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**“OXALATES”**

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**Introduction**

While many people think about oxalates as some rare and undesirable component of food, oxalates are naturally-occurring substances found in a wide variety of foods and they play a supportive role in the metabolism of many plants and animals and in our human metabolism as well. So in terms of our overall health and diet, oxalates are neither rare nor undesirable. (For persons interested in the chemical nature of oxalates, these substances are strong acids constructed out of two carboxylic acids, usually abbreviated in biochemistry as COOH groups.) It is also worth noting here that in a practical and non-technical sense, "oxalate" and "oxalic acid" are two different terms for the same substance.

Oxalates can become problematic, however, if they overaccumulate inside our body. The key site for problems with overaccumulation is our kidneys. If the concentration of oxalates in our urine becomes too high, simultaneous with an overly high concentration of calcium, our kidneys are at risk of calcium oxalate kidney stone formation due to supersaturation of our urine with calcium oxalate salts. Worldwide, 5-15% of all persons are estimated to develop some form of kidney stones, with calcium oxalate stones accounting for about 80% of all stones formed.

**Non-food sources of oxalates**

Even if we did not eat oxalate-containing foods, we would still have oxalates in our body since we are able to make them in a variety of ways. (In fact, only 20-40% of the oxalates in our blood come from the foods we eat.) Our "internal" ways of making oxalates include: (1) creating them from amino acids like hydroxyproline in our liver; (2) taking vitamin C and transforming it into oxalate; and (3) having our red blood cells synthesize oxalates from glyoxylate. Because oxalates can be created from amino acids in our liver, and because proteins are constructed out of amino acids, the total amount of protein that we eat may sometimes be related to the amount of oxalates that are formed using this amino acid pathway.

However, in research studies on healthy persons not at special risk of kidney stone formation, high levels of protein intake nearing 150 grams per day have failed to consistently show increased levels of urinary oxalates or increased risk of kidney stone formation. It is persons already known to have problems with kidney stone formation who have been shown to be affected by high protein intake, with about one-third of "stone formers" getting unwanted increases in their urinary oxalate levels in conjunction with a high protein diet. We mention this protein issue not to try and provide treatment recommendations for persons with kidney stone problems—that step is one that should be taken with a healthcare provider—but to give an example of the way that oxalates can be made inside of our body and why dietary sources of pre-formed oxalate only tell one part of the story here.

It's worth noting that studies on vitamin C supplementation have shown mixed results in terms of their impact on risk of kidney stone formation. Several studies show increased oxalate excretion following vitamin C supplementation. However, some of these same studies show decreased urinary calcium oxalate supersaturation and decreased risk of stone formation. So, the jury is still out on the exact set of relationships here.

**Food sources of oxalates**

As mentioned earlier, about 20-40% of the oxalates in our bloodstream come from preformed oxalates in our food. While oxalates are found in both plant and animal foods, plant foods have long been the research focus here since some plants have especially high concentrations. Among foods, rhubarb is the most concentrated source of preformed oxalates and contains between 450-650 milligrams in about 3-1/2 ounces. Chocolate can also be a concentrated source, with the oxalate content increasing along with the percentage of cocoa contained in the chocolate. An average for 76% cocoa chocolate bars is approximately 250 milligrams per 3-1/2 ounces. But this amount can nearly double in a chocolate bar that is 100% cocoa.

Among foods, the most concentrated oxalate sources (all listed in terms of milligrams per 3-1/2 ounces) include spinach (750-800 mg), beet greens (600-950 mg), almonds (380-470 mg), Swiss chard (200-640 mg), cashews (230-260 mg), and peanuts (140-184 mg). It is important to note that you will often find very different results in plant oxalate content due to differences in varieties, planting conditions, harvesting conditions, and measurement technique. It is also worth pointing out that the leaves of plants almost always contain higher oxalate levels than the roots, stems, and stalks.

Other oxalate-containing foods (listed in milligrams of oxalate per 3-1/2 ounces) include:

* other green leafy vegetables not found in the high-oxalate examples above (5-150 mg)
* berries, which typically contain between 10-50 mg (with the important exception of gooseberries which can contain 60-90 mg)
* lemon and lime peel (80-110 mg)
* nuts besides the high-oxalate nuts listed earlier (40-350 mg)
* legumes (10-75 mg): with legumes, it is also worth noting that lentils, split peas, black-eyed peas, and garbanzo beans tend to fall at the low end of the spectrum with 10 mg or sometimes even less, while black beans, navy beans and soybeans tend to fall at the higher end with 50 mg or more)
* grain flours (40-250 mg): with grains and grain products, it is worth noting that brown rice flour and brown rice pastas are among the lowest in oxalate content
* pasta noodles (made from grains) (20-30 mg)

In addition to this highlighted list above, it is worth nothing that most fruits and vegetables contain measurable amounts of oxalates in the small-to-moderate range. We've seen studies on grapes, for example, showing 3-5 mg; pineapple 5 mg; plums 10 mg; collards 5-75 mg; celery 11-20 mg; and green beans 15 mg. Okra is a vegetable that usually shows up higher on the oxalate scale at 140-150 mg. Parsley is also worth mentioning here at about 100 mg.

One final note about the oxalate content of lemons and limes: as indicated above, the peels of these fruits have consistently been shown to be high in oxalates. However, the juice of these fruits (e.g., lemon and lime juice) are not only low in oxalates, but high in other organic acids called citrates. Research suggests that the high citrate content in lemon and lime juice might actually help prevent calcium oxalate kidney stone formation. By binding together with calcium in place of oxalates, citrates can help prevent supersaturation of the urine with calcium oxalate. In addition, the citrate salts that are formed during this process can help raise the urine pH and further lower the risk of calcium oxalate stone formation (since these stones tend to form at a low urine pH).

Among fruits, vegetables and other food items the biggest oxalate sources are:

* blackberries
* blueberries
* raspberries
* strawberries
* grapes
* fig
* spinach
* chard
* parsley
* leeks
* pulses
* almond
* cashews
* cocoa
* black and green tea

Of all plant parts, almost in all cases leaves contain the most oxalates, while roots and stems usually contain significantly lower amounts.

Oxalates are mostly present in plant food items, while animal origin food items contain negligible amounts of these compounds.

It is assumed that oxalates in plants are used for removing excess calcium. But, according to some studies, plants also use oxalates for protection against infections and parasites.

**Oxalates and health**

Two aspects of oxalates have been extensively studied from a health perspective: their relationship to kidney stone formation and their relationship to calcium absorption and metabolism.

**Kidney Stone Formation**

In research studies, some individuals have been shown to be "hyperabsorbers" of oxalate from the intestinal tract. In other words, their bodies uptake more oxalate than would normally be expected. In principle, the greater the amount of oxalate that gets absorbed into the body, the greater the amount that will reach the kidneys and raise the level of urinary oxalates. When combined with high levels of urinary calcium, there is an increased risk of calcium oxalate kidney stone formation. So, it seems like we can draw a straight line between risk of kidney stone formation and absorption of dietary oxalates from food.

Unfortunately, this general description oversimplifies what turns out to be a fascinating and more complicated set of bodily circumstances. First, oxalate only gets absorbed from our digestive tract when it is in soluble form. Sodium oxalate and potassium oxalate are the predominant soluble forms. By contract, calcium oxalate is insoluble, and magnesium oxalate is poorly soluble. So the form of the oxalate is important in the absorption process.

Second, our gut bacteria turn out to play a critical role in the amount of oxalate available for absorption since numerous species of gut bacteria are able to break down oxalate. These species include Oxalobacter formigenes, numerous species of Lactobacillus, and several species of Bifidobacteria. In fact, a good number of studies are underway to investigate the role of oral probiotic supplements and their impact on oxalate absorption.

Third, research has shown that the overall combination of foods that we eat during a meal (including both oxalate-containing and non-oxalate-containing foods) can significantly impact the amount of soluble oxalates available for absorption from our digestive tract. We've seen a study on Indian cuisine, for example, in which multiple-ingredient dishes like spinach (palak) also containing Indian cottage cheese (paneer) lowered the amount of soluble oxalates available for absorption by about 15-20%. So, as you can see, the relationship between dietary intake of oxalates and oxalate absorption is complicated. In general, since only 20-40% of blood oxalates originate from food, and since 85-95% of individual show no tendency to form calcium oxalate kidney stones, we don't expect most people to have kidney stone-related problems from routine enjoyment of the foods that we profile at WHFoods.

**Calcium Metabolism**

An ongoing controversy in oxalate research involves the degree to which food oxalates interfere with calcium absorption from those foods. In general, calcium can be a somewhat difficult mineral to absorb from food. Even at very low levels of dietary intake—in which case you might expect the absorption rate to increase—calcium only tends to be absorbed at a rate of about 35%. But this generalized rate of absorption can vary dramatically from food to food, and the presence of oxalates in food is definitely a dietary factor that lowers calcium absorption (through the formation of insoluble calcium oxalate salts).

However, two further considerations cause us not to be worried in a broad sense about interference with calcium absorption from oxalates. First is the nature of the public health recommendations for calcium. These recommendations—like all nutrient recommendations—take the realities of absorption into account. At WHFoods, for example, our recommended daily intake level for calcium is 1,000 milligrams. This recommended level factors in the amount of calcium absorption from different foods, including foods like spinach that contain high levels of oxalates.

Second is the research on different populations or population subgroups that eat different mixtures of plant and animal foods. Studies show individuals who eat largely plant-based diets (i.e., vegetarians) do not have greater calcium deficiency or increased risk of osteoporosis, which you might predict if substances like oxalates were impairing calcium absorption in a way that would create a health risk. Calcium is definitely not absorbed as well from oxalate-containing versus non-oxalate-containing foods, but from our perspective this difference does not make intake of oxalate-containing foods either irrelevant or counter-productive in terms of their impact on calcium status. We therefore continue to recommend enjoyment of all WHFoods fruits and vegetables as worthwhile contributors to calcium intake, including those with higher oxalate concentrations.

**Uncommon conditions that require strict oxalate restriction**

There are some relatively rare health conditions that do require strict oxalate restriction. These conditions include absorptive hypercalciuria type II, enteric hyperoxaluria, and primary hyperoxaluria. Dietary oxalates are usually restricted to 50 milligrams per day under these circumstances.

**The effect of cooking on oxalates**

Cooking has a relatively small impact on the oxalate content of foods. In fact, we've seen one recent study examining oxalate changes in 20 different green leafy vegetables in cooked versus raw form which found no significant changes for any of the 20 vegetables. We've also seen studies that have focused on the blanching or boiling of green leafy vegetables and these studies show little to no decrease in oxalate content. At the very most, you should not expect more than a 5-15% decrease in oxalate content from the cooking of a high-oxalate food. For all of the above reasons, it does not make sense to us for you to consider overcooking an oxalate-rich food for the purpose of reducing its oxalate content. Research studies have made it clear that overcooking results in the loss of many different vitamins and minerals, and so the end result of overcooking is very likely to be a much less nutritious diet that is only minimally lower in oxalates.

**Practical take-away**

For the vast majority of individuals who are not at special risk of calcium oxalate kidney stone formation—or do not have any of the rare health conditions that require strict oxalate restriction—oxalate-containing foods should not be a health concern. Under most circumstances, high oxalate foods like spinach (including both baby and larger leafed mature spinach) can be enjoyed either raw or cooked and incorporated into a weekly or daily meal plan. For persons with health histories that make kidney stones a health concern, we recommend consultation with a healthcare provider to develop a diet plan and take other steps that can lower individual health risks.

**When you do need to limit oxalate intake**

Despite the fact that the amounts of oxalates we intake are very small, there are several relatively rare health states that require a strict limitation of oxalate intake.

Such states include hypercalcemia (increased level of calcium in the blood) and primary hyperoxaluria (increased oxalate production in organism). In such cases, oxalate intake should be limited to 50 mg a day. But, how much is 50 mg of oxalates a day?

For example, one cup of raw spinach contains about 200 mg of oxalates. So, patients with such rare diagnosis are allowed only 1/4 of a cup of a spinach a day.

**Table 1. Oxalate content in 100 grams of raw food items**

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| **Raw food item** | **Oxalate content (mg)** |
| *Spinach* | *750* |
| *Beet* | *610* |
| *Parsley* | *100* |
| *Leek* | *89* |
| *Collard* | *74* |