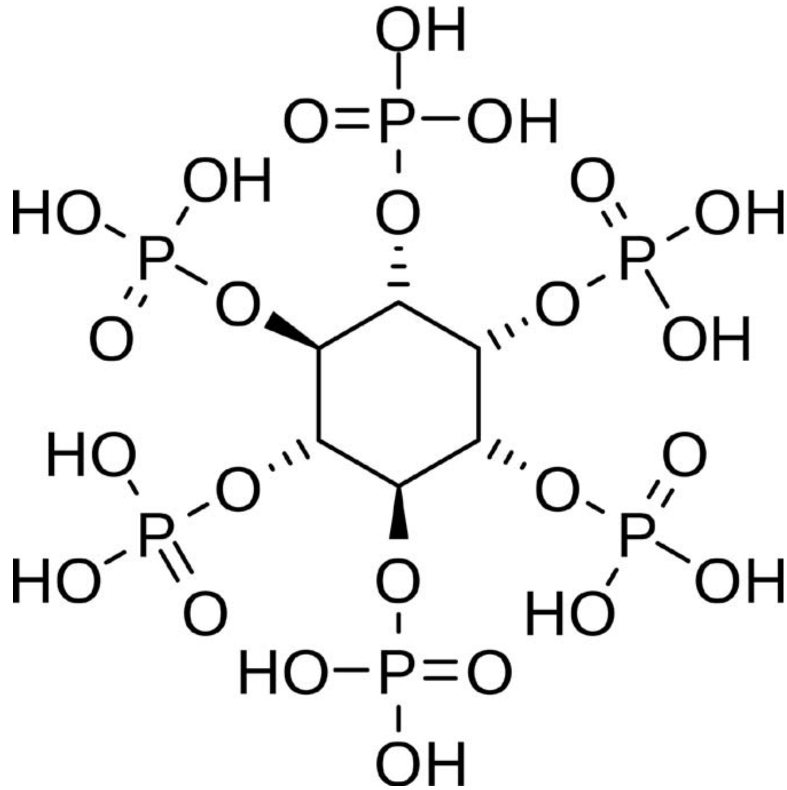
Phytic acid in grains, nuts, seeds and beans represents a serious problem in our diets. This problem exists because we have lost touch with our ancestral heritage of food preparation. Instead we listen to food gurus and ivory tower theorists who promote the consumption of raw and unprocessed "whole foods;" or, we eat a lot of high-phytate foods like commercial whole wheat bread and all-bran breakfast cereals. But raw is definitely not Nature's way for grains, nuts, seeds and beans. . . and even some tubers, like yams; nor are quick cooking or rapid heat processes like extrusion.

Phytic acid is the principal storage form of phosphorus in many plant tissues, especially the bran portion of grains and other seeds. It contains the mineral phosphorus tightly bound in a snowflake-like molecule. In humans and animals with one stomach, the phosphorus is not readily bioavailable. In addition to blocking phosphorus availability, the "arms" of the phytic acid molecule readily bind with other minerals, such as calcium, magnesium, iron and zinc, making them unavailable as well. In this form, the compound is referred to as phytate.

Phytic acid not only grabs on to or chelates important minerals, but also inhibits enzymes that we need to digest our food, including pepsin,[1] needed for the breakdown of proteins in the stomach, and amylase,[2] needed for the breakdown of starch into sugar. Trypsin, needed for protein digestion in the small intestine, is also inhibited by phytates.[3]

Through observation I have witnessed the powerful anti-nutritional effects of a diet high in phytate-rich grains on my family members, with many health problems as a result, including tooth decay, nutrient deficiencies, lack of appetite and digestive problems.

The presence of phytic acid in so many enjoyable foods we regularly consume makes it imperative that we know how to prepare these foods to neutralize phytic acid content as much as possible, and also to consume them in the context of a diet containing factors that mitigate the harmful effects of phytic acid.



Six-sided phytic acid molecule with a phosphorus atom in each arm.

PHYTATES IN FOOD

Phytic acid is present in beans, seeds, nuts, grains—especially in the bran or outer hull; phytates are also found in tubers, and trace amounts occur in certain fruits and vegetables like berries and green beans. Up to 80 percent of the phosphorus—a vital mineral for bones and health—present in grains is locked into an unusable form as phytate.[4] When a diet including more than small amounts of phytate is consumed, the body will bind calcium to phytic acid and form insoluble phytate complexes. The net result is you lose calcium, and don't absorb phosphorus. Further, research suggests that we will absorb approximately 20 percent more zinc and 60 percent magnesium from our food when phytate is absent.[5]

The amount of phytate in grains, nuts, legumes and seeds is highly variable; the levels that researchers find when they analyze a specific food probably depends on growing conditions, harvesting techniques, processing methods, testing methods and even the age of the food being tested. Phytic acid will be much higher in foods grown using modern high-phosphate fertilizers than those grown in natural compost.[6]

Seeds and bran are the highest sources of phytates, containing as much as two to five times more phytate than even some varieties of soybeans, which we know are highly indigestible unless fermented for long periods. Remember the oat bran fad? The advice to eat bran, or high fiber foods containing different types of bran, is a recipe for severe bone loss and intestinal problems due to the high phytic acid content. Raw unfermented cocoa beans and normal cocoa powder are extremely high in phytates. Processed chocolates may also contain phytates. White chocolate or cocoa butter probably does not contain phytates. More evidence is needed as to phytate content of prepared chocolates and white chocolate. Coffee beans also contain phytic acid. The chart in Figure 1 shows the variability of phytate levels in various common foods as a percentage of dry weight. Phytate levels in terms of milligrams per hundred grams are shown in Figure 2.

DETRIMENTAL EFFECTS

High-phytate diets result in mineral deficiencies. In populations where cereal grains provide a major source of calories, rickets and osteoporosis are common.[10]

Interestingly, the body has some ability to adapt to the effects of phytates in the diet. Several studies show that subjects given high levels of whole wheat at first excrete more calcium than they take in, but after several weeks on this diet, they reach a balance and do not excrete excess calcium.[11] However, no studies of this phenomenon have been carried out over a long period; nor have researchers looked at whether human beings can adjust to the phytate-reducing effects of other important minerals, such as iron, magnesium and zinc.

The zinc- and iron-blocking effects of phytic acid can be just as serious as the calcium-blocking effects. For example, one study showed that a wheat roll containing 2 mg phytic acid inhibited zinc absorption by 18 percent; 25 mg phytic acid in the roll inhibited zinc absorption by 64 percent; and 250 mg inhibited zinc absorption by 82 percent.12 Nuts have a marked inhibitory action on the absorption of iron due to their phytic acid content.[13]

Over the long term, when the diet lacks minerals or contains high levels of phytates or both, the metabolism goes down, and the body goes into mineral-starvation mode. The body then sets itself up to use as little of these minerals as possible. Adults may get by for decades on a high-phytate diet, but growing children run into severe problems. In a phytate-rich diet, their bodies will suffer from the lack of calcium and phosphorus with poor bone growth, short stature, rickets, narrow jaws and tooth decay; and for the lack of zinc and iron with anemia and mental retardation.

THE EXPERIMENTS OF EDWARD MELLANBY

As early as 1949, the researcher Edward Mellanby demonstrated the demineralizing effects of phytic acid. By studying how grains with and without phytic acid affect dogs, Mellanby discovered that consumption of high-phytate cereal grain interferes with bone growth and interrupts vitamin D metabolism. High levels of phytic acid in the context of a diet low in calcium and vitamin D resulted in rickets and a severe lack of bone formation.

His studies showed that excessive phytate consumption uses up vitamin D. Vitamin D can mitigate the harmful effects of phytates, but according to Mellanby, "When the diet is rich in phytate, perfect bone formation can only be procured if sufficient calcium is added to a diet containing vitamin D."[20]

Mellanby's studies showed that the rickets-producing effect of oatmeal is limited by calcium.[21] Calcium salts such as calcium carbonate or calcium phosphate prevent oatmeal from exerting rickets-producing effect. According to this view, the degree of active interference with calcification produced by a given cereal will depend on how much phytic acid and how little calcium it contains, or how little calcium the diet contains. Phosphorus in the diet (at least from grains) needs some type of calcium to bind to. This explains the synergistic combination of sourdough bread with cheese. Historically, the cultivation of grains usually accompanies the raising of dairy animals; high levels of calcium in the diet mitigates the mineral-depleting effects of phytic acid.

In Mellanby's experiments with dogs, increasing vitamin D made stronger bones regardless of the diet, but this increase did not have a significant impact on the amount of calcium excreted. Those on diets high in phytate excreted lots of calcium; those on diets high in phosphorus from meat or released from phytic acid through proper preparation excreted small amounts of calcium.

Based on Mellanby's thorough experiments, one can conclude that the growth of healthy bones requires a diet high in vitamin D, absorbable calcium and absorbable phosphorus, and a diet low in unabsorbable calcium (supplements, pasteurized dairy) and unabsorbable phosphorus (phytates). Interestingly, his experiments showed that unbleached flour and white rice were less anti-calcifying than whole grains that contain more minerals but also were higher in phytic acid. Other experiments have shown that while whole grains contain more minerals, in the end equal or lower amounts of minerals are absorbed compared to polished rice and white flour. This outcome is primarily a result of the blocking mechanism of phytic acid, but may be secondarily the result of other anti-nutrients in grains.

Thus, absorbable calcium from bone broths and raw dairy products, and vitamin D from certain animal fats, can reduce the adverse effects of phytic acid.

Other studies show that adding ascorbic acid can significantly counteract inhibition of iron assimilation by phytic acid.[22] Adding ascorbic acid significantly counteracted phytate inhibition from phytic acid in wheat. [23] One study showed that anti-iron phytate levels in rice were disabled by vitamin C in collard greens.[24]

Research published in 2000 indicates that both vitamin A and beta-carotene form a complex with iron, keeping it soluble and preventing the inhibitory effect of phytates on iron absorption.[25] Here we have another reason to consume phytate-rich foods in the context of a diet containing organ meat and animal fats rich in vitamin A, and fruits and vegetables rich in carotenes.

PHYTASE

Phytase is the enzyme that neutralizes phytic acid and liberates the phosphorus. This enzyme co-exists in plant foods that contain phytic acid.

Ruminant animals such as cows, sheep and goats have no trouble with phytic acid because phytase is produced by rumen microorganisms; monogastric animals also produce phytase, although far less. Mice produce thirty times more phytase than humans,[26] so they can be quite happy eating a raw whole grain. Data from experiments on phytic acid using mice and other rodents cannot be applied to humans.

In general, humans do not produce enough phytase to safely consume large quantities of high-phytate foods on a regular basis. However, probiotic lactobacilli, and other species of the endogenous digestive microflora can produce phytase.[27] Thus, humans who have good intestinal flora will have an easier time with foods containing phytic acid. Increased production of phytase by the gut microflora explains why some volunteers can adjust to a high-phytate diet. Sprouting activates phytase, thus reducing phytic acid.[28] The use of sprouted grains will reduce the quantity of phytic acids in animal feed, with no significant reduction of nutritional value.[29]

Soaking grains and flour in an acid medium at very warm temperatures, as in the sourdough process, also activates phytase and reduces or even eliminates phytic acid.

Before the advent of industrial agriculture, farmers typically soaked crushed grain in hot water before feeding it to poultry and hogs. Today, feed manufacturers add phytase to grain mixes to get better growth in animals. Commercial phytases are typically produced using recombinant DNA technology. For example, a bacterial phytase gene has recently been inserted into yeast for commercial production.

Not all grains contain enough phytase to eliminate the phytate, even when properly prepared. For example, corn, millet, oats and brown rice do not contain sufficient phytase to eliminate all the phytic acid they contain. On the other hand, wheat and rye contain high levels of phytase—wheat contains fourteen times more phytase than rice and rye contains over twice as much phytase as wheat.[30] Soaking or souring these grains, when freshly ground, in a warm environment will destroy all phytic acid. The high levels of phytase in rye explain why this grain is preferred as a starter for sourdough breads.

Phytase is destroyed by steam heat at about 176 degrees Fahrenheit in ten minutes or less. In a wet solution, phytase is destroyed at 131-149 degrees Fahrenheit.[31] Thus heat processing, as in extrusion, will completely destroy phytase—think of extruded all-bran cereal, very high in phytic acid and all of its phytase destroyed by processing. Extruded cereals made of bran and whole grains are a recipe for digestive problems and mineral deficiencies!

Phytase is present in small amounts in oats, but heat treating to produce commercial oatmeal renders it inactive. Even grinding a grain too quickly or at too high a temperature will destroy phytase, as will freezing and long storage times. Fresh flour has a higher content of phytase than does flour that has been stored.[32] Traditional cultures generally grind their grain fresh before preparation. Weston Price found that mice fed whole grain flours that were not freshly ground did not grow properly.[33]

Cooking is not enough to reduce phytic acid—acid soaking before cooking is needed to activate phytase and let it do its work. For example, the elimination of phytic acid in quinoa requires fermenting or germinating plus cooking (see Figure 3). In general, a combination of acidic soaking for considerable time and then cooking will reduce a significant portion of phytate in grains and legumes.

THE PHYTATE THRESHOLD

It appears that once the phytate level has been reduced, such that there is more available phosphorus than phytate in the grain, we have passed a critical point and the food becomes more beneficial than harmful. Retention of phosphorus decreases when phytate in the diet is 30-40 percent or more of the total phosphorus.[35]

For best health, phytates should be lowered as much as possible, ideally to 25 milligrams or less per 100 grams or to about .03 percent of the phytate-containing food eaten. At this level, micronutrient losses are minimized. (For phytate content of common foods as a percentage of dry weight, see Figures 4 and 5.)

White rice and white bread are low-phytate foods because their bran and germ have been removed; of course, they are also devitalized and empty of vitamins and minerals. But the low phytate content of refined carbohydrate foods may explain why someone whose family eats white flour or white rice food products may seem to be relatively healthy and immune to tooth cavities while those eating whole wheat bread and brown rice could suffer from cavities, bone loss and other health problems.

PHYTATES AND GERMINATION

Beer home brewers know that in order to make beer, they need malted (sprouted) grains. Soaking and germinating grains is a good idea, but it does not eliminate phytic acid completely. Significant amounts of phytic acid will remain in most sprouted grain products. For example, malting reduces wheat, barley or green gram phytic acid by 57 percent. However, malting reduces anti-nutrients more than roasting.[36] In another experiment, malting millet also resulted in a decrease of 23.9 percent phytic acid after 72 hours and 45.3 percent after 96 hours.[37]

In legumes, sprouting is the most effective way to reduce phytic acid, but this process does not get rid of all of it. Germinating peanuts led to a 25 percent reduction in phytates. After five days of sprouting, chick peas maintained about 60 percent of their phytate content and lentils retained about 50 percent of their original phytic acid content. Sprouting and boiling pigeon pea and bambara groudnut reduced phytic acid by 56 percent.[38] Germinating black eyed beans resulted in 75 percent removal of phytate after five days sprouting.

Germination is more effective at higher temperatures, probably because the heat encourages a fermentation-like condition. For pearled millet, sprouting at 92 degrees F for a minimum of 48 hours removed 92 percent of the phytate. At 82 degrees F, even after 60 hours, only 50 percent of phytic acid was removed. Higher temperatures above 86 degrees F seem less ideal for phytate removal, at least for millet.[39]

Sprouting releases vitamins and makes grains and beans and seeds more digestible. However it is a pre-fermentation step, not a complete process for neutralizing phytic acid. Consuming grains regularly that are only sprouted will lead to excess intake of phytic acid. Sprouted grains should also be soaked and cooked.

ROASTING AND PHYTIC ACID

Roasting wheat, barley or green gram reduces phytic acid by about 40 percent. [40] If you subsequently soak roasted grains, you should do so with a culture that supplies additional phytase, as phytase will be destroyed by the roasting process.

ACIDIC SOAKING AND PHYTIC ACID

For grains and legumes that are low in phytase, soaking does not usually sufficiently eliminate phytic acid. Soaking of millet, soya bean, maize, sorghum, and mung bean at 92 degrees F for 24 hours decreased the contents of phytic acid by 4–51 percent.[43] With these same grains and beans, soaking at room temperature for 24 hours reduced phytic acid levels by 16–21 percent.[44] However, soaking of pounded maize for one hour at room temperature already led to a reduction of phytic acid by 51 percent.[45]

Sourdough fermentation of grains containing high levels of phytase—such as wheat and rye—is the process that works best for phytate reduction. Sourdough fermentation of whole wheat flour for just four hours at 92 degrees F led to a 60 percent reduction in phytic acid. Phytic acid content of the bran samples was reduced to 44.9 percent after eight hours at 92 degrees F.[46] The addition of malted grains and bakers yeast increased this reduction to 92-98 percent. Another study showed almost complete elimination of phytic acid in whole wheat bread after eight hours of sourdough fermentation (See Figure 6).[47]

A study of phytates in recipes used typically by home bread bakers found that leavening with commercial yeast was much less effective at removing phytates. Yeasted whole wheat breads lost only 22-58 percent of their phytic acid content from the start of the bread making process to the complete loaf.[48]

PHYTIC ACID AND YOU

The purpose of this article is not to make you afraid of foods containing phytic acid, only to urge caution in including grains, nuts and legumes into your diet. It is not necessary to completely eliminate phytic acid from the diet, only to keep it to acceptable levels.

An excess of 800 mg phytic acid per day is probably not a good idea. The average phytate intake in the U.S. and the U.K. ranges between 631 and 746 mg per day; the average in Finland is 370 mg; in Italy it is 219 mg; and in Sweden a mere 180 mg per day.[49]

In the context of a diet rich in calcium, vitamin D, vitamin A, vitamin C, good fats and lacto-fermented foods, most people will do fine on an estimated 400-800 mg per day. For those suffering from tooth decay, bone loss or mineral deficiencies, total estimated phytate content of 150-400 mg would be advised. For children under age six, pregnant women or those with serious illnesses, it is best to consume a diet as low in phytic acid as possible.

In practical terms, this means properly preparing phytate-rich foods to reduce at least a portion of the phytate content, and restricting their consumption to two or three servings per day. Daily consumption of one or two slices of genuine sourdough bread, a handful of nuts, and one serving of properly prepared oatmeal, pancakes, brown rice or beans should not pose any problems in the context of a nutrient-dense diet. Problems arise when whole grains and beans become the major dietary sources of calories— when every meal contains more than one whole grain product or when over-reliance is placed on nuts or legumes. Unfermented soy products, extruded whole grain cereals, rice cakes, baked granola, raw muesli and other high-phytate foods should be strictly avoided.

RICE

Brown rice is high in phytates. One reference puts phytate content at 1.6 percent of dry weight, another at 1250 mg per 100 grams dry weight (probably about 400 mg per 100 grams cooked rice). Soaking brown rice will not effectively eliminate phytates because brown rice lacks the enzyme phytase; it thus requires a starter. Nevertheless, even an eight-hour soak will eliminate some of the phytic acid, reducing the amount in a serving to something like 300 mg or less.

The ideal preparation of rice would start with home-milling, to remove a portion of the bran, and then would involve souring at a very warm temperature (90 degrees F) at least sixteen hours, preferably twenty-four hours. Using a starter would be ideal (see sidebar recipe). For those with less time, purchase brown rice in air-tight packages. Soak rice for at least eight hours in hot water plus a little fresh whey, lemon juice or vinegar. If you soak in a tightly closed mason jar, the rice will stay warm as it generates heat. Drain, rinse and cook in broth and butter.

NUTS

In general, nuts contain levels of phytic acid equal to or higher than those of grains. Therefore those consuming peanut butter, nut butters or nut flours, will take in phytate levels similar to those in unsoaked grains. Unfortunately, we have very little information on phytate reduction in nuts. Soaking for seven hours likely eliminates some phytate. Based on the accumulation of evidence, soaking nuts for eighteen hours, dehydrating at very low temperatures—a warm oven—and then roasting or cooking the nuts would likely eliminate a large portion of phytates.

Nut consumption becomes problematic in situations where people on the GAPS diet and similar regimes are consuming lots of almonds and other nuts as a replacement for bread, potatoes and rice. The eighteen-hour soaking is highly recommended in these circumstances.

It is best to avoid nut butters unless they have been made with soaked nuts—these are now available commercially. Likewise, it is best not to use nut flours—and also coconut flour—for cooking unless they have been soured by the soaking process.

It is instructive to look at Native American preparation techniques for the hickory nut, which they used for oils. To extract the oil they parched the nuts until they cracked to pieces and then pounded them until they were as fine as coffee grounds. They were then put into boiling water and boiled for an hour or longer, until they cooked down to a kind of soup from which the oil was strained out through a cloth. The rest was thrown away. The oil could be used at once or poured into a vessel where it would keep a long time.[50]

By contrast, the Indians of California consumed acorn meal after a long period of soaking and rinsing, then pounding and cooking. Nuts and seeds in Central America were prepared by salt water soaking and dehydration in the sun, after which they were ground and cooked.

BEANS

All beans contain phytic acid and traditional cultures usually subjected legumes to a long preparation process. For example, according to one source, “Lima beans in Nigeria involve several painstaking processes to be consumed as a staple.”[51] In central America, beans are made into a sour porridge called chugo, which ferments for several days.

The best way of reducing phytates in beans is sprouting for several days, followed by cooking. An eighteen-hour fermention of beans without a starter at 95 degrees F resulted in 50 percent phytate reduction.[52] Lentils fermented for 96 hours at 108 degrees F resulted in 70-75 percent phytate destruction.[53] Lentils soaked for 12 hours, germinated 3-4 days and then soured will likely completely eliminate phytates.

Soaking beans at moderate temperatures, such as for 12 hours at 78 degrees F results in an 8-20 percent reduction in phytates.[54]

When legumes comprise a large portion of the diet, one needs to go to extra steps to make beans healthy to eat. Beans should usually have hull and bran removed. Adding a phytase-rich medium to beans would help eliminate the phytic acid in beans. Adding yeast, or effective micororganisms, or kombu seaweed may greatly enhance the predigestive process of the beans. One website suggests using a starter containing effective microorganisms and cultured molasses for soaking beans.[55]

At a minimum, beans should be soaked for twelve hours, drained and rinsed several times before cooking, for a total of thirty-six hours. Cooking with a handful of green weed leaves, such as dandelion or chickweed, can improve mineral assimilation.

TUBERS

Sweet potatoes and potatoes contain little phytic acid but yams and other starchy staples contain levels of phytate that we cannot ignore. The phytic acid content of arrowroot is unknown, but it may contain a significant amount.[56] These foods should be fermented—as they usually are in traditional cultures—if they are a staple in the diet. For occasional eating, cooking well and consuming with plenty of butter and vitamin C-rich foods should suffice.

BREAD

Bread can only be called the staff of life if it has undergone careful preparation; otherwise bread can be the road to an early grave. For starters, the flour used in bread should be stone ground. Wheat and rye contain high levels of phytase, but this is destroyed by the heat of industrial grinding, and also lessens over time. Fresh grinding of wheat or rye berries before use will ensure that the original amount of phytase remains in the flour.

Rye has the highest level of phytase in relation to phytates of any grain, so rye is the perfect grain to use as a sourdough starter. Phytates in wheat are greatly reduced during sourdough preparation, as wheat is also high in phytase. Yeast rising bread may not fully reduce phytic acid levels.[57] Phytate breakdown is significantly higher in sourdough bread than in yeasted bread.[58]

Yet even with the highly fermentable rye, a traditional ancient recipe from the French calls for removal of 25 percent of the bran and coarse substances.[59] As an example of this practice, one small bakery in Canada sifts the coarse bran out of the flour before making it into bread.[62]

OATS

Oats contain very little phytase, especially after commercial heat treatment, and require a very long preparation period to completely reduce phytic acid levels. Soaking oats at 77 degrees F for 16 hours resulted in no reduction of phytic acid, nor did germination for up to three days at this temperature.[63] However, malting (sprouting) oats for five days at 52 degrees F and then soaking for 17 hours at 120 degrees F removes 98 percent of phytates. Adding malted rye further enhances oat phytate reduction.[64] Without initial germination, even a five-day soaking at a warm temperature in acidic liquid may result in an insignificant reduction in phytate due to the low phytase content of oats. On the plus side, the process of rolling oats removes a at least part of the bran, where a large portion of the phytic acid resides.

How do we square what we know about oats with the fact that oats were a staple in the diet of the Scots and Gaelic islanders, a people known for their robust good health and freedom from tooth decay? For one thing, high amounts of vitamin D from cod’s liver and other sources, helps prevent calcium losses from the high oat diet. Absorbable calcium from raw dairy products, consumed in abundance on mainland Scotland, provides additional protection.

In addition, it is likely that a good part of the phytase remained in the oats of yore, which partially germinated in stacks left for a period in the field, were not heat treated and were hand rolled immediately prior to preparation. And some Scottish and Gaelic recipes do call for a long fermentation of oats before and even after they are cooked.

Unprocessed Irish or Scottish oats, which have not been heated to high temperatures, are availabile in some health food stores and on the internet. One study found that unheated oats had the same phytase activity as wheat.[65] They should be soaked in acidulated water for as long as twenty-four hours on top of a hot plate to keep them at about 100 degrees F. This will reduce a part of the phytic acid as well as the levels of other anti-nutrients, and result in a more digestible product. Overnight fermenting of rolled oats using a rye starter—or even with the addition of a small amount of fresh rye flour—may result in a fairly decent reduction of phytate levels. It is unclear whether heat-treated oats are healthy to eat regularly.

SEEDS

Seeds—such as pumpkin seeds—are extremely high in phytic acid and require thorough processing to remove it. Some may be removed by soaking and roasting. It is best to avoid consuming or snacking on raw seeds. By the way, cacao is a seed. Cacao contains irritating tannins and is said to be extremely high in phytic acid, although studies verifying phytic acid levels in cacao could not be located. Some brands of raw cocoa and cocoa powder may be fermented, others may not be. Check with the manufacturer before indulging!

CORN

Corn is high in phytic acid and low in phytase. The Native Americans fermented cooked corn meal for two weeks, wrapped in corn husks, before preparing it as a flat bread or tortilla. In Africa, corn is fermented for long periods of time using a lactobacillis culture to produce foods like kishk, banku, or mawe. No such care is given to corn products in the western world! But you can prepare healthy corn products at home. As with oatmeal, the addition of a rye starter or rye flour to the soaking water may be particularly helpful in reducing phytate content—think of the colonial "Ryn'n'Injun" bread made from rye and corn. In one research project, soaking ground corn with 10 percent whole rye flour resulted in a complete reduction of phytate in six hours.[66] Again, more research—and more experimenting in the kitchen—is needed!

RYE TO THE RESCUE

For those who need to reduce phytic acid to minimum levels—those suffering from tooth decay, bone loss and nutrient deficiencies—the magic ingredient is rye. To bring the phytate content of your diet to the absolute minimum, add freshly ground rye flour or a sourdough rye culture to rolled or cut oats, cornmeal, rice and other low-phytase grains, then soak in an acidic medium—preferably water with whey, yogurt or sour milk added—on a hot plate to bring the temperature up to about 100 degrees F. This is a better solution than consuming white rice and white flour, which are relative low in phytate but have a greatly reduced mineral content (see Figure 7).

The intention of the article is not to impose a decision about whether or not to consume grains, nuts, seeds and beans; rather it is to clarify how to consume them with awareness. This way you can maximize your health by making grain-based foods more digestible and absorbable. Now it is very clear which foods contain phytic acid and how much they contain, what the health effects of phytic acid are and how to mitigate phytic acid in your diet with complementary foods rich in vitamin C, vitamin D and calcium. Methods for preparation of grains, seeds, and beans have been clarified, so that you can estimate how much phytic acid you are consuming. One meal high in phytic acid won't cause a healthy person any harm. But high phytic acid levels over weeks and months can be very problematic.

Fortunately, not only are properly prepared foods better for you, they also taste great. Now you can enjoy some well fermented sourdough bread, together with a piece of raw milk cheese, lots of butter and a slice of meat of your choice and taste the essence of life.

Note to readers: This article is a work in progress. Please send additional information or comments to phytates@curetoothdecay.com

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SIDEBARS

FIGURE 1: FOOD SOURCES OF PHYTIC ACID[7]
As a percentage of dry weight

FOOD	MINIMUM	MAXIMUM
Sesame seed flour	5.36	5.36
Brazil nuts	1.97	6.34
Almonds	1.35	3.22
Tofu	1.46	2.90
Linseed	2.15	2.78
Oat meal	0.89	2.40
Beans, pinto	2.38	2.38
Soy protein concentrate	1.24	2.17
Soybeans	1.00	2.22
Corn	0.75	2.22
Peanuts	1.05	1.76
Wheat flour	0.25	1.37
Wheat	0.39	1.35
Soy beverage	1.24	1.24
Oats	0.42	1.16
Wheat germ	0.08	1.14
Whole wheat bread	0.43	1.05
Brown rice	0.84	0.99
Polished rice	0.14	0.60

Chickpeas	0.56	0.56
Lentils	0.44	0.50

FIGURE 2: PHYTIC ACID LEVELS[8]
In milligrams per 100 grams of dry weight

Brazil nuts	1719
Cocoa powder	1684-1796
Brown rice	1250[9]
Oat flakes	1174
Almond	1138 – 1400
Walnut	982
Peanut roasted	952
Peanut ungerminated	821
Lentils	779
Peanut germinated	610
Hazel nuts	648 – 1000
Wild rice flour	634 – 752.5
Yam meal	637
Refried beans	622
Corn tortillas	448
Coconut	357
Corn	367
Entire coconut meat	270
White flour	258
White flour tortillas	123
Polished rice	11.5 – 66

Strawberries	12

PHYTATES: A BENEFICIAL ROLE?

As evidence of the detrimental effects of phytates accumulates, reports on alleged beneficial effects have also emerged. In fact, a whole book, *Food Phytates*, published in 2001 by CRC press, attempts to build a case for "phytates' potential ability to lower blood glucose, reduce cholesterol and triacylglycerols, and reduce the risks of cancer and heart disease."[14]

One argument for the beneficial effects of phytates is based on the premise that they act as anti-oxidants in the body. But recent studies indicate that an overabundance of anti-oxidants is not necessarily a good thing as these compounds will inhibit the vital process of oxidation, not only in our cells but also in the process of digestion.

Another theory holds that phytates bind to extra iron or toxic minerals and remove them from the body, thus acting as chelators and promoting detoxification. As with all anti-nutrients, phytates may play a therapeutic role in certain cases.

For example, researchers claim that phytic acid may help prevent colon cancer and other cancers.[15] Phytic acid is one of few chelating therapies used for uranium removal.[16]

Phytic acid's chelating effect may serve to prevent, inhibit, or even cure some cancers by depriving those cells of the minerals (especially iron) they need to reproduce.[17] The deprivation of essential minerals like iron would, much like other broad treatments for cancer, also have negative effects on non-cancerous cells. For example, prolonged use of phytic acid to clear excess iron may deprive other cells in the body that require iron (such as red blood cells).

One theory is that phytates can help patients with kidney stones by removing excess minerals from the body. However, a long-term study involving over forty-five thousand men found no correlation between kidney stone risk and dietary intake of phytic acid.[18]

Phytates also have the potential for use in soil remediation, to immobilize uranium, nickel and other inorganic contaminants.[19]

OTHER ANTI-NUTRIENTS

Phytates represent just one of many anti-nutrients in grains, nuts, tubers, seeds and beans. These include oxalates, tannins, trypsin inhibitors, enzyme inhibitors, lectins (hemagglutinins), protease inhibitors, gluten, alpha-amylase inhibitors and alkylresorcinols .

Anti-nutrients exist in these plant foods because they are part of the process of life. The natural world requires them in order to perform many important tasks, including protection against insects, maintaining freshness of seeds for germination, and protection against mold and fungus. In order to consume these foods on a regular basis we must remove the phytates and other anti-nutrients through processing in harmonious ways. Many people in the health field assure us that if something is from nature, then it doesn't require processing. Phytates act as the seed's system of preservatives, like the impossible-to-open plastic packaging of many consumer goods. To get to the item we need —namely, phosphorus—we need to unwrap the phytate-phosphorus package.

FIGURE 3: QUINOA PHYTATE REDUCTION[34]

PROCESS	PHYTATE REDUCTION
Cooked for 25 minutes at 212 degrees F	15-20 percent
Soaked for 12-14 hours at 68 degrees F, then cooked	60-77 percent
Fermented with whey 16-18 hours at 86 degrees F, then cooked	82-88 percent
Soaked 12-14 hours, germinated 30 hours, lacto-fermented 16-18 hours, then cooked at 212 degrees F for 25 minutes	97-98 percent

FIGURE 4: PHYTATE[41]

As Percentage of Dry Weight

Sesame seeds dehulled	5.36
100% Wheat bran cereal	3.29
Soy beans	1.00 – 2.22
Pinto beans	0.60 – 2.38
Navy beans	0.74 – 1.78
Parboiled brown rice	1.60
Oats	1.37
Peanuts	1.05 – 1.76
Barley	1.19
Coconut meal	1.17
Whole corn	1.05
Rye	1.01
Wheat flour	0.96
Brown rice	0.84 – 0.94
Chickpeas	0.28 – 1.26
Lentils	0.27 – 1.05
Milled (white) rice	0.2

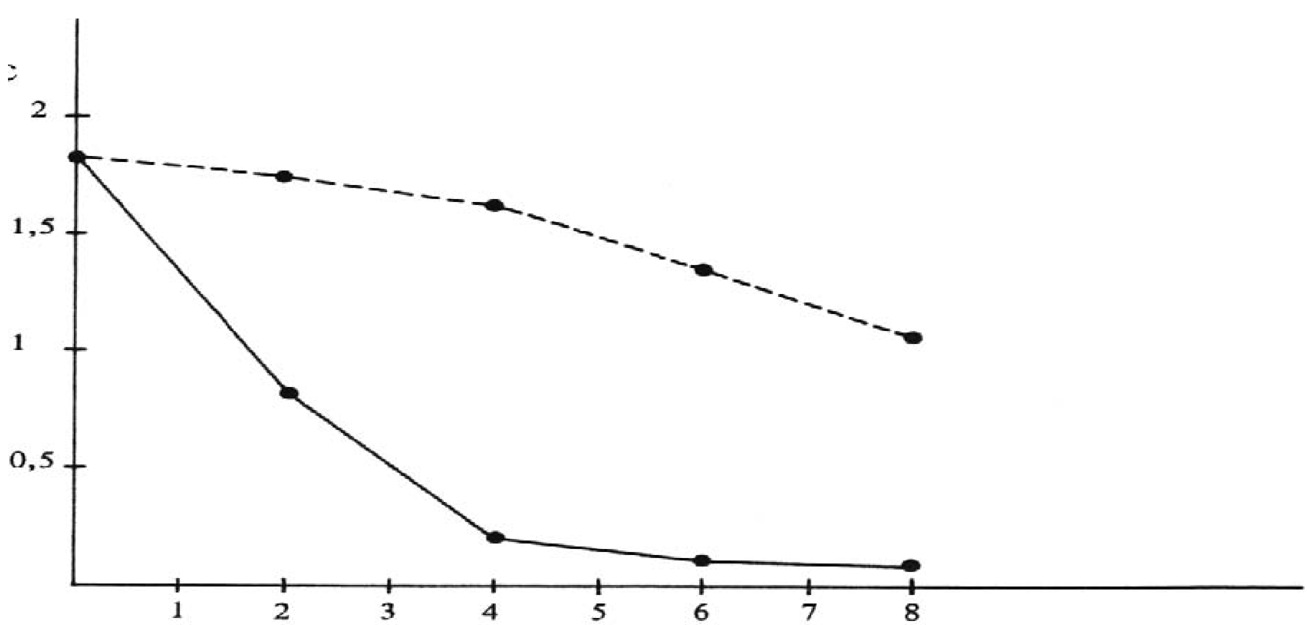
FIGURE 5: BREAD PHYTATES[42]

As Percentage of Weight

Cornbread	1.36
Whole wheat bread	0.43-1.05
Wheat bran muffin	0.77-1.27
Popped corn	0.6
Rye	0.41
Pumpernickel	0.16
White bread	0.03- .23
French bread	0.03
Sourdough rye	0.03
Soured buckwheat	0.03

FIGURE 6: REDUCTION OF PHYTIC ACID IN WHOLE WHEAT SOURDOUGH BREAD[47]

Percentage of Phytic Acid



Time

—- Yeast Fermentation

___ Sourdough Fermentation

PREPARATION OF BROWN RICE

1. Soak brown rice in dechlorinated water for 24 hours at room temperature without changing the water. Reserve 10% of the soaking liquid (should keep for a long time in the fridge). Discard the rest of the soaking liquid; cook the rice in fresh water.

2. The next time you make brown rice, use the same procedure as above, but add the soaking liquid you reserved from the last batch to the rest of the soaking water.

3. Repeat the cycle. The process will gradually improve until 96% or more of the phytic acid is degraded at 24 hours.

Source: Stephan Guyenet http://wholehealthsource.blogspot.com/2009/04/new-way-to-soak-brown-rice.html.

PHYTATES IN BRAN

A survey of indigenous dishes shows that the bran is consistently removed from a variety of grains. The only exception seems to be beer. Traditional beer production—involving soaking, germination, cooking and fermentation—removes phytic acid and releases the vitamins from the bran and germ of grains.

The traditional method for preparing brown rice is to pound it in a mortar and pestle in order to remove the bran. The pounding process results in milled rice, which contains a reduced amount of the bran and germ. Experiments have verified the fact that milled rice, rather than whole brown rice, results in the highest mineral absorption from rice.

The idea we should eat bran is based on the idea of "not enough." We somehow believe that grains without the bran do not provide enough nutrients. But solving the problem of a lack of bioavailable minerals in the diet may be more a question of soil fertility than of consuming every single part of the grain. A study of the famous Deaf Smith County Texas, the "town without a toothache"—because of their mineral-rich soil producing fabulous butter fat—found that its wheat contained six times the amount of phosphorus as normal wheat.[60] In this case, wheat minus the bran grown in rich soils will have significant amounts or even more phosphorus compared to wheat with the bran grown in poor soil. Low nutrient content in food seems to be better solved by focusing on soil fertility, rather than trying to force something not digestible into a digestible form.

There are many studies in which researchers have tried to find out how to make the bran of different grains digestible and to provide additional nutrition. But small additions of phosphorus- and calcium-rich dairy products, such as milk and cheese, or phosphorous-rich meat will make up for the moderate reductions in mineral intakes from grains without the bran. In one study, the calcium, magnesium, phosphorous and potassium in diets made up with 92 percent flour (almost whole wheat) were less completely absorbed than the same minerals in diets made up with 69 percent flour (with a significant amount of bran and germ removed).[61] This study involved yeasted bread. With sourdough bread, the phytate content of bran will be largely reduced if a phytase-rich starter is used and the flour is fermented at least twenty-four hours.

FIGURE 7: NUTRIENTS IN GRAINS AND OTHER FOODS[67]
In milligrams per 100 grams.

	Calcium	Phosphorus	Iron	Calories
Whole grain wheat flour	34	346	3.9	339
Unenriched white flour	15	108	1.2	364

White rice	9	108	0.4	366
Milled rice	10-30	80-150	.2-2.8	349-373
Brown rice	10-50	170-430	.2-5.2	363-385
Blue corn mush (Navajo)	96	39	2.9	54
Acorn stew	62	14	1	95
Milk	169	117	0.1	97
Free range buffalo steak	4	246	3.8	146
Cheese, mozarella	505	354	0.4	300

SOME FERMENTED GRAIN FOODS FROM AFRICA

KISHK, a fermented product prepared from parboiled wheat and milk, is consumed in Egypt and many Arabian countries. During the preparation of kishk, wheat grains are boiled until soft, dried, milled and sieved in order to remove the bran. Milk is separately soured in earthenware containers, concentrated and mixed with the moistened wheat flour thus prepared, resulting in the preparation of a paste called a hamma. The hamma is allowed to ferment for about 24 hours, following which it is kneaded. Soured salted milk is added prior to dilution with water. Fermentation is allowed to proceed for a further 24 hours. The mass is thoroughly mixed, formed into balls and dried.

BANKU is a popular staple consumed in Ghana. It is prepared from maize or a mixture of maize and cassava. The preparation involves steeping the raw material in water for 24 hours followed by wet milling and fermentation for three days. The dough is then mixed with water at a ratio of 4 parts dough to 2 parts water; or 4 parts dough to 1 part cassava and 2 parts water. Continuous stirring and kneading of the fermented dough is required to attain an appropriate consistency during subsequent cooking. Microbiological studies of the fermentation process revealed that the predominant microorganisms involved are lactic acid bacteria and moulds.

MAWE is a sour dough prepared from partially dehulled maize meal which has undergone natural fermentation for a one- to three-day period. Traditional mawe production involves cleaning maize by winnowing, washing in water and crushing in a plate disc mill. The crushed maize is screened by sieving whereby grits and hulls are separated by gravity and the fine endosperm fraction collected in a bowl. The grits are not washed but home dehulled, following which they are mixed with the fine fraction, moistened over a 2- to 4-hour period and milled to a dough. The kneaded dough is then covered with a polyethylene sheet and allowed to ferment naturally to a sour dough in a fermentation bowl, or wrapped in paper or polyethylene. In the commercial process which takes place entirely in a milling shop, the grits are washed by rubbing in water, following which the germ and remaining hulls are floated off and discarded along with the water. The sedimented endosperm grits are subsequently blended with the fine endosperm fraction. The dominant microorganisms in mawe preparation include lactic acid bacteria and yeasts.

INJERA is the most popular baked product in Ethiopia. It is a fermented sorghum bread with a very sour taste. The sorghum grains are dehulled manually or mechanically and milled to flour which is subsequently used in the preparation of injera. On the basis of production procedures three types of injera are distinguishable: thin injera which results from mixing a portion of fermented sorghum paste with three parts of water and boiling to yield a product known as absit, which is, in turn, mixed with a portion of the original fermented flour; thick injera, which is reddish in color with a sweet taste, consisting of a paste that has undergone only minimal fermentation for 12-24 hours; and komtata-type injera, which is produced from over-fermented paste, and has a sour taste. The paste is baked or grilled to give a bread-like product. Yeasts are the major microorganisms involved in the fermentation of the sweet type of injera. Source: http://www.fao.org/docrep/x2184e/x2184e07.htm#pre

IRISH AND SCOTTISH OATMEAL

Commercial oats in the U.S. are heat treated to about 200° F for four or five hours, to prevent rancidity—oats are rich in polyunsaturated oils that can go rancid within three months, especially at warm temperatures, and oats are harvested only once a year. Heat treatment kills enzymes that accelerate oxidation and helps prevent a bitter taste, although it surely damages the fragile polyunsaturated oils as well.

While Irish and Scottish oatmeal is said to be "unheated," this is not exactly true; these oats are also heat treated — for the same reasons, to minimize rancidity—but usually at lower temperatures. McCann's Irish steel cut oats are heated to 113-118° F but Hamlyn's heats to 212° F. Truly raw rolled oats are available from www.rawguru.com.

The Alford brand, available only in the U.K., is kiln dried for four hours according to their website www.oatmealofalford.com; they do not provide temperatures.

Hulless oats that have not been heat treated are available from www.sproutpeople.com; these can be ground or rolled at home before soaking and preparation as oat meal.

UPDATE ON PHYTIC ACID by Rami Nagel

The article on phytic acid (Spring, 2010) was written in response to reports of dental decay, especially in children, even though the family was following the principles of traditional diets. Phytates become a problem when grains make up a large portion of the diet and calcium, vitamin C and fat-soluble vitamins, specifically fat-soluble vitamin D, are low. In the diet advocated by WAPF, occasional higher phytate meals will not cause any noticeable health effects for people in good health. Significantly more care is needed with whole grains when the diet is low in fat-soluble vitamins and in diets where two or more meals per day rely significantly on grains as a food source. Vitamin C reduces the iron and perhaps other mineral losses from phytic acid. Vitamin D can mitigate the harmful effects of phytates. Calcium (think raw milk, raw cheese, yogurt, and kefir) balances out the negative effects of phytates. The best indicator of whether dietary phytic acid is causing problems can be seen in the dental health of the family. If dental decay is a recurrent problem, then more care with grain preparation and higher levels of animal foods will be needed. Article Correction , Brown Rice Preparation The article stated: "Soak brown rice in dechlorinated water for 24 hours at room temperature, without changing the water. Reserve 10 percent of the soaking liquid (which should keep for a long time in the fridge). Cook the rice in the remaining soaking liquid and eat. This will break down about 50 percent of the phytic acid." The soaking water is to be discarded and the rice should be cooked in fresh water. Readers have noted that after the fourth cycle using the brown rice starter the brown rice becomes significantly softer and more digestible.

PHYTIC ACID IN potatoes , YAMS AND SWEET POTATOES

White potatoes have 0.111-0.269 percent of dry weight of phytic acid, a level approximately equivalent to the amount in white rice. Cooking does not significantly remove phytates in potatoes, but consumption of potatoes with plenty of butter or other animal fat in the context of a nutrient dense diet should be enough to mitigate the effects of phytate. Yams contain an amount of phytate equal to or less than that in white potatoes, and sweet potatoes contain no phytate at all. One idea for corn would be to soak/sour it with wheat such as in the process of making corn bread. Corn generally is prepared without the whole kernel, removing the kernel will reduce the phytate content a little bit. I don't have further details on corn preparation, an entire article could be written on corn and traditional preparation.

PREPARATION OF OATS AND CORN

When preparing these grains according to traditional methods, such as those provided in Nourishing Traditions, the best idea is to add one or more tablespoons of freshly ground rye flour. Rye flour contains high levels of phytase that will be activated during the soaking process. This method reflects new information obtained since the publication of Nourishing Traditions. Even without the rye flour, overnight soaking of oats and other low-phytase grains greatly improves digestibility but won't eliminate too much phytic acid. Another grain that benefits from added rye flour during soaking is sorghum, which is lower in phytic acid than wheat but lacking in phytase. (Buckwheat contains high levels of phytase and would not need added rye flour.) You can keep whole rye grains and grind a small amount in a mini grinder for adding to these grains during the soaking process.

PREPARATION OF BEANS

If beans are a staple of your diet, extra care is needed in their preparation, including soaking for twenty-four hours (changing the soaking water at least once) and very long cooking. In general, soaking beans and then cooking removes about 50 percent of phytic acid. One report with peas and lentils shows that close to 80 percent of phytic acid can be removed by soaking and boiling. Boiling beans that haven't been soaked may remove much less phytic acid. Germinating and soaking, or germinating and souring is the best way to deal with beans; dosas made from soaked and fermented lentils and rice is a good example from India. In Latin America, beans are often fermented after the cooking process to make a sour porridge, such as chugo.

PREPARATION OF NUTS

We still do not have adequate information on nut preparation to say with any certainty how much phytic acid is reduced by various preparation techniques. Soaking in salt water and then dehydrating to make "crispy nuts" makes the nuts more digestible and less likely to cause intestinal discomfort, but we don't know whether this process significantly reduces phytic acid, although it is likely to reduce at least a portion of the phytic acid.

Roasting probably removes a significant portion of phytic acid. Roasting removes 32-68 percent of phytic acid in chick peas and roasting grains removes about 40 percent of phytic acid. Germinated peanuts have 25 percent less phytic acid then ungerminated peanuts. Several indigenous groups cooked and or roasted their nuts or seeds. I notice that I like the taste and smell of roasted nuts.

The real problem with nuts comes when they are consumed in large amounts, such as almond flour as a replacement for grains in the GAPS diet. For example, an almond flour muffin contains almost seven hundred milligrams of phytic acid, so consumption should be limited to one per day. Eating peanut butter every day would also be problematic.

PREPARATION OF COCONUT FLOUR

We do not have enough information about the preparation of coconut flour to say whether soaking reduces phytic acid, but as with other phytic-acid containing foods, the likelihood is that it is at least partially reduced.

MORE UPDATES

COCONUT AND PHYTIC ACID

I'm writing in regard to the article written by Ramiel Nagel titled "Living with Phytic Acid" (Spring 2010). In the article there are references to the phytic acid content of coconut. Since the publication of this article people have been asking me whether they should soak coconut or coconut flour to reduce the phytic acid.

Phytic acid occurs in nuts and seeds in two forms—phytic acid and phytic acid salts [Reddy, NR and Sathe, SK (Eds.) *Food Phytates*. CRC Press, 2001]. Both are generally referred to as "phytates." Together, these two compounds make up the total percentage of phytates reported in various foods. However, they do not possess the same chelating power. So the chelating effect of the phytates in corn, wheat, or soy are not the same as those in coconut. You cannot predict the chelating effect based on total phytate content alone.

The mineral-binding effect of the phytates in coconut is essentially nonexistent. It is as if coconut has no phytic acid at all. In a study published in 2002, researchers tested the mineral binding capacity of a variety of bakery products made with coconut f lour. Mineral availability was determined by simulating conditions that prevail in the small intestine and colon. The researchers concluded that "coconut flour has little or no effect on mineral availability." (Trinidad, TP and others. The effect of coconut flour on mineral availability from coconut flour supplemented foods. *Philippine Journal of Nutrition* 2002;49:48-57). In other words, coconut flour did not bind to the minerals. Therefore, soaking or other phytic acid-neutralizing processes are completely unnecessary.

Soaking has been suggested as a means to reduce the phytic acid content in grains and nuts. Some suggest coconut flour should also be soaked. To soak coconut flour doesn't make any sense. The coconut meat from which the flour is made, is naturally soaked in water its entire life (12 months) as it is growing on the tree. To remove the meat from the coconut and soak it again is totally redundant. After the coconut meat has been dried and ground into flour, soaking it would ruin the flour and make it unusable. You should never soak coconut flour.

In the tropics coconut has been consumed as a traditional food for thousands of years. Those people who use it as a food staple and regard it as "sacred food," do not soak it or process it in any way to remove phytates. It is usually eaten raw. This is the traditional method of consumption. They apparently have not suffered any detrimental effects from it even though in some populations it served as their primary source of food.

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