Better World Blog

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Why I Use Agave Nectar: An Examination of Agave Facts and Fiction

As the owner of a small cookie business using organic, whole-foods ingredients, I create custom products for customers with varying health needs. My standard products are sweetened with organic cane sugar, but I use a wide variety of natural sweeteners for custom orders and I'm an avid consumer of alternative health information — so I've paid close attention to the dramatic and alarming information circulating recently about agave nectar, particularly a handful of articles by Dr. Joseph Mercola, Ramiel Nagel, and Sally Fallon condemning agave as uniquely deleterious among sweeteners. As it turns out, these authors all reference a single source — Russ Bianchi — to substantiate their claims.

This curiosity alone inspired me to get to the bottom of these questions: who is Russ Bianchi? If agave nectar is really that harmful, where are the references to credible, peer-reviewed studies? A perfunctory reading of these authors reveals some basic flaws in matters of fact and logical reasoning; but general concerns over agave nectar are informed by broader speculation about the relative safety of dietary fructose in all sweeteners. These questions impact me and my customers, so I've spent some time wading through relevant information to explore what agave nectar is, what it is not, and whether it's safe to use in cooking and baking. I've found that agave nectar is indeed a safe and beneficial product which I intend to keep on using. More importantly, there are some disturbing oversights and blatant errors coming from trusted information sources.

What follows is a brief overview of the chemistry of sugars, a comparison of agave nectar to other sweeteners, and an analysis of where the agave critics confuse basic science with misleading assertions.

WHAT'S THE DIFFERENCE BETWEEN NATURAL SWEETENERS?

Before comparing the sugars in natural sweeteners, it's helpful to understand what they are and how they are metabolized. All carbohydrates consist of **monosaccharides**, or single sugar molecules, in either "bound" or "unbound" form. Monosaccharides are "unbound" when they exist in foods as single, stand-alone molecules that do not require further digestion to be absorbed. Glucose and fructose are important monosaccharides in human nutrition that exist in many fruits and vegetables in their unbound form. Glucose is the most fundamental nutrient our bodies use for fuel, and "blood sugar" refers to the level of glucose in the bloodstream. Other more complex sugars are composed of simple sugar molecules bonded together — for instance, refined white sugar contains the **disaccharide** (two-sugar molecule) sucrose, which is composed of bonded glucose and fructose molecules. The disaccharide lactose, the primary sugar in milk, is composed of the monosaccharides glucose and galactose. Complex starches such as those in wheat and corn are composed of **polysaccharides**, or bonded chains of many simple sugar molecules.[1]

Figure 1: Unbound Monosaccharide Molecules

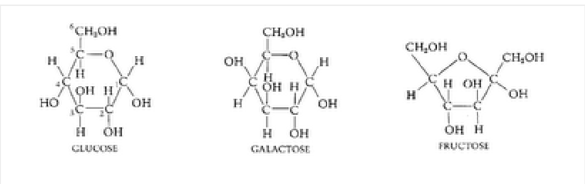

Figure 2: Sucrose Molecule (Disaccharide - glucose and fructose molecules joined with a shared oxygen bond)

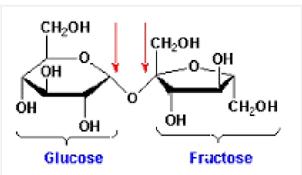

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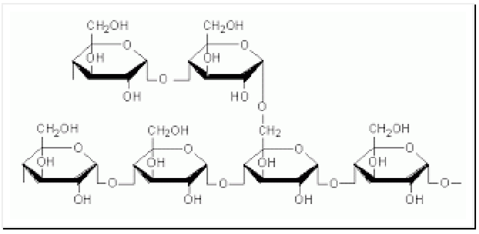
Figure 3: Amylopectin Molecule (Component of starch - polysaccharide with multiple bonded monosaccharides)



When we eat carbohydrate-rich foods such as starchy vegetables and grains, the disaccharides and polysaccharides must be digested into simple sugars through **enzymatic hydrolysis** before they can be absorbed and used by our bodies as energy. Hydrolysis, the process whereby compounds are split into separate components, occurs when microvilli in the small intestine secrete digestive enzymes which split complex sugar molecules into monosaccharides and transport them to other cells.[2] Glucose is transported directly into the bloodstream, while fructose, like other nutrients such as lipids and proteins, is transported to the liver and metabolized for energy or storage.

WHAT IS AGAVE NECTAR?

Agave is a succulent native to the desert regions of the Americas, most commonly found in the American Southwest and Mexico. Agave nectar or "syrup" is a natural sweetener made from the juice or sap extracted from the agave plant. There are two varieties of agave currently used to produce agave nectar sold in the US: *Agave tequiliana*, used for "blue agave nectar" and tequila;[3] and *Agave salmiana,* used to make agave nectar and a traditional alcoholic drink called *pulque.***[4]**

Agave nectar is made either from liquid extracted from the baked *piña* (core) of *Agave tequiliana* plants*,* or from raw sap (*aguamiel*) gathered from *Agave salmiana* plants. The agave liquid is converted to syrup by evaporating moisture and converting the complex sugars in the agave fructans (plant fibers) into fructose and glucose. This is achieved by boiling the *Agave tequiliana* juice (thermal hydrolysis), or the "raw" process of vacuum evaporating the *Agave tequiliana* sap at relatively low temperatures, after which natural enzymes are added to convert the fructans into monosaccharides.[5] This is very similar to the process whereby bees produce honey: bees in the hive regurgitate plant nectar repeatedly to introduce natural enzymes that cleave the complex sugars in the nectar into fructose and glucose. This mixture is high in water content and natural yeasts, so like raw *aguamiel*, it would rapidly ferment without evaporation. At this stage the bees flap their wings to create a strong draft in the hive that evaporates the water and concentrates the honey to about 18% moisture.[6]

All organic sweeteners including honey, maple syrup, rice syrup, and fruit juice can be found in non-organic commercial varieties that contain fillers and additives, and it's important to select organic products from a quality source. There are several high-quality varieties of organic agave nectar available, and for the purpose of this article I will discuss Madhava organic amber agave nectar. Madhava organic amber agave nectar is made from *Agave salmiana* sap converted to syrup through vacuum evaporation and low heat. One tablespoon contains 60 calories and 16 grams of total sugars — 11.6 grams fructose and 4.4 grams glucose.[7]

WHAT ARE THE BENEFITS OF AGAVE NECTAR?

1. **Organic agave nectar is relatively mild, is not chemically processed, and is free from harmful additives.** Organic agave nectar contains beneficial fiber and many trace nutrients including calcium, iron, and vitamins B and C. Organic agave nectar contains no chemical additives, fillers, or "mystery" ingredients, period. Agave nectar is 77% total sugars, compared with 100% refined white sugar. Because the sweetness of fructose is perceived earlier than that of other sugars,[8] relatively less agave can be used in many preparations to achieve the same taste.

2. **Agave has beneficial properties which support digestive health.** Agave contains naturally occurring inulin, a form of fructan found in a number of vegetables including onions, green beans, asparagus, and artichokes. The fructans in agave have been demonstrated to support the growth of beneficial microbial flora in the digestive tract.[9] Recent studies indicate the presence of fructans in the digestive tract also protects against osteoporosis by increasing the absorption of calcium and magnesium, and may protect against diabetes and colon cancer.[10]

   Agave plants are composed of fructans and contain no starch of any kind, so agave nectar is appropriate for those on a gluten-free diet. And like honey, agave nectar is composed of the unbound monosaccharides fructose and glucose, which can be directly absorbed without digestive hydrolysis. This makes agave an appropriate sweetener for those suffering from digestive disorders, whose ability to properly digest disaccharides such as sucrose and lactose is compromised. When complex sugars are not digested properly, they can feed harmful bacteria in the gastro-intestinal tract and perpetuate digestive disease.[11]

3. **Agave has a relatively low Glycemic Index (GI).** The primary sugar in agave is fructose, which has a relatively low GI. *A word about the glycemic index*: GI is a specific metric measuring the relative short-term effect of foods on blood sugar. While it is not a comprehensive indicator of any food's long-term impact on the full spectrum of human endocrine function or overall health, GI is an important metric for diabetics or anyone interested in controlling short-term fluctuations in blood sugar.

4. **Agave is mild-tasting and easy to use in beverages, cooking, and baking.** The success of any diet depends largely on the inclusion of familiar, enjoyable foods. Compared to honey and other organic syrups, agave nectar is mild-tasting, dissolves easily in liquids, and converts seamlessly into traditional recipes. Agave is an ideal sweetener for those looking to improve familiar dishes and desserts using whole foods and organic ingredients.

WHAT ARE THE DRAWBACKS OF AGAVE NECTAR? IS AGAVE POTENTIALLY HARMFUL?

Organic agave nectar is 56% fructose by weight, so it is not appropriate for fructose-intolerant individuals or anyone looking to eliminate all sugars from their diet. Fructose also browns more quickly than other saccharides,[12] so recipes substituting agave nectar for granulated sugar must compensate with lower temperatures. It's also important to note that the molecular structure of fructose changes when heated, making it less sweet. Fructose heated to 140°F becomes about as sweet as table sugar, so agave recipes prepared at low heat require some experimentation for success.[13]

While these considerations hardly disqualify agave nectar as a suitable sweetener, recent critics link agave with problems ranging from obesity to miscarriage. Let's examine the validity of each of these claims.

ARE THE SAPONINS IN AGAVE NECTAR HARMFUL?

Agave tequiliana and *Agave salmiana* contain saponins, a naturally occurring element in many common foods including chickpeas, lentils, oats, beets, spinach, and green peas. While saponins may become toxic in *very high* concentrations, the low levels of saponins found in these common foods are not harmful, and are further reduced during cooking and soaking.[14] Though Fallon and Nagel claim that "saponins in many varieties of agave plants...are to be avoided during pregnancy or breastfeeding because they might cause or contribute to miscarriage,"[15] there is no evidence associating agave nectar with miscarriage or gestational problems, and dietary saponins have actually been found to lower plasma cholesterol in many animal species.[16] In fact, consumption of *pulque* is so widespread among pregnant and lactating women in Mexico that in 2003 a panel of experts conducted a study to measure the impact of alcohol consumption on pregnant Mexican women. They found that while the alcohol impacted gestational growth and birth weight as expected, these effects were somewhat offset by the nutrients in *pulque*, particularly iron and folate.[17]

IS AGAVE NECTAR THE SAME AS HIGH FRUCTOSE CORN SYRUP (HFCS)?

No, agave nectar and HFCS are not the same. Agave nectar, honey, fruits and fruit juices, and HFCS do all contain fructose, but the similarity ends there. To convert the complex starch molecules into the simple sugars in HFCS, first dried corn is mixed with sulfur dioxide, hydrochloric acid, enzymes, and water to separate the complex starches (corn starch) from the insoluble fibers. The resulting starch slurry is then mixed with acid and heated under pressure to yield glucose syrup. A portion of the glucose syrup is then "isomerized," or further processed with isomerase enzymes, pressure, and controlled acidity to convert one monosaccharide (glucose) into another (fructose). That solution is then mixed back into the glucose to yield HFCS in which the saccharide mix is either 42%, 55%, or 90% fructose. Because corn syrup is initially glucose, corn syrup with any converted fructose is considered to be "high-fructose."[18]

The production of many natural sweeteners such as honey, agave nectar, brown rice syrup, and amazake use natural enzymatic action to convert complex starches and sugars into their simpler components. However, HFCS is chemically processed from non-organic, genetically modified corn using caustics and acids, and retains none of the nutrients of the whole food from which it was made.

IS AGAVE NECTAR "WORSE" THAN HFCS?

Attention has turned in recent years toward increased HFCS consumption and increases in obesity, heart disease, and diabetes in the United States. These parallel trends have caused speculation about the possible role of dietary fructose in disease, and amid these general concerns, critics have characterized agave nectar as "worse" and "more concentrated" than HFCS with no defined standard of comparison. A rudimentary examination of nutrition data reveals that a serving of organic agave nectar has a similar profile to fruits and other natural sweeteners.

There are several ways to measure the amount of fructose in a food: we can measure the total amount of fructose by weight or the proportion of fructose to total sugars (how much of the sugar in a food is fructose). Table 1 below compares the relative sugar content of common foods and sweeteners.

Table 1: Relative Sugar Content of Common Foods[19]

Common Food	A) %Fructose by weight	B) %Glucose by weight	C) %Sucrose by weight	D) %Other Sugars by weight	E) %Total Sugars by weight	F) %Fructose of Total Sugars
Blackberries	2	2	0	0	5	49
Grapes	8	7	0	0	15	53
Pear	6	3	1	0	10	64
Apple	6	2	2	0	10	60
Dried figs	23	25	0	0	48	48
Raisins	30	28	0	1	59	50
Golden Raisins	37	33	1	0	71	53
Honey[20]	42	34	1	4	82	52
Organic Agave Nectar[21]	56	18	0	3	77	72
High fructose corn syrup (55)	42	31	0	4	77	55
High fructose corn syrup (90)	72	7	0	1	80	90
Pure refined fructose powder	93	0	0	0	93	100

Note that honey and HFCS-55 have exactly the same proportion of fructose by weight (A), and that honey is a slightly more concentrated sweetener than either agave nectar or HFCS-55 (E). When we consider how much total sugar content of a food is fructose (F), grapes, golden raisins, honey, and HFCS-55 are about the same, while fresh apples, fresh pears, and agave nectar are slightly higher. So what is the criterion by which agave nectar is supposedly "worse" than other dietary fructose? If it is fructose content by weight (A), then honey is "as bad as we thought" and we must also assume raisins are dangerous, based on their fructose content compared with fresh fruits. If it is the proportion of fructose to other sugars (F), fresh apples and pears are also significantly "worse" than HFCS and honey.

While all of the sweeteners shown in Table 1 have relatively high sugar content compared to whole foods (E), it's important to evaluate sweeteners as they are actually consumed — natural sweeteners are used sparingly along with liquids, proteins, lipids, carbohydrates, and dietary fiber in a whole foods diet. To accurately measure the real relative impact of agave nectar in a healthy diet, Table 2 compares common foods sweetened with agave nectar to the whole foods listed in Table 1.

Table 2: Comparison of Whole Foods and Foods Sweetened with Agave Nectar[22]

Common Food	Serving Size	Fructose (grams)	Calories	A) % Fructose by weight	E) % Total Sugars by weight	F) % Fructose of Total Sugars
Blackberries	1 cup (144 g)	3.5	62	2	5	49
Grapes	1 cup (151 g)	12.3	104	8	15	53
Pear	1 med. (178 g)	11.1	103	6	10	64
Apple	1 med. (182 g)	10.7	95	6	10	60
Dried figs	1/4 cup (37 g)	8.5	93	23	48	48
Raisins	1/4 cup (41 g)	12.2	123	30	59	50
Golden Raisins	1/4 cup (41 g)	12.8	125	37	71	53
6 oz. black tea with 1 tsp. agave nectar	192 g	3.9	22	2	3	72
8 oz. brewed coffee with 1 tbsp. half & half and 1 tsp. agave nectar	259 g	3.9	42	2	2	72
1 serving chocolate soufflé (1 tbsp. agave nectar per serving) [23]	1 cup (92 g)	11.7	255	13	18	70

If we were to assume that unbound dietary fructose is the single underlying culprit in the rising rates of disease loosely correlating with increased HFCS consumption, we would expect to see similar results when honey, dried fruits, or fruit juices are substituted. Nagel and Fallon's claim that agave nectar should be avoided but "unheated raw honey or dates work well...or even freshly juiced apple juice or orange juice can provide delicious and relatively safe sweetness" contradicts their basic premise. These misguided recommendations are driven by a basic misunderstanding of dietary fructose and human nutrition.

IS ALL DIETARY FRUCTOSE UNHEALTHY?

Though clinical studies performed on rats have linked *massive* doses of pure refined fructose (30-66% of total calories) to risk factors such as obesity and insulin resistance,[24] rodent data is not universally reliable in predicting metabolic effects on humans,[25] and results of human studies do not consistently bear out these results.[26] Claire Hollenbeck presents an excellent summary of the challenges and inconclusive data surrounding human fructose studies in "Dietary Fructose Effects on Lipoprotein Metabolism and Risk for Coronary Artery Disease." While Hollenbeck expresses concern over the possible implications of some studies, she concedes that "perhaps the most general conclusion that could be drawn from this review...is how little we actually know. Despite the more than 18 studies that have addressed this issue over the years, fewer than 45% provide useful experimental data."[27]

This sentiment is echoed by many of the authors of these studies; however, a handful of dietary experts such as Dr. Mercola have interpreted this data as unequivocal proof that fructose is uniquely harmful among monosaccharides. Even proponents of low-carb diets do not unanimously conclude that a relatively high proportion of fructose in a food's sugar content is in itself harmful. Gary Taubes speculates in *Good Calories, Bad Calories* that it is actually the half glucose/half fructose ratio in both sucrose and HFCS-55 that may be problematic, presenting "the worst of both sugars. The fructose will stimulate the liver to produce triglycerides, while the glucose will stimulate insulin secretion."[28]

If massive doses of pure refined fructose may be harmful in a nutritionally poor diet, does that mean moderate amounts of *any* source of dietary fructose are also harmful, regardless of any other factors in the diet and overall health of each individual? Should we be counting fructose grams with no distinction between whole foods and refined sweeteners, as dieters counted calories in the 1970's and 80's? It is exactly this kind of oversimplified interpretation of clinical data that has spurred a swinging pendulum of conflicting dietary recommendations over the past five decades, none of which consider a holistic view of human nutrition. In fact, there is strong evidence that moderate intake of dietary fructose plays an important role in regulating glucose metabolism.[29]

The clinical trial period for human consumption of fresh fruit, and thus unbound dietary fructose, has been going on for over 200,000 years. Our closest evolutionary cousins, primates, subsist entirely on fruit and minimal proteins (scavenged meat and insects).[30] Fresh fruits impart essential dietary fiber, vitamins, minerals, antioxidants, and live enzymes that can be assimilated without being cooked. High-protein foods especially require these nutrients for digestion and assimilation — traditional societies in extreme climates without access to fresh fruits compensate with foods unavailable or impractical in a modern setting, such as raw animal blood[31] or decomposing sea birds.[32] While the platitude "use in moderation" has been called upon to justify every processed food in existence, many valuable elements of a whole foods diet such as unrefined sea salt, fermented condiments, and natural organic sweeteners can provide vital nutrients and enhance enjoyment when used moderately — but can induce harmful effects if overused.

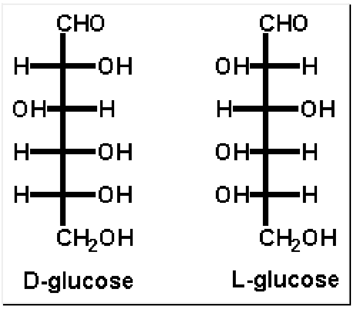
IS THE FRUCTOSE IN AGAVE "DIFFERENT" THAN FRUCTOSE IN HONEY AND FRUIT?

No, absolutely not. Nagel incorrectly asserts that "fructose is not what is found in fruit"[33] and joins Fallon to present an even greater distortion: "...most of the fructose in fruit is in the form of L-fructose or levulose; the fructose in HFCS is a different isomer, D-fructose. Small amounts of D-fructose do occur in fruit, but the D-fructose in HFCS has the reversed isomerization and polarity of a refined fructose molecule."[34]

These claims are just wrong, and in the words of the late great Dr. Wolfgang Pauli, a few are so not right, they're not even wrong. (How would we "refine" a fructose molecule?) First let's correctly define the terms **isomer, polarity,** and **levulose**.

An **isomer** is a molecule with the same molecular formula as another, but different structural arrangements of atoms. Note in Figure 1 above that glucose, fructose, and galactose are isomers — all have the molecular formula $C_6H_{12}O_6$ but they are arranged differently. Carbohydrate molecules also have properties called **handedness** and **polarity**, which are each separate and distinct. **Handedness** refers to a pair of isomers which are mirror-image forms of one another, or **optical isomers.** These molecules are either right-handed or left-handed depending on their shape, and named with prefixes D- or L- after the Latin *dexter* (right) and *laevus* (left). See Figure 4 to compare the isomers D-glucose and L-glucose, in which the arrangement of hydrogen atoms (H) and hydroxyl groups (OH) are reversed. [35]

Figure 4: Comparison of isomers D-glucose and L-glucose



In addition to handedness, isomers have **polarity** — a property defining whether a compound rotates a beam of polarized light clockwise (**dexorotation**) or counterclockwise (**levorotation**). These definitions also include the prefixes "dexo" and "levo" indicated with *lowercase* d- or l- or the symbols (+) and (-) respectively. D-fructose is named **levulose** because of its polarity; though it is a right-handed molecule, it is **levorotary**, or bends polarized light to the left.[36]

Carbohydrates occur in nature almost exclusively as right-handed molecules. All fructose occurring naturally in foods, whether bound in a complex molecule or in its unbound form, is always D-fructose (levulose) — the unbound D-fructose (levulose) molecules are exactly the same in fruits and vegetables, honey, and agave nectar, and they will appear the same when examined under magnification. When bees make honey and when we digest white cane sugar, natural enzymes cleave the bound D-fructose (levulose) and D-glucose molecules from the disaccharides in plant nectar and table sugar.

Research funded by NASA during the 1960's did yield spinoff technology to chemically synthesize the left-handed isomers L-glucose and L-fructose — these molecules cannot be metabolized by the body, i.e., they have no digestible calories. Though L-fructose and L-glucose proved to be too expensive to mass-produce commercially as artificial sweeteners, the same technology yielded the low-calorie sweetener "Tagatose" used in 7-11 Diet Slurpees.[37] The patented process to chemically synthesize L-fructose is achieved through acid hydrolysis.[38] There is no chemically synthesized L-fructose in any food or commercial sweetener that is digestible caloric fructose, including HFCS. Though I don't use HFCS for reasons outlined above, I do think it's important to distinguish blatant errors and scare tactics from facts.

FACT VERSUS FICTION

Fallon and Nagel made the easy mistake of confusing the terms "L-fructose" and "levulose" (l-fructose), which would be somewhat immaterial (and perhaps in poor taste to point out) if not for their fictitious distinctions between molecules and unsubstantiated conclusions about the relative safety of common foods. It's useful to note how legitimate the false claims appear to be in their original context, and how lengthy an explanation is required to show that they are nonsense.

Though the authors' complete mischaracterization of dietary fructose may be an honest mistake, it is one that allows them to distort the relative benefits and impacts of concentrated sweeteners. In *Nourishing Traditions*, Fallon recommends a wide array of natural sweeteners, defining them as "products sweet foods which the nutrients have not been removed (sic), or may even be concentrated due to boiling down and evaporation."[39] She goes on to extol the virtues of enzymes and nutrients in honey, maple syrup, "evaporated cane juice," and grain syrups, among others, yet she and Nagel completely dismiss the same properties in organic agave nectar. Fallon and Nagel's false assumption that agave nectar is synthesized also obscures a more fundamental problem with their argument: why would moderate intake of unbound fructose in agave be injurious when the same amount of fructose consumed in fruit and honey has caused no ill effects for millennia?

Nagel and Fallon were the first to print Russ Bianchi's erroneous distinctions between "different" sources of fructose, after which Mercola referenced their article, followed by dozens of others. As the primary representative for the Weston A. Price Foundation, Fallon is a steward of Dr. Price's research and thus a trusted source among thousands of readers who care about their health. Her readers deserve factual, clear explanations informed by a basic understanding of organic chemistry and human nutrition.

IS RUSS BIANCHI A VALID AUTHORITY ON AGAVE NECTAR?

Russ Bianchi is an ingredient broker and beverage formulator, and the CEO of Adept Solutions, Inc. — a company that independently markets a sugar-sweetened energy drink.[40] Ramiel Nagel, a citizen journalist and energy healer, published Bianchi's remarks about agave nectar on several forums without sufficient external verification. Adequate research reveals that most of Bianchi's claims are unverified and/or simply incorrect — but as often happens on the Internet, they have been widely circulated as fact. I have addressed and clarified many of the errors here, and Bianchi's other claims are easily researched through standard sources.

While I don't intend to lob ad hominem attacks, it is important to consider Bianchi's background and perspective when evaluating his statements, particularly if he is the only known source of the information in question. Why would Bianchi circulate negative information about agave nectar without publishing articles himself that support his allegations with documented facts? Only Mr. Bianchi can fully understand his personal motivation, but readers should be aware that Bianchi is actively marketing competing products without disclosing the full ingredients or nutrition information, and he was successfully sued in 2006 for attempting to appropriate the chemical formula for a low-calorie sweetener called "Replace."[41]

A number of reputable health practitioners sell products that presumably help readers implement their recommendations, and the sale of products need not automatically cast doubt on the veracity of an author. However, inconsistent or contradictory claims about the products an author sells versus competing products should be approached with skepticism. For instance, Dr. Mercola sells honey[42] and perpetuates the myth that the fructose in his honey is different from that in agave nectar.[43]

These distinctions are often hard to identify when sorting through thousands of online sources for valid information, particularly for those who seek out alternative perspectives to mainstream views of health and nutrition. Trustworthy, accurate information should meet basic academic standards, presenting well organized and clearly stated ideas. Arguments should be backed up with peer-reviewed research and references genuinely supporting the concepts cited. (Though it's time-consuming, it's a good idea to confirm that cited references are actually relevant to the ideas in the primary document.) "Personal conversations" should be cited to verify factual evidence or scientific concepts only if the conversation occurred with a recognized, published expert on the concept being discussed, i.e., "personal conversation with Dr. Linus Pauling." Proven facts, hypotheses, anecdotes, and personal opinions all have their place in journalism, and rigorous authors are careful to distinguish each clearly in their writing.

CONCLUSION

Sweeteners are concentrated foods that should not be overused, and anyone with health issues should consult a medical professional when choosing appropriate foods. However, it's important to acknowledge the huge demand for occasional sweets and the value of natural organic sweeteners in whole foods diets. Though all organic sweeteners can be found in low-quality commercial varieties containing additives, carefully chosen, high-quality sweeteners play an important role in the long-term success of maintaining a healthy diet. Organic agave nectar is an excellent choice among natural sweeteners, offering beneficial trace nutrients and dietary fiber, low impact on short-term blood sugar, mild taste, and ease of use.

Clinical research is an invaluable tool in understanding human health; however, it is the responsibility of health practitioners to interpret clinical data cautiously when evaluating how each new discovery fits in the very complex puzzle of human nutrition. We can reasonably conclude that massive amounts of any processed sweetener included in a highly processed, nutritionally deficient diet may increase our risk factors for disease. However, there is no evidence that the unbound fructose in fruits has historically been problematic, and I have found no compelling evidence that healthy, whole foods products cannot safely include moderate dietary fructose in natural organic sweeteners -- including agave nectar. I encourage everyone who takes care in selecting high-quality organic foods to seek the same high quality in information and advice about their health.

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[1] John McMurry and Mary E. Castellion, *Fundamentals of General, Organic, and Biological Chemistry* (Englewood Cliffs: Prentice Hall, 1992), 590-612.

[2] Elaine Gottschall, *Breaking the Vicious Cycle* (Baltimore, Ontario, Canada: Kirkton Press, 2004), 22.

[3] http://en.wikipedia.org/wiki/Agave_tequilana

[4] http://www.wisegeek.com/what-is-pulque.htm

[5] http://en.wikipedia.org/wiki/Agave_nectar

[6] See http://www.honey.com/nhb/about-honey/honey-and-bees and http://www.thepaleodiet.com/nutritional_tools/fruits_table.html

[7] Nutrition information for Madhava organic amber agave nectar compiled from www.madhava.com and independent analysis conducted by Warner Independent Labs

[8] Donald L. Pavia, *Introduction to Organic Laboratory Techniques: A Small Scale Approach* (Belmont: Thomson Learning, 2005), 440-441.

[9] M.G. López and J.E. Urías-Silvas, "Prebiotic Effect Of Fructans From Agave, Dasylirion And Nopal," ISHS International Symposium on Human Health Effects of Fruits and Vegetables (Québec City, Canada) 2007 (http://www.actahort.org/books/744/744_45.htm).

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[11] Gottschall, 17-20.

[12] Fatih Yildiz, Ted Labuza, Mohamed Besri, *Applied Food Biochemistry* (Boca Raton: CRC Press, 2010), 364.

[13] Harold McGee, *On Food and Cooking: the Science and Lore of the Kitchen* (New York: Scribner, 2004), 654.

[14] Ruchi Mishra and S. Wal (ed.), *Encyclopedia of Health, Nutrition, and Family Welfare* (New Dheli: Sarup & Sons, 2000), 73-74.

[15] See http://www.naturalnews.com/024892.html, and note that the references supporting this claim are taken inappropriately out of context. Tyler's *Honest Herbal* does not associate the edible sap or core of agave plants with miscarriage, nor does the "Childbirth Solutions" website which discusses the use of *all* species agave plants as herbs in regard to menstrual flow with no supporting peer-reviewed research.

[16] Gene A. Spiller, *Handbook of Lipids in Human Nutrition* (Boca Raton: CRC Press, 1996), 107.

[17] Backstrand, et al, "Pulque intake during pregnancy and lactation in rural Mexico: alcohol and child growth from 1 to 57 months," European Journal of Clinical Nutrition (2004) 58, 1626–1634 (http://www.nature.com/ejcn/journal/v58/n12/full/1602019a.html).

[18] See http://www.madehow.com/Volume-4/Corn-Syrup.html and http://en.wikipedia.org/wiki/High-fructose_corn_syrup#Production.

[19] Figures in Table 1 are compiled with data from the USDA National Nutrient Database (http://www.nal.usda.gov/fnic/foodcomp/search/) and data published from The Nutrition V Database (http://www.thepaleodiet.com/nutritional_tools/fruits_table.html), except where noted - see notes 20 and 21

[20] Because some commercial bee keepers have fed bees HFCS in recent years, this data is compiled from USDA National Nutrient Database data published in September 1987 (http://www.nal.usda.gov/fnic/foodcomp/Data/Other/herr48.pdf) before this practice became widespread.

[21] Data for agave nectar compiled from Warner Laboratories independent analysis of Madhava Organic Agave Nectar

[22] Figures in Table 2 are compiled with data from the USDA National Nutrient Database (http://www.nal.usda.gov/fnic/foodcomp/search/) and data published from The Nutrition V Database (http://www.thepaleodiet.com/nutritional_tools/fruits_table.html), except data for agave nectar - see note 21

[23] Recipe for chocolate soufflé made with 4 oz. unsweetened chocolate, ½ cup organic agave nectar, 6 egg yolks, 8 egg whites, 5 tbsp. butter, 1 tbsp. pure vanilla extract, 1/8 tsp. sea salt. Recipe yields 8 servings.

[24] See the following: Elliot et al, "Fructose, weight gain, and the insulin resistance syndrome," American Journal of Clinical Nutrition, 76:5 (November 2002), 911-922 (http://www.ajcn.org/cgi/reprint/76/5/911).

Huang, et al, "Fructose-induced insulin resistance and hypertension in rats," *Hypertension* 1987:10, 512-516 (http://hyper.ahajournals.org/cgi/reprint/10/5/512).

[25] Alan Aragon, "Newsflash: Rats are not Humans," *Alan Aragon's Research Review* March 2010, 3 (http://www.alanaragon.com/researchreview)

[26] For scientific review and meta-analyses on studies of dietary fructose, see the following: http://www.ncbi.nlm.nih.gov/pubmed/19592634

http://www.ncbi.nlm.nih.gov/pubmed/18996880

http://www.ncbi.nlm.nih.gov/pubmed/20047139

http://www.ncbi.nlm.nih.gov/pubmed/20086073

(as cited in http://www.alanaragonblog.com/2010/02/19/a-retrospective-of-the-fructose-alarmism-debate/)

[27] Claire B. Hollenbeck, "Dietary Fructose Effects on Lipoprotein Metabolism and Risk for Coronary Artery Disease," *American Journal of Clinical Nutrition* 58 (1993): 800S-807S (http://www.ajcn.org/cgi/reprint/58/5/800S).

[28] Gary Taubes, *Good Calories, Bad Calories* (New York: Random House, 2007), 201.

[29] Shiota et al, "Inclusion of low amounts of fructose with an intraduodenal glucose load markedly reduces postprandial hyperglycemia and hyperinsulinemia in the conscious dog," *Diabetes* 51:2 (Feb 2002), 469-78 (http://www.ncbi.nlm.nih.gov/pubmed/11812757).

[30] Loren Cordain, "Implications of Plio-Pleistocene Hominin Diets for Modern Humans" from ***Early Hominin Diets: The Known, the Unknown, and the Unknowable,***

Ungar, P (Ed.), (Oxford: Oxford University Press, 2006), 363-83
(http://www.thepaleodiet.com/articles/2006_Oxford.pdf).

[31] Bill Hayes, *Five quarts: A Personal and Natural History of Blood* (New York: Random House, 2005), 188.

[32] J. C. H. King, Birgit Pauksztat, Robert Storrie (ed), *Seabirds: Arctic clothing of North America—Alaska, Canada, Greenland* (London: The British Museum Press, 2005), 63.

[33] http://www.naturalnews.com/024892.html

[34] http://www.westonaprice.org/modern-foods/1604-agave-nectar-worse-than-we-thought.html (Note that in this article, reference 12 cited to support this incorrect definition actually links to a site describing the isomerization process whereby D-glucose molecules in corn syrup are converted to D-fructose.)

[35] McMurry and Castellion, 591, 595, A-13.

[36] McMurry and Castellion, 593.

[37] http://www.sti.nasa.gov/tto/Spinoff2004/ch_4.html

[38] http://www.freepatentsonline.com/4623721.html

[39] Sally Fallon and Mary Enig, *Nourishing Traditions* (Washington DC: New Trends Publishing, 2001), 536-7.

[40] http://www.russbianchi.com/aboutruss.html

[41] *Zinco-Sherman, Inc. v. Adept Food Solutions, Inc.,* 2006 WL 1061917 (April 21, 2006 S.D. Tex.) See http://www.willamette.edu/wucl/journals/wlo/iplaw/06news/20060423.htm and http://wombletradesecrets.blogspot.com/2006_04_01_archive.html.

[42] http://products.mercola.com/honey

[43] http://articles.mercola.com/sites/articles/archive/2010/03/30/beware-of-the-agave-nectar-health-food.aspx

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