Chris Kresser
LET'S TAKE BACK YOUR HEALTH—*Starting Now.*

EBOOK

All About Sweeteners

by CHRIS KRESSER

All About Sweeteners

Humans are hard-wired to like sweet foods. Sweet tastes are strongly tied to the reward centers in our brain, and can actually relieve pain and reduce symptoms of depression, PMS, and stress. (1)

Unfortunately, these properties strongly dispose us to over-consume sweeteners, and it's pretty clear that the huge quantities of concentrated sweeteners consumed today are harmful to our health.

People are always searching for ways to enjoy sweet foods without the health repercussions, and this is an eBook that I hope will help you do just that! But before we jump into the nitty-gritty of different types of sweeteners and how they can fit into a healthy diet, I want to set the stage with some history and evolutionary background.

SWEETENERS IN EVOLUTION

Most of us primarily think of taste – especially sweetness – in terms of enjoyment, but sweetness is not just another source of pleasure. As omnivores, hunter-gatherers had a wide array of potential foods to choose from, and the sweet taste sensation is one of the ways humans could identify safe, non-poisonous foods with a high nutrient-to-toxin ratio.

Honey was the only concentrated sweetener available for much of human history, and common belief is that honey was quite rare, and only consumed in small quantities. While this is undoubtedly true for many hunter-gatherer groups, it doesn't appear to be true for all of them.

We can get an idea about the role of honey in Paleolithic diets by studying modern hunter-gatherer societies like the Hadza; during the wet season, honey comprises up to 20% of their diet by weight. (2) Given honey's caloric density, this likely represents a much larger portion of their total calories. When asked to rank their dietary staples in order of preference, honey was ranked highest, above meat, berries, tubers, and baobab

(a large tree fruit). The Mbuti pygmies of the Congo can obtain up to 80% of their calories from honey, although only during the 2-month honey season. (3)

One interesting paper hypothesized that honey was actually far more abundant throughout early history than we typically acknowledge, and that the consumption of honey at certain times in history may rival our current consumption of sweeteners. (4) Some researchers have even posited that honey, along with meat and starchy tubers, helped make us human by providing concentrated glucose to support brain growth. (5) Although it's impossible to know exactly how much honey early humans had access to, we do know that people went to great lengths to obtain honey, even when other foods were more readily available. (6, 7)

THE EVOLUTION OF SWEETENERS

Once hunter-gatherers began settling down, humans gradually discovered new sources of concentrated sugars. Maple syrup was introduced by Native Americans, and became popular in North America. (8) Jaggery, produced from sugar cane, became popular in India and its use is still widespread. (9) Some sweeteners common in early China include "tree honey" and "thorn honey," both extracted from different plants. (10) And in the 17th or 18th century, table sugar surpassed all of these traditional foods and became the world's leading sweetener. (11)

Fast forward to 1970, when the average American's consumption of added sugar was 23.7 teaspoons per person per day according to loss-adjusted availability data. (12) By 2012, that amount had increased to 24.7 teaspoons, and the percentage of total calories obtained from sweeteners had risen from 13% in 1977 to 16%. (13) Significantly, 80% of this increase was from sugar-sweetened beverages, rather than solid food.

CHANGING ATTITUDE TOWARDS SWEETENERS

Amidst all this background, I think it's particularly interesting to note the shift in attitude towards sweeteners. For modern hunter-gatherers like the Hadza, a sweetener (honey, in their case) is just another food, albeit a highly prized one. We can probably assume that traditional hunter-gatherers didn't have a conception of "healthy" and "unhealthy" like we do today, and if they did, they probably would have classified concentrated sweeteners as one of their "healthiest" foods, because they provide ample nutrients without causing illness.

Now our beliefs are quite different – opposite, in fact. Most of us have become conditioned to think of "sweet" as "unhealthy," and instead of using sweet taste as a guide to the most calorie-dense foods, people are trying to figure out how to avoid caloric density, while still enjoying sweet tastes. This can be seen in the widespread use of non-caloric sweeteners, as well as the current research into sweet-tasting proteins that could sweeten foods without triggering an insulin response. (15)

And along with the desire to limit caloric density in general, there's now a growing fear of sugar itself, and refined sweeteners such as table sugar and HFCS are often labeled 'toxins.' This is a dramatic shift from our evolutionary background, where sweetness signaled safety and a lack of toxins.

This brief history of sweeteners leaves us with many questions. If the Hadza obtain a large portion of calories from sweeteners, why can't we? What makes traditional sweeteners like honey so different from table sugar, and for that matter, which sweeteners are healthiest? Why has sugar become such a bane to our health? Is it really addictive? And ultimately, how can sweeteners fit into a healthy diet? These are all questions I'll attempt to answer in this eBook.

Does It Matter If A Sweetener Is "Natural"?

The ancestral health community and other heath-conscious bloggers have increasingly embraced natural sweeteners such as honey, stevia, and maple syrup as healthier alternatives to refined sugar. But just how much healthier, really, are these natural sweeteners?

I'll now review the three major "natural" sweeteners typically used by Paleo dieters, and determine whether or not these foods belong in a healthy eating plan.

HONEY

As I mentioned before, honey has long been an important food in the human diet. Its fructose to glucose ratio is similar to that of high fructose corn syrup, with about 38% fructose and 31% glucose (the rest being primarily water). (16) Honey also contains enzymes and other proteins, trace minerals, flavonoids and other polyphenols.

Although honey is “Paleo” even in the strictest sense, it can be easy to think of it as just another source of sugar; better than table sugar, perhaps, but still an indulgence that should be kept to an absolute minimum. Sugar is sugar, right? On the contrary, increasing evidence indicates that honey is a functional food with uniquely beneficial physiological effects.

For example, two human studies found that supplementing with 3-5 tbsp of honey per day (depending on body weight) increases serum antioxidant levels, including vitamin C and glutathione reductase. (17, 18) In another study, the same dose of honey lowered plasma prostaglandin levels by 48-63% after 15 days, signaling a reduction in inflammation. (19)

In overweight and obese patients, consumption of about 3.5 tbsp honey per day for a month resulted in lower LDL cholesterol, triglycerides, and C-reactive protein (particularly in people with elevated values), and higher HDL cholesterol. (20) In another study, honey also reduced levels of homocysteine and blood glucose. (21)

Honey also has antibacterial activity, and can shorten the duration of acute bacterial diarrhea in children. (22) Honey might even be an effective treatment in some cases of h. pylori infection. (23) Other potential benefits of honey include antiviral, antitumor, and antimutagenic effects, and reduction of IBD-associated inflammation, but these have yet to be tested on humans. (24) So it would appear that honey has many benefits that outweigh the potential downsides of consuming a concentrated sweetener. I recommend using raw honey, which will have the most enzymes and nutrients when destructive heat has not been used.

STEVIA

Stevia continues to be a contentious topic in the ancestral health world, with some respected bloggers **endorsing it heartily** and others **cautioning against it**. Although I’ve seen good points raised by both sides, the majority of the evidence indicates that stevia, used in reasonable quantities, is a harmless (and possibly beneficial) natural sweetener.

Because stevia contains almost no calories, one potential issue with stevia is that the sweet taste without the influx of sugar might confuse our insulin response (I’ll talk about this at length when I cover artificial sweeteners). While this is an understandable concern,

stevia has actually been used traditionally as a treatment for diabetics and may actually improve blood sugar control. (25)

In one study, participants were given a dose of either sucrose or stevia before lunch. Compared with the sucrose preload, the stevia preload resulted in lower blood sugar after the meal and a lower insulin load, even compared with aspartame. (26) Also, even though the stevia provided fewer calories than the sucrose, participants didn't compensate by consuming more calories at lunch.

Another small study with 16 volunteers found that 5-gram doses of stevia extract every 6 hours for three days improved glucose tolerance. (27) In insulin-resistant and diabetic rats, stevia improved insulin sensitivity, glucose tolerance, and liver and kidney function. (28, 29, 30)

Stevia has also been called into question due to its potential negative impact on fertility. Stevia was used traditionally in South America as a contraceptive, although we don't know how effective it was, and results from animal studies have been mixed.

One study found that doses of stevioside up to 2.5g/kg bodyweight per day didn't affect the fertility of hamsters, even after three generations. (31) For a human, this would translate to about 0.34g/kg, so a person weighing 70 kg (about 150 lbs) would need to consume almost 24 stevia packets every single day to reach that dose. That's far more than anyone would reasonably consume, even if they were consciously trying to maximize their stevia intake.

Although two other studies did find that stevia reduced fertility in male and female rats, those conclusions have since been refuted by studies using more reliable methods. (32, 33, 34) Overall, the risk of negatively impacting fertility by consuming moderate amounts of stevia is very slim, but I would still advise people to be wary of stevia if they're struggling with infertility.

As for other potential benefits of stevia, a 2-year RCT in Chinese adults with mild hypertension found that taking 500mg of stevioside powder 3 times per day significantly reduced blood pressure compared with baseline and placebo, from an average of 150/95 to 140/89. (35) However, smaller doses didn't provide the same benefit, and there isn't

enough evidence to recommend large doses of stevia as a supplement to **lower blood pressure**. (**36**)

Finally, stevia appears to have anti-cancer, anti-inflammatory, antioxidant, and antibacterial properties, but thus far we don't know whether these properties have practical significance in humans. (**37**, **38**) Ultimately, I think stevia is a good sweetener to use for those who have blood sugar control issues and would prefer to use a non-caloric sweetener.

MAPLE SYRUP, COCONUT SUGAR, AND MOLASSES

Maple syrup, coconut sugar, and molasses are other popular natural sweeteners, but they don't have the modern research or the traditional background that honey and stevia do. Composition-wise, they're all relatively similar: they're mostly sucrose, with some free glucose and fructose. (**39**) They all contain some minerals such as calcium, zinc, and iron, but they're not going to contribute all that much to your daily mineral needs. (The exception to this might be molasses, which contains 20% of the daily value for potassium, 10% DV for calcium and vitamin B6, 15% DV for iron, and 8% DV for magnesium in just a tablespoon. (**40**))

All three are lower on the glycemic index than white sugar, which falls at around 65, with the award-winner being coconut sugar at 35. (**41**) Maple syrup has gotten a little research attention, and preliminary analytical and in vitro studies show that it has antioxidant and anticancer properties, as well as potential for the management of type 2 diabetes. (**42**, **43**, **44**, **45**) However, this isn't anywhere near being of clinical significance for humans.

If you're just looking for an alternative to refined sugar to use occasionally, all of these are fine sweetener choices; they're natural, minimally processed (depending on the quality you purchase), and still contain the minerals and phytonutrients that occur naturally. They also have favorable fructose:glucose ratios, which can be an important consideration for those with gut issues or fructose intolerance. (This is one reason I don't recommend agave nectar.)

But if you're looking for health benefits beyond simply replacing refined sugar with something a little healthier, current research (and tradition) sides with honey and stevia.

What About Artificial Sweeteners?

Artificial sweeteners continue to be a controversial public health issue, and the research keeps coming. In fact, a **new study** on artificial sweeteners and weight loss was just published in May of 2014, and the **FDA approved a new artificial sweetener** (advantame) in the same week.

On one hand, many people are adamantly opposed to the use of artificial sweeteners because of the purported link with increased risk for cancer and other diseases. But on the other hand, artificial sweeteners are becoming increasingly popular as people try to reduce calorie consumption and lose weight.

There's too much research out there to cover comprehensively in an eBook, but I'll try to cover these basics: will artificial sweeteners give you cancer or other diseases? Do they actually help with weight loss, or do they hurt? And ultimately, should you be eating them?

CANCER

Artificial sweeteners were first tied to cancer risk in the 1970's after a study showed that a combination of saccharin and cyclamate (another early artificial sweetener) caused bladder cancer in lab rats. The mechanism behind these effects was later found to be specific to rats and not generalizable to other animals or humans (in these rats, comparable doses of vitamin C can also cause bladder cancer), and further studies demonstrated that neither sweetener is carcinogenic. (**46**, **47**)

However, this study cast a shadow of doubt over artificial sweeteners, and thanks in part to the media's penchant for blowing things way out of proportion, the reputation of artificial sweeteners has never recovered.

A later study suggested a link between aspartame consumption and brain tumors. The authors based this hypothesis on the fact that both brain cancer and aspartame consumption had increased since 1980 – despite not knowing whether the people getting brain tumors actually consumed artificial sweeteners – and on a rat study where aspartame supplemented diets led to the formation of brain tumors. (**48**)

This association has been more or less dismissed by the research community because three case-control studies have found no association between brain tumors and aspartame consumption, and subsequent animal studies haven't been able to replicate the aspartame-induced brain tumors found in the original rat study. (49)

Artificial sweeteners have also been implicated in the development of lymphoma and leukemia, and one observational study found a weak link between artificial sweetener consumption and development of non-Hodgkin lymphoma and multiple myeloma in men, but not in women. (50) The study authors concluded that due to the inconsistency in their results, there isn't likely a causal link, although it can't be ruled out.

Artificial sweeteners have also been tested for associations with other cancers, including breast, pancreatic, stomach, colon, and endometrium, with no correlations found. (51) Based on the evidence, I don't think artificial sweeteners are a huge risk factor for cancer, although the possibility can't be ruled out and caution is warranted.

DIABETES, HEART DISEASE, AND METABOLIC SYNDROME

Artificial sweeteners have also been increasingly tied to increased risk for developing metabolic syndrome and related diseases such as diabetes and cardiovascular disease. Numerous observational studies have attempted to parse out a consistent association with disease risk, but for every study that has linked artificial sweetener consumption with metabolic syndrome, heart disease, or diabetes, there's another that has found no association. (52, 53, 54)

This inconsistency shouldn't come as a surprise, given the inherent limitations of observational evidence, but because there's little to no clinical evidence in humans to test these hypotheses, the effect of artificial sweeteners on risk for these diseases remains inconclusive.

PRE-TERM DELIVERY

There has been concern in recent years over a potential link between artificial sweetener consumption and pre-term delivery, prompted by two observational studies published in 2010 and 2012. (55, 56) These studies have significant limitations: the associations are small and not linearly dose-dependent; not all artificially-sweetened beverages were accounted for; and women who consume more artificially sweetened drinks also tend to

smoke more, have higher BMI, and lower socioeconomic status. (57) All told, the risk seems small, but I would advise pregnant women to avoid artificial sweeteners just to be on the safe side.

WEIGHT LOSS

For most people, the primary motivation for consuming artificial sweeteners is a desire to reduce calorie consumption and lose weight. But do artificial sweeteners actually help achieve that goal? Yet again, the evidence is mixed. Many observational studies have found a positive association between artificial sweetener intake and obesity, but in this situation, reverse-causality is particularly likely. (58, 59, 60, 61)

In other words, while it's possible that artificial sweeteners contributed to weight gain in these studies, it's also possible that people who are overweight are more likely to choose diet beverages and other artificially sweetened foods in an effort to lose weight. We also have a decent number of clinical trials testing the weight loss effects of artificial sweeteners in humans, although many are too short-term to have much practical significance.

In one study, overweight subjects were given supplements of either sucrose or artificial sweeteners for 10 weeks. (62) At the end of the trial period, subjects in the artificial sweetener group on average had experienced a reduction in weight, fat mass, and blood pressure, while subjects in the sucrose group gained weight and had increased blood pressure.

A study just published this week on weight loss and artificial sweeteners was surprisingly positive: over a 12-week period, participants who were instructed to drink 24 ounces of artificially sweetened beverages every day actually lost more weight than participants who were instructed to drink 24 ounces of water daily. (63) (It's worth noting that this study was fully funded by The American Beverage Association.) Other trials have also shown successful calorie reduction and weight loss in participants who consumed artificial sweeteners (usually in the form of beverages). (64, 65, 66)

Based on this evidence, it seems that artificial sweeteners can be helpful for weight loss in some circumstances, at least over the short term. However, due to the limited nature of these studies and the evidence I'll present next, I hesitate to draw any conclusions.

DO ARTIFICIAL SWEETENERS 'CONFUSE' THE BODY?

For most of human history, sweeteners were inextricably tied to caloric density. If our sweet taste receptors evolved primarily to help us identify calorie-rich food sources, how will our bodies respond when our taste receptors are consistently bombarded with sweetness, but with no concomitant calorie surge?

Animal models certainly indicate that artificial sweeteners can impair the innate ability to regulate caloric intake. Rats who are fed with artificial sweeteners consistently gain more weight than rats who are fed with glucose or sucrose. (67, 68) Additionally, the rats don't tend to lose the excess weight, even after their diets are switched back to glucose or sucrose to re-establish the calorie-predictive nature of sweet taste.

Interestingly, rats who were given stevia solutions gained significantly more weight than the glucose-fed rats, and similar amounts of weight to the saccharin-fed rats. (69) Rats fed with artificial sweeteners also develop an impaired ability to respond to sugar-containing foods. In one study, rats who had been fed artificial sweeteners were unable to compensate for the calorie content of a sugar preload by eating less chow afterwards, while rats who had been fed sugar-containing food compensated almost perfectly for the extra calories in the preload by eating less chow. (70)

Rats that have been conditioned with saccharin also display a reduced thermic effect in response to consumption of a caloric sugar-containing meal, as well as higher blood glucose, compared with rats who had been conditioned with glucose. (71, 72) Additionally, saccharin-fed rats secreted less GLP-1 (which is implicated in satiety and glucose homeostasis) when given a sugar-containing test meal. (73)

Unfortunately, although the animal evidence is fairly robust, evidence in humans is limited. However, two interesting studies that used MRI to measure brain responses to sucrose solutions indicate that artificial sweeteners may alter the brain's response to sweet tastes in humans. In one study, people who regularly consume artificially sweetened drinks had higher reward responses to both saccharin and sucrose compared with people who don't consume artificial sweeteners. (74)

Additionally, people who don't consume artificial sweeteners had different brain responses to the saccharin and sucrose, while those who regularly consume artificial

sweeteners responded the same to both sweeteners. Another study found that the amygdala's response to sucrose consumption was inversely related to artificial sweetener use. (75) (The amygdala is part of the brain that is involved with taste-nutrient conditioning.)

SHOULD YOU BE EATING ARTIFICIAL SWEETENERS?

My conclusion might seem a little anticlimactic after all that information, but the point I'd like to drive home is that artificial sweeteners are extremely new to the human diet, and for modern, industrial foods, the operating principle should always be "guilty until proven innocent." We've conducted what are essentially population-wide experiments with the introduction of other industrial foods (such as high omega-6 vegetable oils) because the initial evidence seemed promising, and **we can see how well that worked out**.

Despite some successful short-term weight loss studies, I don't think the potential therapeutic effects of artificial sweeteners have been demonstrated clearly enough thus far to warrant widespread consumption, especially given the conflicting links with disease risk and the questionable influence on appetite regulation and weight control. Ultimately, while artificial sweeteners are perhaps not as scary as some might believe, I don't recommend including them in your diet.

Are Xylitol, Sorbitol, and Other Sugar Alcohols Safe Replacements For Sugar?

Now I want to talk about sugar alcohols, which are another popular low-calorie sugar substitute.

Xylitol is the most popular and most extensively researched, so I'll focus my discussion on it, but the general takeaway of what I'm about to say applies to other sugar alcohols as well, such as sorbitol and erythritol.

WHAT EXACTLY ARE SUGAR ALCOHOLS?

Sugar alcohols are a type of 'low-digestible carbohydrate,' a category that also includes fiber and resistant starch. Sugar alcohols occur naturally in many fruits and are also known as 'polyols,' which you may recognize as a **FODMAP**. Unlike artificial sweeteners, sugar alcohols aren't completely calorie-free, because we are able to digest and absorb

them to some extent. The absorption rate varies among sugar alcohols, from about 50% for xylitol to almost 80% for sorbitol, depending on the individual. (76) Erythritol is almost completely absorbed, but is not digested, so it provides almost no calories. (77)

Compared with artificial sweeteners, sugar alcohols have very few safety and toxicity studies, and are generally accepted as safe. (78) In one long-term human study, 35 participants consumed xylitol as their primary dietary sweetener for two years, and no adverse effects other than GI distress were observed, and GI symptoms dissipated after the first couple months. (79) The amount of xylitol consumed during this trial regularly exceeded 100g per day, often going over 200g per day, depending on the participant.

METABOLIC EFFECTS OF SUGAR ALCOHOLS

Sugar alcohols are a popular choice for weight loss due to their reduced calorie content, and for diabetics due to their low glycemic index. There's not nearly as much research on the metabolic effects of sugar alcohols as there is on artificial sweeteners, but the evidence we have suggests that sugar alcohols are at least harmless, and possibly beneficial.

For the most part, sugar alcohols cause no appreciable changes in blood glucose or insulin in humans, and sorbitol and xylitol have not been found to raise blood glucose following consumption. (80) In diabetic rats, 5 weeks of xylitol supplementation (as 10% of their drinking water) reduced body weight, blood glucose, and serum lipids, and increased glucose tolerance compared with controls. (81) Two other rat studies also found that xylitol-supplemented rats gained less weight and fat mass compared with control rats, and had improved glucose tolerance. (82, 83)

Because sweetness does not predict caloric value in sugar alcohols, one might expect that they would cause the same 'metabolic confusion' that is seen with noncaloric artificial sweeteners. Unfortunately there isn't enough evidence to form a conclusion about this, but my feeling based on what I've read is that this isn't a significant issue for sugar alcohols.

For one, sugar alcohols aren't 'intense sweeteners' like artificial sweeteners, which are hundreds of times sweeter than sugar. In fact, many are less sweet than sugar. Also,

sugar alcohols do provide some calories, so there's not as much of a discrepancy between the caloric load your body expects and the caloric load it actually gets.

DOES XYLITOL PREVENT TOOTH DECAY?

The most well-known health benefit of xylitol is easily its effect on dental health, and evidence for xylitol's ability to prevent tooth decay is pretty robust. (84) A couple trials have found xylitol to be more effective at preventing cavities than fluoride, and benefits of xylitol consumption have even been observed in children whose mothers chewed xylitol-containing gum. (85) Unsurprisingly, the most drastic effects are observed when xylitol replaces sucrose in either the diet or in chewing gum, but significant reductions in cavities have been observed when xylitol is simply added on top of a normal diet as well. (86, 87)

Although some effects of xylitol are undoubtedly due to nonspecific factors such as increased saliva production or the replacement of sugar, it does appear to have specific properties that support dental health. Xylitol is not fermentable by common plaque-forming oral bacteria like sugar is, so it doesn't provide a food source. (88) Additionally, xylitol actively inhibits the growth of these bacteria. It also forms complexes with calcium, which may aid in remineralization.

SUGAR ALCOHOLS AND DIGESTIVE HEALTH

While sugar alcohols appear to be safe and potentially therapeutic, they are also notorious for causing digestive distress. Because sugar alcohols are FODMAPs and are largely indigestible, they can cause diarrhea by pulling excess water into the large intestine. The fermentation of sugar alcohols by gut bacteria can also cause gas and bloating, and sugar alcohols may decrease fat absorption from other foods. (89, 90) However, most evidence indicates that people can adapt to regular sugar alcohol consumption, and the adverse GI effects reported in studies tend to fade after the first month or two.

Erythritol is probably the best-tolerated sugar alcohol, and a few human trials have found that if the amount of erythritol is gradually increased and doses are spread throughout the day, many people can tolerate large amounts (up to1g/kg of body weight) of erythritol without GI distress. (91, 92) The average tolerance for xylitol and sorbitol is lower; most

study subjects could tolerate about 30g per day without a problem, but significant adaptation was necessary to increase xylitol content in the diet. (93)

A few studies indicate that sugar alcohols may have a prebiotic effect. This isn't too surprising, considering the prebiotic effects of other low-digestible carbohydrates such as fiber and resistant starch. Animal studies have found that xylitol causes a shift from gram-negative to gram-positive bacteria, with fewer Bacteroides and increased levels of Bifidobacteria. (94, 95) A similar shift has been observed in humans, even after a single dose of xylitol. (96) Additionally, the shifts observed allowed for more efficient use of the sugar alcohols by gut bacteria, which largely explains the reduction in GI symptoms after a few months of regular consumption.

In addition to the potential metabolic, dental, and prebiotic benefits already discussed, xylitol shows promise for preventing age-related decline in bone and skin health. One interesting study found that 10% xylitol supplementation over 20 months increased collagen synthesis in the skin of aged rats, resulting in thicker skin. (97) Preliminary rat studies have also shown that xylitol can increase bone volume and mineral content and protect against bone loss. (98, 99, 100)

Overall, sugar alcohols appear to be safer than artificial sweeteners with several potentially therapeutic effects. Although the metabolic and weight loss benefits of sugar alcohols haven't been studied as extensively, I would recommend sugar alcohols over artificial sweeteners to anyone who needs a low-calorie sweetener, although I wouldn't recommend that anyone consume huge amounts of them. I'll also be interested to see additional research on their ability to alter the gut microbiome and disrupt biofilms, because this could make sugar alcohols a useful tool for certain patients.

At this point, there don't seem to be any major problems with sugar alcohols, so if it's something you're interested in, I would experiment with your own tolerance and see how they affect you. However, people with gut issues should be cautious.

Is Refined Sugar Really Toxic?

But what about plain old white sugar? And what about the increasingly common industrial sweetener, high fructose corn syrup? These two get a pretty bad rap, even

from mainstream media, and although much of their reputation is deserved, there are some misconceptions that I'd like to straighten out.

THE EVIDENCE

Most of you are probably aware that excess refined sugar isn't great for your health. Sugar and HFCS are particularly detrimental when consumed in liquid form, because we don't tend to compensate for calories we drink by reducing our calorie consumption elsewhere. (101) This can lead to weight gain from overeating, along with elevated triglycerides, insulin resistance, and other indicators of metabolic syndrome.

Refined sugar has also been implicated in reduced immune system efficiency. (102, 103) In one study, immune cells demonstrated a significantly reduced capacity to kill pathogens (e.g. viruses, bacteria) following sugar consumption (from sucrose, glucose, fructose, honey, or orange juice) when compared with fasting levels; starches didn't have this effect. Unfortunately, this study was quite small and I haven't found further evidence to corroborate or refute these results. I believe it's a good idea to avoid sugar when your immune system is compromised.

Refined sugar is also thought to promote cancer growth by 'feeding' the cancer. While it's true that cancer feeds on sugar, it actually feeds on the glucose in your blood; not necessarily the sugar you eat. (104) While those two factors are obviously linked, it's more important to be aware of your own blood sugar control, and don't consume more sugar (or carbs in general) than you can effectively metabolize. After all, you will always have glucose in your blood as long as you're alive, so the goal is to avoid having high blood glucose over a prolonged period of time, not to eliminate glucose entirely.

But while there's plenty of evidence that excess sugar or HFCS can be harmful to health, there's actually no evidence that small amounts of refined sugar in the context of a nutrient-dense, whole foods diet (and active lifestyle) is harmful. The problem is that limiting yourself to small amounts of sugar is often easier said than done.

IS SUGAR ADDICTIVE?

Addictive properties of sugar have been observed in rat models where food is restricted for 12 hours, encouraging a binge-like pattern of consumption. (105) These rats experience dopamine and opiod release that resembles the neurological response to

substances of abuse, although significantly smaller in magnitude. Additionally, these rats experience opiate-like withdrawal symptoms after being given an opiate-blocker, or after a period of fasting.

Most human studies, however, have not reproduced these findings in rodents. (106, 107) (As always, it's worth noting that the second reference was partially funded by the World Sugar Research Organization.) At least one small study which interviewed obese individuals did find that, based on self-reported symptoms, some obese patients fit the profile for sugar addiction, particularly those who also suffer from binge eating disorder (BED). (108) But as of yet, there's little to no rigorous evidence that sugar is chemically addictive in humans.

However, some evidence does indicate that sugar can interfere with the normal hormone signaling from ghrelin and leptin, both of which help control appetite and satiety. (109) So although this isn't an 'addiction' mechanism, it's another way in which sugar can encourage overconsumption in susceptible individuals.

Whether sugar is addictive or not, from a practical standpoint, it's often easy to eat more sugar than you mean to. Certain people are going to be far more sensitive to these effects than others, so it's really a matter of being familiar with your own eating behavior when it comes to potentially addictive foods.

IS HIGH FRUCTOSE CORN SYRUP REALLY WORSE THAN WHITE SUGAR?

So far, I've been talking about white sugar and high fructose corn syrup (HFCS) somewhat interchangeably. But HFCS is without a doubt the more vilified of the two, both in the natural health community and in mainstream media. Foods and beverages sweetened with "real sugar" instead of HFCS are seen by many as 'healthier' and more 'natural,' and even big soft drink companies like Pepsi are trying to cater to the 'natural' crowd by offering **"made with real sugar" sodas**. If HFCS can make sugar look like a health food by comparison, it must be pretty terrible for you, right?

Well, first, let's talk chemical composition. White sugar, or 'table sugar,' is simply sucrose, a disaccharide composed of one glucose molecule and one fructose molecule bonded to each other. This means that table sugar is always 50% glucose and 50% fructose.

Contrary to popular belief, HFCS has about the same amount of **fructose** as white sugar. It's also the same level of sweetness. (**110**) The two most common forms of HFCS in our food supply are HFCS-42, which is 42% fructose, and HFCS-55, which is 55% fructose. This is certainly "high fructose" compared to regular corn syrup, which has no fructose, but most people hear "high fructose" and think 'mostly fructose,' which is definitely not the case.

The main difference is that the fructose and glucose in HFCS exist primarily in their free monosaccharide form, instead of as the disaccharide sucrose as in table sugar. And given the similarities between the two sweeteners, it should come as no surprise that HFCS does not have significantly different metabolic effects from sugar. (**111**, **112**)

I know many of you are also concerned about GMOs in HFCS. Genetically modified varieties of both sugarbeets and corn are grown and consumed in the US, with corn much more widely so. (**113**) Overall I'd say you're probably better off with table sugar rather than HFCS from a GMO perspective, because it's produced from crops that are less commonly GMO. It's also pretty easy to find organic, non-GMO sugar.

SO, HOW "TOXIC" ARE SUGAR AND HFCS?

White sugar and HFCS are not "toxins" in the sense that even small amounts are highly undesirable and potentially harmful. Excess refined sugar can have undesirable health effects, but its addictive power is not comparable to a drug, and HFCS isn't that much different from table sugar. Some people may be highly sensitive to even small amounts of sugar, often due to severe **gut dysbiosis**, and in this case they're justified in avoiding it vigilantly.

But barring extreme sensitivity, there's no evidence to indicate that refined sugar (or HFCS) is actually toxic in moderate amounts, and most people would be better off avoiding the stress that comes from being unnecessarily fearful of any food that has even a trace amount of refined sugar in it.

I'd even go as far to say that intentionally consuming sugar on occasion shouldn't be a problem for most people. If every now and then you decide to indulge in a piece of dark chocolate or have a scoop of real ice cream made with refined sugar, you shouldn't mentally and emotionally beat yourself up or force yourself into a week-long "detox" to

make up for your dietary transgression. The stress that comes along with excessive food restrictions can be much more harmful than having a bit of refined sugar here and there.

Sugar is neither a toxin nor a replacement for real food. Ultimately, small amounts of sugar can fit into a whole foods, nutrient-dense, healthy diet, as long as you recognize it for what it truly is: a treat.

Is All Sugar Created Equal?

You've probably heard it countless times, especially in low-carb circles: sugar is sugar is sugar. This is true in principle – the glucose, fructose, and sucrose found in table sugar or high fructose corn syrup (HFCS) are the same molecules as the glucose, fructose, and sucrose in honey, fruit, and starchy vegetables.

But when it comes to the way your body uses these sugars, these foods are hardly comparable. I'm about to show you why all sugar is not created equal, and why you should care.

FRUCTOSE AND HIGH FRUCTOSE CORN SYRUP ARE NOT THE SAME THING

I've already compared HFCS with white sugar and concluded that these two sweeteners are more or less metabolically equivalent. But some people suggest that fructose is metabolized very differently from glucose, and that it's actually metabolized more like alcohol.

I'll address that research in a second, but first, understand this: high fructose corn syrup is not the same thing as fructose. **Fructose** is a simple sugar molecule with a specific chemical structure, while HFCS is a mixture of fructose and glucose in a roughly 1:1 ratio.

Now, there are certainly some scary studies about the metabolic effects of pure fructose. In animal models, fructose administration can cause dyslipidemia, non-alcoholic fatty liver disease, insulin resistance, and even type 2 diabetes. (**114**)

But these harmful effects result from animals being fed large amounts of pure, isolated fructose. In this form, fructose does act much like a toxin in the body, and it would be a terrible idea to start sweetening your food with pure fructose. But because fructose isn't

found in isolation in nature or even in our food supply, these studies are largely irrelevant to practical nutrition.

Already, we're beginning to see that all sugar is not created equal, and that form and "packaging" makes a huge difference in metabolic effect. In this case, pure fructose does not affect the body the same way as fructose in sugar or HFCS. Now, what about fructose in fruit?

FRUIT: MORE THAN JUST A HIT OF SUGAR

Although conventional wisdom holds that fruit is unquestionably a health food, the push to avoid sugar and excess carbohydrates has in many cases left people hesitant, even afraid to eat fruit. While it's typically acknowledged that eating an apple is better than eating a bag of candy, fruit is still often seen as a source of sugar that should be consumed in strict moderation, and the phrase "sugar is sugar" is a common refrain, especially in Paleo or low-carb communities. The problem with this viewpoint is that added sweeteners and fruit have completely different metabolic effects.

First of all, the fiber and water found in whole fruit increase satiety, which makes it less likely that you'll go into caloric excess. Studies going back more than forty years have shown that naturally occurring sugars in fruits are beneficial to health and do not promote weight gain, and we can see these effects in traditional cultures such as the Kuna, who obtain a significant percentage of their calories from fruit while remaining lean. (115, 116)

And despite some claims to the contrary, there's no evidence that we should avoid whole fruit simply because it contains fructose. (117) Far from being a health hazard, like pure fructose or added sweeteners, studies overall suggest that eating whole, fresh fruit may actually decrease the risk of obesity and diabetes. (118) Additionally, randomized controlled trials have shown that eating fruit reduces oxidative stress markers and blood glucose in diabetics. (119) Further, limiting fruit intake has no effect on blood sugar, weight loss, or waist circumference. (120)

For most people, 3-5 servings of fruit per day is perfectly fine, although certain people with insulin resistance, diabetes, or metabolic syndrome may see improvements by restricting fruit intake to one to two servings a day, and by choosing fruits that are lower

in sugar. Additionally, some benefits of fruit restriction for digestive issues come more from avoiding **high FODMAP fruits** as opposed to fruits altogether.

SOLID SUGAR VS. LIQUID SUGAR

Another angle to consider is the issue of sweeteners in beverages versus sweeteners in solid foods. Countless studies have demonstrated that drinking your sugar has uniquely harmful effects, primarily because most people fail to reduce their caloric intake to compensate for the extra calories they're consuming in sweetened drinks. (121)

For example, a study of 323 adults found that subjects who increased the number of calories they obtained from sugar-sweetened beverages didn't decrease their caloric consumption from other sources. (122)

Another study showed that total calorie intake among sixteen patients was greater on the days that sugar-sweetened beverages were given at lunch than on the days they weren't. So even when the sweetener used is the same (usually sugar or HFCS), consuming it in a beverage will have different health effects than consuming it in a food.

REAL HONEY VS. FAKE HONEY

I've already written about the **unique metabolic effects of honey**, and there have been studies comparing the effects of honey and "artificial honey" on blood lipids, insulin response, and blood sugar. Although artificial honey is a mixture of glucose and fructose in the same ratio as was found in natural honey, its metabolic effects are completely different.

In one study, supplementation with real honey decreased triglycerides and LDL cholesterol, increased HDL cholesterol, and even decreased plasma homocysteine. (123) On the contrary, the artificial "honey" raised triglycerides and LDL cholesterol. Other similar studies have found that natural honey results in more stable postprandial blood sugar and insulin response when compared with artificial honey. (124, 125)

There are further examples that I won't get into, but I hope I've demonstrated that the phrase "sugar is sugar" is simply not accurate when it comes to nutrition and "real" food. The source of sugar does make a difference, and we as a community need to be careful

about generalizing study results where they may not apply, and demonizing foods that don't deserve to be demonized.

Can Sweeteners Fit into a Healthy Diet?

Now I want to give you all some practical advice on how to incorporate sweeteners into a healthy, whole-foods diet. As with everything else, my recommendations are different depending on your health, both past, present, and hopeful future. I hope to give you some guidance on how to healthily and mindfully incorporate sweeteners into your diet.

IF YOU WANT TO LOSE WEIGHT

As I've mentioned a few times already, one of the main problems with refined sugar (and sweeteners in general) is a tendency to promote overeating, which can lead to weight gain and inhibit weight loss. For this reason, I recommend that anyone trying to lose weight minimize or avoid foods that are sweetened, even with natural sweeteners.

And although artificial sweeteners are popular for weight loss and some trials have shown them to be effective, I recommend avoiding them in this case. Aside from the simple fact that they're not real food, the mismatch between sweet taste and caloric load could potentially disrupt appetite regulation and metabolic response, which is counter to any goals of weight loss. If you want something sweet, stick with whole fruit, because the fiber and water in fruit make it more difficult to over-eat, while promoting healthy gut bacteria.

IF YOU HAVE DIABETES OR INSULIN RESISTANCE

For those with insulin resistance or diabetes, I have similar advice: avoid concentrated sweeteners as much as possible, whether natural or refined. Some studies have found that consuming whole fruit does not increase blood sugar or insulin even in people with type 2 diabetes, but I've found in my practice that this really depends on the individual. If you have a blood sugar problem and you're wondering whether you can safely consume whole fruit, I recommend purchasing a glucometer and following the procedure I outline in **this article** to answer that question.

For those who can't tolerate even whole fruit, stevia can be a good choice for when you want something sweet. Stevia has actually been used traditionally as a treatment for

diabetes, and some studies indicate that it can have therapeutic effects in diabetic patients. (126)

Sugar alcohols are another viable option if stevia doesn't work for you. They have fewer toxicity concerns than artificial sweeteners, and some preliminary research suggests that sugar alcohols (particularly xylitol and erythritol) might even be therapeutic for diabetic patients. (127, 128)

Sugar alcohols aren't something I recommend consuming regularly, and I think stevia is a much better option since it has a long history of human consumption, while sugar alcohols are comparatively new. But if you can't (or choose not to) use stevia, occasional use of sugar alcohols could help you not feel deprived. Just keep in mind that tolerance of sugar alcohols varies, both with regards to blood sugar control and digestion (sugar alcohols are high **FODMAP**) so be sure to test your own tolerance.

IF YOU'RE DEALING WITH DIGESTIVE ISSUES

People with IBS, reflux, or other digestive problems often have trouble with concentrated sweeteners. One reason for this is that large quantities of fructose can be difficult to digest and absorb, and **undigested fructose** can lead to unpleasant digestive symptoms. Additionally, sugar is a prime food for gut bacteria, so anyone with small intestinal bacterial overgrowth (SIBO) might experience gas and bloating from intestinal bacteria digesting the sugar before it can be absorbed.

My general advice on sweeteners for those suffering from digestive issues is to go with what your gut can tolerate. This usually means avoiding large amounts of any concentrated sweetener, and avoiding any sweeteners (such as agave nectar) that contain a high proportion of fructose. Raw honey may have some therapeutic properties for digestion despite having a high fructose content, and it's definitely the most "Paleo" sweetener out there, so it's a good option if you tolerate it well.

IF YOU'RE PRONE TO SUGAR CRAVINGS

As I mentioned earlier, sugar can certainly be addictive for some people, and those who have strong cravings for sweet foods can find it difficult to incorporate sweeteners into their diet without crowding out other, more nutrient-dense foods. In this case, it's

probably best to avoid concentrated sweeteners altogether, but this is easier said than done when you have strong cravings!

If you struggle with sugar cravings or addiction, make sure you're getting enough healthy non-sweet carbs – especially dense sources like potatoes and other root vegetables, plantains, and white rice (if you tolerate it). A simple need for carbs can often manifest as cravings for sweets, so making sure you get plenty of healthy carbs can prevent bingeing on sugary foods.

When you do want something sweet, just eat some whole fruit! (Are you sensing a theme here?) However, it can be helpful for some people to restrict your fruit consumption to meal times, especially if you find yourself mindlessly snacking on fruit all day instead of eating other foods.

Another trick for addressing sugar cravings is eating a teaspoon or two of coconut oil. Coconut oil has medium chain triglycerides in it, which are a type of fatty acid that is rapidly absorbed and turned into usable energy.

IF YOU JUST WANT TO OPTIMIZE YOUR HEALTH

If you don't have any particular health concerns or goals, a variety of sweeteners can fit well into a healthy diet. Natural, minimally-refined sweeteners are the best choices, and honey, stevia, and molasses might even provide some health benefits. Although other natural sweeteners such as maple syrup or coconut sugar aren't significantly different from plain old white sugar on a nutritional basis, choosing natural sweeteners ensures that you avoid **GMOs** and possible contaminants introduced during processing.

And it's always a good idea to eat foods that are as close to their whole, unrefined state as possible, even if modern research indicates that they affect the body the same way as more refined foods. That said, occasional consumption of refined sweeteners isn't something to worry about.

Conclusion

When it comes to diet, a primary goal should definitely be to maximize nutrient-density and healthfulness, but actually enjoying your food is just as important. Humans are hard-wired to enjoy sweet foods, and for most people, excluding sweeteners from the diet in the name of health is unnecessarily restrictive. As we've seen, some sweeteners actually have health benefits, and even refined sweeteners aren't as scary and harmful as they're often portrayed to be.

Depending on your health status, health goals, and personal dietary preferences, sweeteners of a variety of types can fit into a healthy diet. The trick is to make sure you're not replacing other nutrient-dense foods with sugar-laden junk, while still allowing yourself to enjoy an appropriate amount of sweet taste, based on your particular needs. Don't limit sugar just because some Paleo "guru" called it poison - rather, objectively consider the role of any type of sweetener in your diet, whether that be cane sugar, honey, stevia, or any of the other sweeteners we discussed in this eBook.

Ultimately, sweeteners are not a necessary component of a healthy diet, but they're also not a serious problem when consumed intelligently. I hope you better understand the truth about sweeteners now, and feel confident to make smart choices next time you're considering indulging in your sweet tooth!