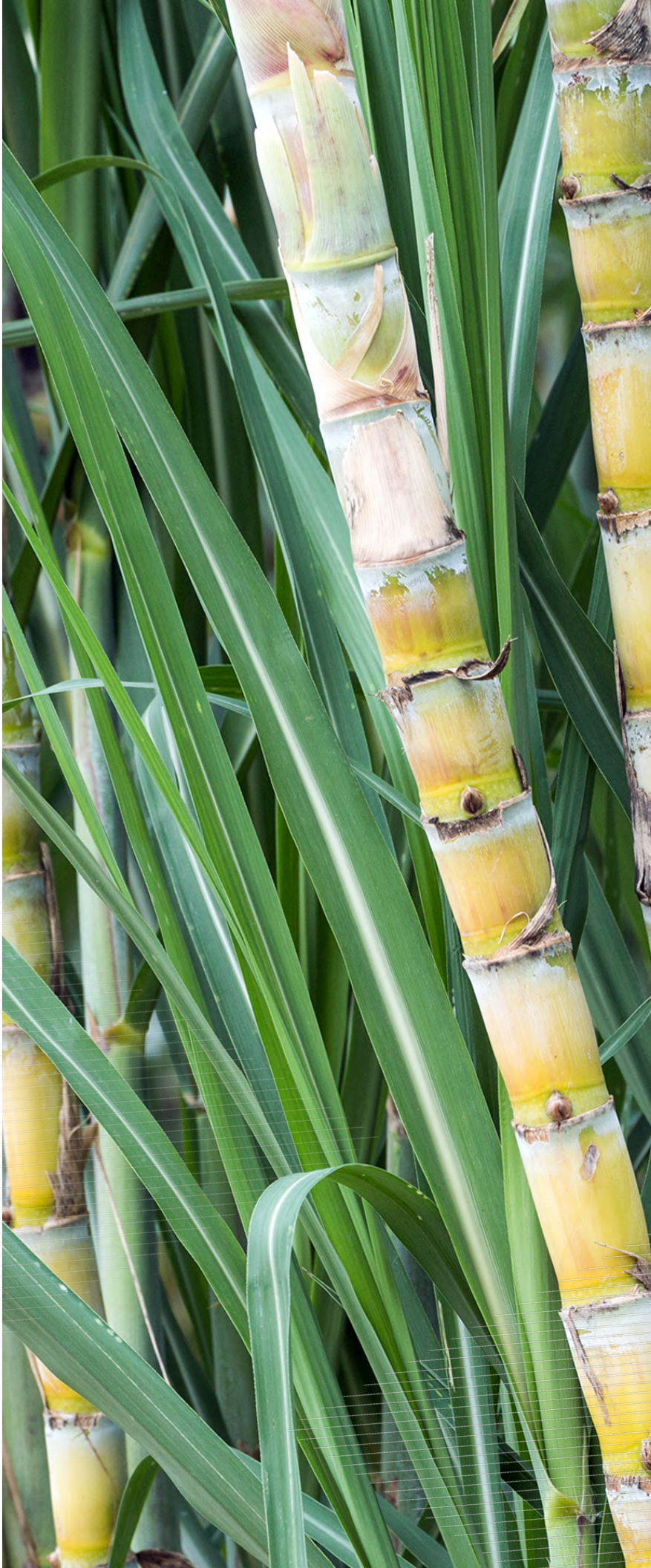
SUGAR CANE JUICE



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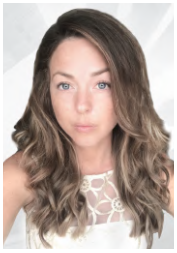
STATEMENT OF PURPOSE

In loose terms, the Paleo Diet is a diet based on the types of foods presumed to have been eaten by early humans before the advent of agriculture. These foods included meat and seafood, nuts and seeds, roots and tubers, and fruits and berries. The diet of our ancient Paleolithic ancestors presumably excluded dairy, grains, and highly refined foods.

Unfortunately, the food landscape has changed significantly in the past 10,000 years, which makes defining items that fall into a 21st century Paleo Diet a bit… tricky. Because the diet is theoretical in nature and up for wide interpretation, no single unified 'Paleo Diet' definition exists, and disagreements over specific food items and processing among the Paleo Community is common.

The purpose of the Consensus Reports for Paleo products is to offer producers and Paleo Community members alike, a more transparent view of The Paleo Foundation standards and procedures of deliberation.

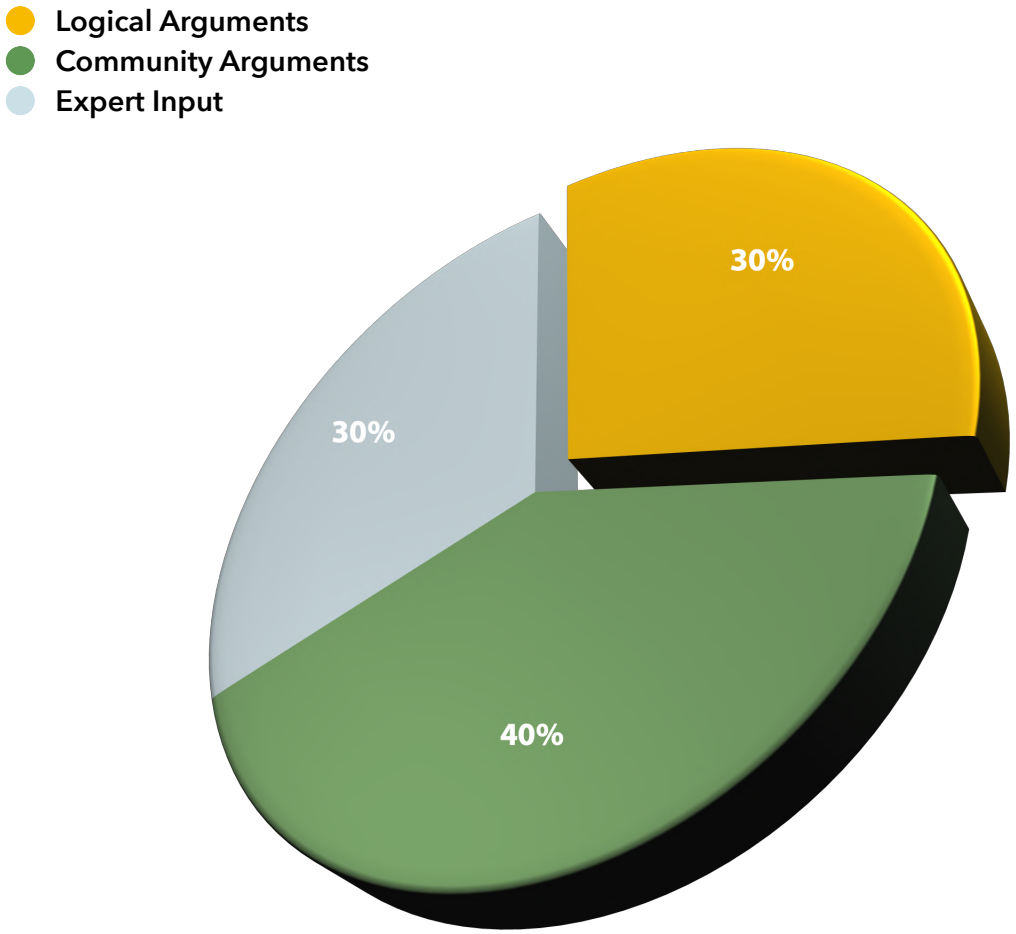


Karen Pendergrass
Paleo Foundation
CEO

WEIGHTED INPUTS

The Paleo Foundation Consensus Reports provide a comprehensive look at how arguments made by the Paleo and Keto communities, leading experts, and the Paleo Foundation are weighted in creating the standards for the Certified Paleo and Keto Certified programs for food products, highlighting The Paleo Foundation deliberation process.

The Paleo Foundation Consensus Reports serve as definitive, comprehensive, and current guides for foods and food ingredients.



Can Sugar Cane Juice Without Additional Refinement be Certified Paleo?

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Community Arguments

1) The sugar cane or sugarcane plant was not available in the areas that Paleolithic humans occupied.
2) The technology to produce sugar cane juice did not exist in the Paleolithic era.
3) Sugar cane juice has a high score on the glycemic index.
4) Sugar cane juice does not contain any nutrients.
5) Sugar cane juice is unhealthy.
6) The Paleo Diet is a low-carbohydrate diet and does not include sugary foods.

KEYWORDS
Paleolithic Diet, Carbohydrates, Glycemic Index (GI), Phytonutrients, Modal Scope Fallacy

1 | BACKGROUND

Since the Paleo Diet [Appendix] was first popularized, sugar cane juice has been a source of controversy within the Paleo community. The majority of Paleo community members believe that sugar cane juice — or any product derived from sugar cane production — is not a Paleo food item [**Figure 1**].

However, as a certification organization, The Paleo Foundation is tasked with making community-wide decisions regarding Paleo food items and must consider controversial ingredients carefully. In this Consensus Report, we will critically examine arguments from the Paleo community on the topic of sugar cane juice and offer additional input from leading Paleo experts. In the conclusions of this report, we will offer our decision to include or exclude sugar cane juice in the Certified Paleo Standards.

2 | LOGICAL ARGUMENTS

- The sugar cane or sugarcane plant was not available in the areas that Paleolithic humans occupied.

Sugar cane or sugarcane are several species of tall perennial true grasses of the genus *Saccharum*, belonging to the grass family *Poaceae*. Sugar cane has stout, fibrous stalks similar to bamboo, that are rich in sucrose, which accumulates in the internodes of its stalks. The sugarcane can grow up to six meters (twenty feet tall) and is native to warm, tropical regions of South Asia, Southeast Asia, and New Guinea.

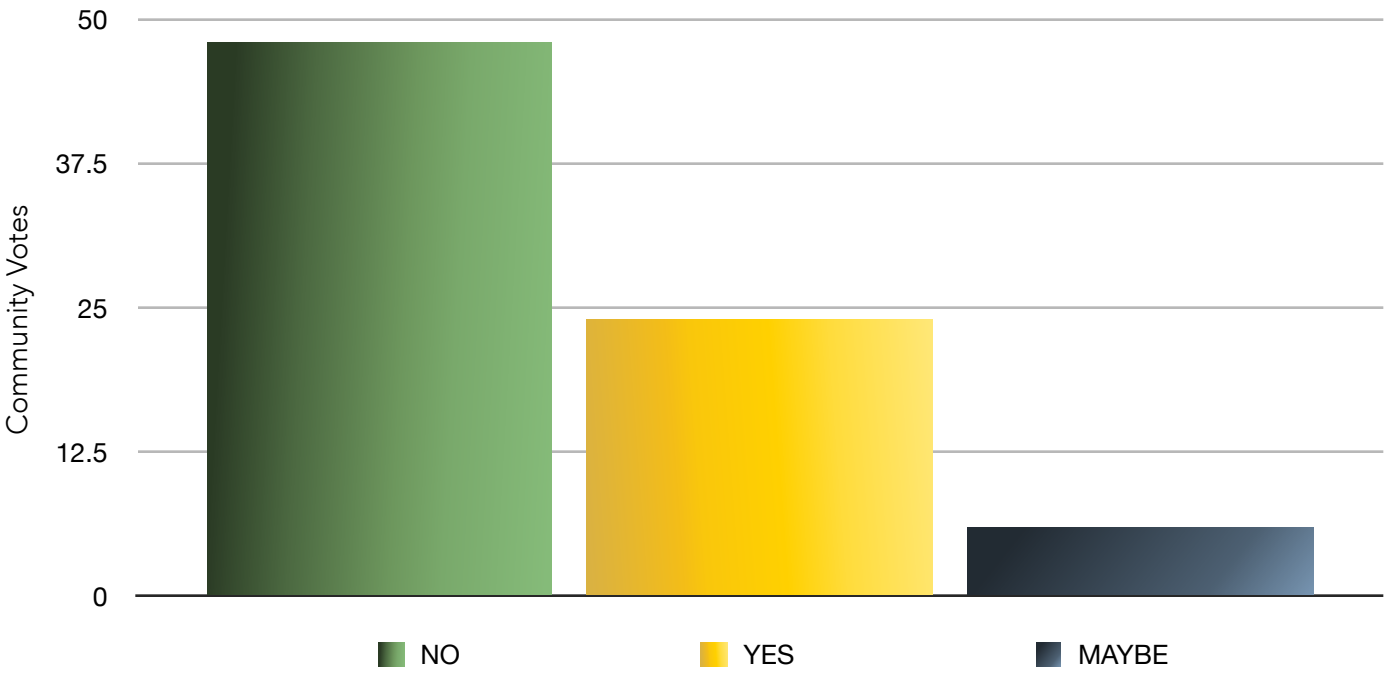


Figure 1. "*Is Sugar Cane, extracted from crushing, boiling, or chewing, Paleo?*" Poll conducted on The Paleo Foundation Instagram September 12, 2019 [1].

One popular community argument suggests that the sugar cane plant did not exist in areas that humans occupied in the Paleolithic Era. However, there is evidence of sugarcane consumption in Papua New Guinea in the late period of the Paleolithic era around 8000 BC [2]. And prehistorians estimate that humans have occupied the Sahul continent (Australia, Papua New Guinea, and Tasmania) for 50,000 - 60,000 years [3].

In other words, sugar cane did exist in the locations that people inhabited in the Paleolithic era, and evidence suggests that it was consumed by humans during that period as well. Thus, this is a poor argument for excluding sugar cane juice in the Paleo diet.

- **The technology to produce sugar cane juice did not exist in the Paleolithic era.**

In modern sugar cane juice extraction, sugar canes are cleaned and cut into small pieces and passed through large, mechanical roller crushers to extract 90-95% of the cane juice [4, Appendix].

However, sugar cane juice may be extracted by other non-mechanical, primitive ways. This includes crushing the canes with heavy objects and extracting the liquid, boiling the sugar cane in water, or simply chewing the sugar cane itself. Primitive objects necessary for crushing sugar cane include heavy rocks or wood.

Boiling sugar cane only requires fire, water, and pottery. The earliest evidence of humans' control of fire dates back a million years [5], and the world's oldest known pottery was discovered in regions near areas that humans occupied in the Paleolithic era, dating back 20,000 years [6].

Thus, contrary to many beliefs, the technology required to produce sugar cane juice — and even traditional cane sugar products, like jaggery [Appendix] — did exist in the Paleolithic era.

- **Sugar cane juice has a high glycemic index.**

Most carbohydrates in food are ultimately broken down into glucose inside the body, which then enters the bloodstream. The glycemic index (GI) is a number from 0 to 100 assigned to a food that represents how quickly the carbohydrate content of that food will be broken down by the average person's body into glucose, with pure glucose given the value of 100 [Appendix]. In essence, the glycemic index is a rating system of how fast a food item can raise blood sugar levels [**Figure 2**] in the average person.

The glycemic index may have some utility for individuals with conditions such as diabetes or other metabolic disorders. However, the GI, as a rating system, has many limitations. For example, when people eat carbohydrates as part of a mixed meal in a non-fasted state, the GI of the meal may be significantly altered by the components of the meal. Further, combinations of foods, rather than single food items, impact blood sugar differently as well [7].

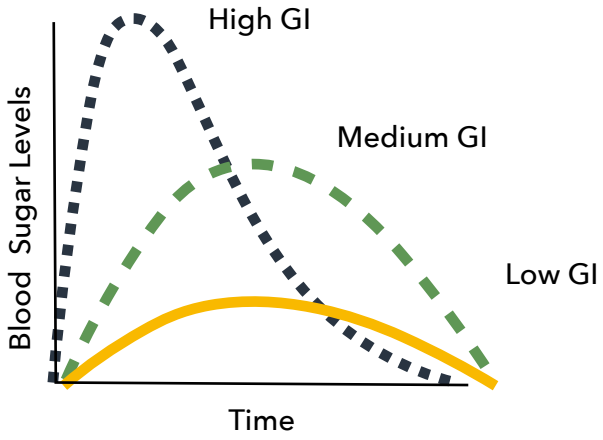


Figure 2. Glycemic Index (GI)

The GI ranking also does not rank foods based on nutrient content, caloric content, and only includes foods that contain carbohydrates. Further, the GI does not take the amount of carbohydrate consumed into account. What you eat matters, but the quantity consumed matters as well.

Thus, a food may have a low GI score but may have a large amount of carbohydrates in one serving, which will lead to a large increase in blood sugar levels. These issues may be resolved by using a similar rating scale based on the glycemic index, known as the glycemic load (GL), The glycemic load takes the glycemic index of foods and standardizes it by the amount of carbohydrates consumed in one serving.

However, none of these measures can accurately predict an individual's response to eating a particular food. So even if one food may have a particular GI/GL score, it does not mean two individuals eating that same food, and the same amount of it, will have the same or even similar changes in blood glucose levels.

In 2019, a group of researchers led by Tim Spector, Professor of Genetic Epidemiology at King's College London, studied a group of 1,000 participants and found that blood sugar level responses to food are highly individual. The study found that even identical twins had remarkably different responses to the same foods. In one example, one twin was found to have more than double the spike in blood glucose to her identical twin, when consuming the same sugary drink. And when the twins consumed other foods, a similar pattern emerged as well. In short, the metabolic responses to the same foods in identical twins were profoundly different [8].

These findings support the adage that "One size does not fit all," and that variability in several environmental factors such as sleep, stress level, activity level, and even the gut microbiome may have more to do with what makes a food healthy for the individual than the food's glycemic index, exposing a huge flaw in the way the system is often used today to determine the healthfulness of a food.

While the glycemic index itself may be flawed, these flaws pale in comparison to the flaw of using it as a means to determine the 'Paleo' status of a particular food or ingredient.

Glycemic index is only assigned as a number associated with the length of time it takes for a carbohydrate to digest, or how quickly the carbohydrate content of a food will be broken down by the average person's body into glucose — not by its prehistoric utility. But to punctuate this point, pizza, spaghetti, and Snickers bars are low-glycemic index foods, with glycemic indices of 52, 50, and 41, respectively [9, 10, 11]. None of these low glycemic foods are widely considered 'Paleo.'

And while sugar cane juice is most often reported as having a glycemic index of 43, which would classify it a low glycemic food [12,13], foods like carrots, parsnips, and watermelon[14, 15] have high glycemic index scores (82, 97, and 72 respectively), and are largely considered to be Paleo. Thus, "Sugar cane juice has a high score on the glycemic index" is a poor argument to disqualify sugar cane juice as a Paleo food as it is a false statement, and the glycemic index is an incredibly poor measure to assess whether something is or is not 'Paleo.'

- **Sugar cane juice does not contain any nutrients.**

Sugar cane juice is abundant in potassium and contains various amounts of calcium, magnesium, iron, manganese, various amino acids, zinc, thiamin, and riboflavin [16]. Not only does sugar cane contain many nutrients, making this claim false, but the phytochemicals and pharmacological activity of sugar cane juice have also gained increased interest due to their potential health benefits.

Sugar cane and sugar cane juice contain various phytonutrients including policosanols, long-chain aliphatic fatty acids, phytosterols, polyoxygenated keto steroids, terpenoids, flavones, and flavone glycosides which are associated with numerous health benefits [17].

Policosanols are a mixture of waxy alcohols derived from a variety of plant sources including sugar cane. These waxy alcohols are recognized for their effectiveness as a treatment in patients with intermittent claudication, or cramping and burning in the legs as a result of peripheral vascular disease (PAD) [18, 19, 20, 21]. These compounds are also recognized for their potential effectiveness against coronary heart disease [22] via their cholesterol-lowering effects [23, 24]. Studies suggest that just 20 mg of Policosanol reduces platelet aggregation about as much as 100 mg aspirin per day [25].

Long-chain aliphatic acids are a class of well-recognized antimicrobials and antifungals, acting through different mechanisms than most conventional antibiotic and antifungal treatments [26]. As antibiotics continue to lose their effectiveness due to antibiotic resistance, compounds with antibiotic activity may have greater clinical importance.

Phytosterols are substances naturally found in plants that are structurally similar to cholesterol. The main phytosterols of clinical relevance are beta-sitosterol, campesterol, and stigmasterol. Sugar cane contains campesterol and stigmasterol. Phytosterols have been found to be effective for treating hypercholesterolemia [27, 28, 29, 30, 31], especially when taken with statin medications [32, 33].

Phytosterols have shown promising evidence in treating colorectal cancer [34], gastric cancer [35], metabolic syndrome [36, 37], myocardial infarction [38], and obesity [39]. Further, some predictive modeling analysis suggests that replacing regular vegetable-oil spreads with phytosterol-enriched spreads can reduce the risk of cardiovascular disease over time [40].

Keto Steroids are synthesized in many plants such as sugar cane, which are unconventional, polyoxygenated, vitamin D-like molecules. Of particular interest, polyoxygenated sterols like those found in sugar cane juice have been examined for their potential as inhibitors of HIV [41].

Terpenoids are a diverse class of organic hydrocarbons that are derived biosynthetically from an intermediate with a simple five-carbon skeleton. **Higher terpenoids**, on the other hand, are more complex terpenoid structures that have between 20 and 40 carbon atoms, and include diterpenes, sesterterpenes, triterpenes, sterols, tetraterpenes, and polyterpenes.

Of the higher terpenoids present in sugar cane juice, some preliminary results show that Hydroxystigmast-4-en-3-one molecules may be potential candidates for use in the treatment of some human cancers including human colon carcinoma and hepatocellular carcinoma [42], while hydroxycampest terpenoids shows significant cytotoxic activity against lung cancer cells [43].

Phenolic Compounds are a class of chemical compounds consisting of a hydroxyl group bonded directly to an aromatic hydrocarbon group. Preliminary evidence suggests that the hydrocinnamic acid phenolic compounds found in sugar cane juice may have potent antioxidant activity, and have been found to inhibit LDL oxidation [44], which increases the risk of cardiovascular disease, and herpes simplex virus [45], as well as showing anti-metastatic and anti-tumor effects on hepatocarcinoma cells with few reported side effects [46]. Other studies have found that caffeic acid is capable of inducing apoptosis in human cervical cancer cells [47].

Flavones are compounds that make up one of the several classes of flavonoids. Flavones are naturally found in many fruits and vegetables and are widely recognized for their antioxidant activity.

Flavonoids have received attention due to their anti-inflammatory, anti-microbial, antioxidant, and anti-cancer activities. However, the understanding of the molecular mechanisms responsible for these activities is not yet fully understood.

Apigenin, a flavone abundant in sugar cane juice, was found to prevent endothelial damage during acute inflammation by reducing reactive oxygen species (ROS), and restoring mitochondrial function [48]. Apigenin also reduced breast cancer cell migration, suggesting the use of the flavone as a potential adjunct therapy to reduce metastasis [49]. It also induced apoptosis in leukemia, prostate, lung, and skin cancer [50, 51, 52].

Like apigenin, luteolin, another flavone in sugar cane juice, also inhibits leukocyte migration in experimental allergic encephalitis, resulting in the prevention of inflammation and neuronal damage [53]. Luteolin was also identified as one of the most potent inhibitors of xanthine oxidase [54], a key enzyme in the production of reactive oxygen species, which are responsible for the damage of cell structures.

Flavone Glycosides are the glycosylated compounds of flavones. Orientin is the 8-C glucoside of luteolin, while compounds like vitexin and Isoschaftoside are apigenin flavone glucosides. Flavone glycosides have similar biological activity as their flavone counterparts.

Orientin, a flavone glycoside found in sugar cane has been widely studied for its antioxidant, antiviral, antibacterial, anti-inflammatory, cardioprotective, radioprotective, neuroprotective, and antiadipogenic and antinociceptive effects [55].

Vitexin has also been studied for its antioxidant, anti-viral, antibiotic, anti-inflammatory, anti-cancer, anti-diabetic, and anti-aging, effects [56].

In short, sugar cane juice contains several nutrients and phytonutrients. Thus, "Sugar cane juice does not have any nutrients" is a poor and incorrect argument for why cane juice is not 'Paleo,' as it is not a true statement.

- **Sugar cane juice is unhealthy.**

Despite the caloric content and sugar content of sugar cane juice, the presence of the aforementioned flavonoids, phenolic acids, and several other phenolic compounds, with recognized antioxidant activity, should be the first indication that the maligned sugar cane and its products may have more health benefits than previously anticipated.

There are approximately 180 calories in an 8-ounce glass of sugarcane juice, as well as 30 grams of sugar. While this may be an astounding amount of sugar in an increasingly sugar-phobic world, the total polyphenolic content of sugar cane juice is relatively high, 160 mg CAE/L. In other words, the consumption of a glass of 250 mL of sugar cane juice would result in an intake of 40 mg of phenolics.

If sugar cane juice was compared to other popular commercial soy-based beverages (which are often touted as excellent sources of phytonutrients, which contain 18 to 83 mg of isoflavones/L, with an average of 32 mg/L [57]), sugar cane juice would be a better alternative to increase the ingestion of polyphenols than soy-based beverages. Therefore, sugar cane juice would offer an excellent alternative to other popular and heavily promoted dietary sources of antioxidant compounds.

Further, several studies on sugar cane, sugar cane juice, and sugar cane extracts have reported the different biological activities and benefits of sugar cane in various in–vitro and in–vivo test models. These findings indicate that there are many health benefits directly associated with the consumption of sugar cane juice. These benefits include:

ANTIOXIDANT ACTIVITY

Antioxidant Activity of Phenolics Compounds From Sugar Cane (Saccharum officinarum L.) Juice [57]. Compounds in sugar cane juice were identified and shown to contain a range of phenolic molecules such as flavonoids and cinnamic acids (apigenin, luteolin, tricin derivatives, caffeic, sinapic acids, and isomers of chlorogenic acid).

Mercurial compounds are known to damage the immune system and to be involved in various diseases, including autoimmune and inflammatory disorders. In this study, the phenolic extracts obtained from sugar cane juice showed a protective effect against in vivo MeHgCl (methylmercuric chloride) intoxication, and dose-dependent, potent inhibition of ex vivo lipoperoxidation of rat brain homogenates. These results support the use of sugar cane juice, a natural source of phenolic antioxidants and a useful alternative therapy for oxidative stress.

ANTIHEPATOTOXIC ACTIVITY

Protective effect of sugar cane juice on isoniazid induced hepatotoxicity [58]. Isoniazid (INH) is currently the standard therapy for tuberculosis (TB), and it is a well-known cause of acute clinical liver injury, which can be severe and sometimes fatal. Because the liver is responsible for the detoxification of drugs, it is particularly susceptible to damage by reactive oxidative species. It has been reported by several studies that there is involvement of oxidative stress in the mechanism of INH-induced hepatotoxicity.

Free oxygen radicals produce injury by lipid peroxidation of hepatocytes, so plant-derived antioxidants such as vitamin E, vitamin C, polyphenols, including flavonoids, apigenin, luteolin, anthocyanins, and catechins, are increasingly recommended to reduce liver injury in patients treated with INH.

Another study, **"Immunological activity of sugar cane polysaccharides"** [59] found that the aqueous extract of sugar cane stems, administered intraperitoneally to mice, was active against chloroform–induced hepatotoxicity.

IMMUNOTHERAPEUTIC ACTIVITY

Immunotherapeutic effects of sugar cane (*Saccharum officinarum L.*) extracts against coccidiosis in industrial broiler chickens [60]. Coccidiosis is one of the most important protozoal diseases affecting poultry worldwide in terms of mortality and morbidity. The results of this study demonstrated that the extracts of sugar cane possess immune-enhancing properties and that their administration in chickens augments the protective immunity against coccidiosis.

Chickens that were administered an aqueous extract of sugar cane juice or ethanolic extract of sugar cane bagasse [Appendix] showed significantly less coccidial oocysts per gram of droppings [**Figure 3**]. Further, postmortem findings of the control chickens revealed extensive hemorrhagic lesions on the intestine and caeca. No or minimal lesions were recorded in chickens of the experimental groups that were given the sugar cane extract.

Another chicken study, "**Immunostimulating Effects of the Polyphenol-Rich Fraction of Sugar Cane (Saccharum officinarum L.) Extract in Chickens"** [61] found significant increases in phagocytic activity of peripheral blood leukocytes (PBL) compared to control chickens receiving a saline solution.

While these studies were performed in chickens, these findings may have clinical relevance for humans. These results suggest that sugar cane juice extracts exhibit immunostimulating and immunotherapeutic effects.

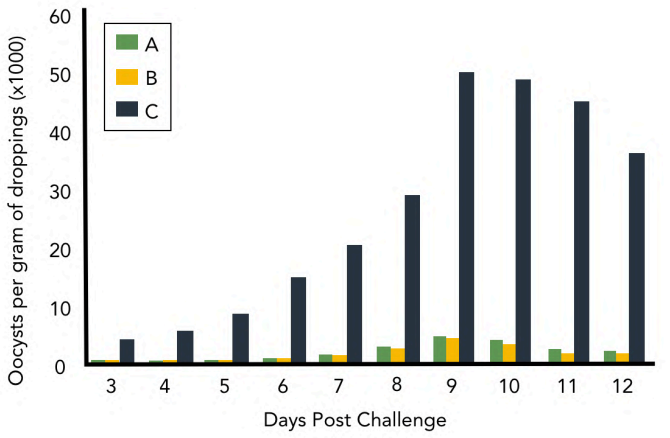


Figure 3. Oocysts per gram of droppings post challenge with Eimeria species (local isolates.) A= aqueous extract of sugar cane juice; B = ethanolic extract of sugar cane bagasse; C = non-treated infected control. Graph derived from Anwar et al. [60].

ANTI-ENDOTOXEMIC SHOCK ACTIVITY

Endotoxic shock induced by gram-negative bacteria does not respond well to conventional treatment [62], and has been reported to be associated with the overproduction or excessive release of inflammatory cytokines, such as tumor necrosis factor-α (TNF-α) and interleukin-1 (IL-1) from monocytes and macrophages activated by lipopolysaccharide (LPS) (also known as endotoxin), a major component of the outer membrane of gram-negative bacteria.

Antibiotics are usually used in the treatment of infectious diseases. However, a sudden release of an excess amount of endotoxin from the antibiotic disrupted bacteria can result in endotoxic shock [63].

"Reduced Lipopolysaccharide (LPS)-Induced Nitric Oxide Production in Peritoneal Macrophages and Inhibited LPS-Induced Lethal Shock in Mice by a Sugar Cane (Saccharum officinarum L.) Extract" [64] showed that the aqueous extracts of sugar cane juice were capable of preventing lethal shock [**Figure 4]** in mice injected with LPS and a sensitizing agent (GaIN).

A similar study, "**Protective Effects of Sugar Cane Extract on Endotoxic Shock in Mice" [65],** had similar results. The results of these two studies suggest that compounds derived from sugar cane have a protective effect against LPS.

ANTI-HYPERCHOLESTEROLEMIC ACTIVITY

"**Cholesterol-lowering effect of policosanol on rabbits with hypercholesterolemia induced by a wheat starch-casein diet"** [66]. The anti-hypercholesterolemic effect of policosanols derived from sugar cane was examined in rabbits. The study found that there was a dose-dependent, significant decrease in total cholesterol and low-density lipoprotein cholesterol (LDL-C), as well as a decrease in serum triglycerides.

In the study "**Protective effect of policosanol on atherosclerotic lesions in rabbits with exogenous hypercholesterolemia"** [67], sugar cane policosanols were examined for their anti-hypercholesterolemic and anti-atherosclerotic effects in rabbits fed a cholesterol-rich diet for 60 days.

This study demonstrates that policosanol, administered orally to rabbits fed a cholesterol-rich diet, was effective in preventing the development of atherosclerotic lesions in the aorta, and at the lowest dose tested, was able to prevent the increase in cholesterol and LDL levels in rabbits fed a fat-free, casein-rich diet (a model of endogenous hypercholesterolemia). Further, the intima thickness of policosanol–treated rabbits was also significantly less compared to the control animals.

"**Effect of policosanol in lowering cholesterol levels in patients with type II hypercholesterolemia"** [68]. A randomized, double-blind, placebo-controlled study was conducted in 45 patients with type II hypercholesterolemia to investigate the efficacy and safety of sugarcane policosanol administered at 10 mg daily. The study found that sugar cane derived policosanol significantly decreased total cholesterol by 162%, and low-density lipoprotein cholesterol (LDL-C) by 21.5% and was well tolerated in patients with type II hypercholesterolemia.

Challenge	Treatment	Survivors/ Mice Tested	Survival Rate (%)[1]
LPS + GaIN	PBS	1/15	6.7
LPS + GaIN	SCE (at -3 h) [2]	12/13	92.3
LPS + GaIN	SCE (at 0 h)	0/8	0
LPS + GaIN	SCE (at 3 h)	0/8	0

[1] Survival rate was determined at 24h after challenge.
[2] Time of injection of SCE before (-) or after challenge

Figure 4. Highlighting the protective effects of sugar cane juice challenge on survival rate in LPS-induced mice. Table derived from Hirota et al. [64].

ANTIHEPATOTOXIC ACTIVITY

"**Protective effect of sugar cane juice on isoniazid induced hepatotoxicity"** [69]. Isoniazid (INH) is currently the standard therapy for tuberculosis (TB), and it is a well-known cause of acute clinical liver injury which can be severe and sometimes fatal.

Because the liver is associated with the detoxification of drugs, it is particularly susceptible to damage by reactive oxidative species. It has been reported by several studies that there is involvement of oxidative stress in the mechanism of INH-induced hepatotoxicity.

Free oxygen radicals produce injury by lipid peroxidation of hepatocytes, so plant-derived antioxidants such as vitamin E, vitamin C, polyphenols including flavonoids, apigenin, luteolin, anthocyanins, and catechins are increasingly recommended to reduce liver injury in patients treated with INH.

This study documented the hepatoprotective effects of sugar cane juice in isoniazid (INH) induced hepatotoxicity, finding that although INH-induced liver injury is associated with oxidative stress, the administration of sugar cane juice (15ml/Kg bw) reduces this damage significantly.

Another study, "**Immunological activity of sugar cane polysaccharides"** [70] found that aqueous extract of dried sugar cane stems, administered intraperitoneally to mice, at a dose of 25 mg/kg, was active against chloroform–induced hepatotoxicity.

ANTI-OBESIGENIC ACTIVITY

In order to study the hypoglycemic effects of sugar cane juice polysaccharide fractions on hyperlipidemia and the arteriosclerosis induced by high sugar consumption, one study, "**Effect of Glycans of Saccharum Officinarum on Carbohydrate and Lipid Metabolism of Rats"** [71] examined a sugar cane polysaccharide fraction (glycan) for its metabolic effects on rats fed a high sugar diet.

At 14 weeks, there was no significant difference in body weight for rats in the control group and the high sugar diet group. However, the high sugar diet group had an elevation of serum glucose and significant accumulation of lipid peroxides in the serum and liver.

However, in the high sugar diet rats receiving combined feeding with glycan, body weight decreased 22%, and the accumulation of lipid peroxides in the serum and liver was inhibited. The study also showed that endothelial cell swelling in the ascending aorta was found in one-third of the control group receiving the high sugar diet, but no pathological change was observed in any of the rats given the sugar cane polysaccharide.

OTHER POTENTIAL HEALTH BENEFITS

It is estimated that 422 million people are living with diabetes in the world or 1 in 11 of the world's adult population. This figure is expected to rise to 642 million by 2040, according to the World Health Organization (WHO) [72].

Diabetes mellitus is a chronic metabolic disorder characterized by a high blood glucose concentration (hyperglycemia), which is due to insulin deficiency and/or insulin resistance. Hyperglycemia occurs because the liver and skeletal muscle cannot store glycogen, and the tissues are unable to take up and utilize glucose.

Treatment of diabetes includes the following: (i) diet and exercise, (ii) insulin replacement therapy, and (iii) the use of oral hypoglycemic agents. Recognized plants constituents reportedly possessing hypoglycemic activity include the following [73]:

- Alkaloids;
- Flavonoids and related compounds;
- Glycosides/Steroids/Terpenoids;
- Polysaccharides/ Proteins; and
- Miscellaneous compounds

The consideration of the healthfulness of sugar cane juice thus far has briefly discussed the flavonoids, glycosides, steroids, terpenoids, and polysaccharide fractions found in the sugar cane plant. While these studies are promising, more randomized controlled trials using chemical components of sugar cane juice are warranted to determine the health benefits of the plant.

In short, stating that cane sugar is not Paleo because it is unhealthy commits the modal scope fallacy [Appendix], as considering it unhealthy for human consumption is not a logical truth. Thus, using the argument that cane sugar is not Paleo because it is unhealthy is a logically poor argument.

- **The Paleo diet is a low-carbohydrate diet and does not contain sugary foods.**

Kitava is one of the four major islands in the Trobriand Islands archipelago group of the Solomon Sea, located in the Milne Bay Province of southeastern Papua New Guinea. Swedish researcher Staffan Lindeberg studied the modern hunter-gatherer Kitavans, finding that they eat a diet consisting of 70% carbohydrate and 20% fat. He also found that the Kitavans did not have obesity, heart disease, or diabetes, and live well into their 90s, often while maintaining a smoking habit [74] [**Figure 5**].

Another one of the remaining hunter-gatherer societies is the Hazda of northern Tanzania. An estimated 72% of their diet comes from carbohydrate sources. In other words, the hunter-gatherer Hazda diet is a high-carbohydrate diet. Evidence suggests that the Hazda diet has remained largely unchanged since prehistoric times [75].

However, one interesting feature of the Hadza is the sheer amount of honey they consume in their diets, and their coevolved mutualistic relationship with the honeyguide bird, spanning 1.9 million years to find honey [76] [**Figure 6**].

Figure 6. Yao honey-hunter and a wild, untamed, free-living honeyguide. Image from Begg et al. [77].

In a rare case of mutualism between humans and a wild animals, African honeyguide birds are known to regularly lead human honey-hunters to bee colonies [77]. The human-honeyguide relationship is noteworthy in that it involves human cooperation with wild animals in natural settings, whose regular, mutualistic interactions with humans over the millennia likely evolved through natural selection.

Figure 5. Kitavan smoking a cigarette. Lindeberg et al. [74]

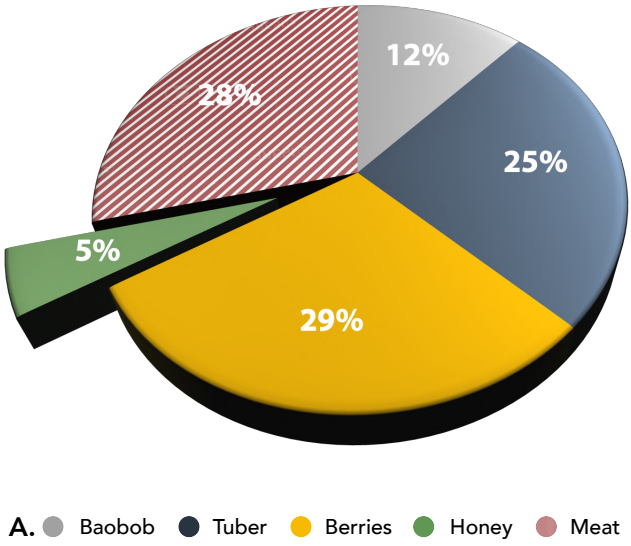
Observational studies of the Hazda suggest that 14% of their caloric intake is from honey [75] [**Figure 7**]. However, the Hazda are not alone in their honey consumption. Other hunter-gatherers, such as the Mbuti of the Congo forests, also eat large amounts of honey. At times, and especially during the rainy seasons, up to 80% of the calories in their diet come from honey [78].

Where honey is available, it has traditionally been an important food for hunter-gatherers. Of the warm climates studied (Effective Temperature ≥ 13 °C), all hunter-gatherer societies consumed honey, with the exception of the Badjau of the Philippines, who spend most of their time on boats [75] [**Figure 8].**

Despite the high sugar, high carbohydrate content (278.39 grams of sugar per cup (or 339 g), a 99.7% carbohydrate food) [79], honey is a verifiably Paleolithic food. Some scientists believe that honey would have played a vital role in meeting the metabolic requirements of higher neural development and function, and may have even been responsible for human evolution in the region [76].

In effect, the Paleo Diet is not an inherently low carbohydrate diet, rendering the statement that "The Paleo Diet is a low-carbohydrate diet" a modal scope fallacy and not a logical truth. In light of the honey consumption of Paleolithic people and current hunter-gatherer societies, the argument that the Paleo Diet does not inherently include sugary foods — even those devoid of fiber — is also false.

Thus, "The Paleo diet is a low-carbohydrate diet and does not contain sugary foods" is a poor argument against the inclusion of **sugar cane juice** in the Paleo Diet.



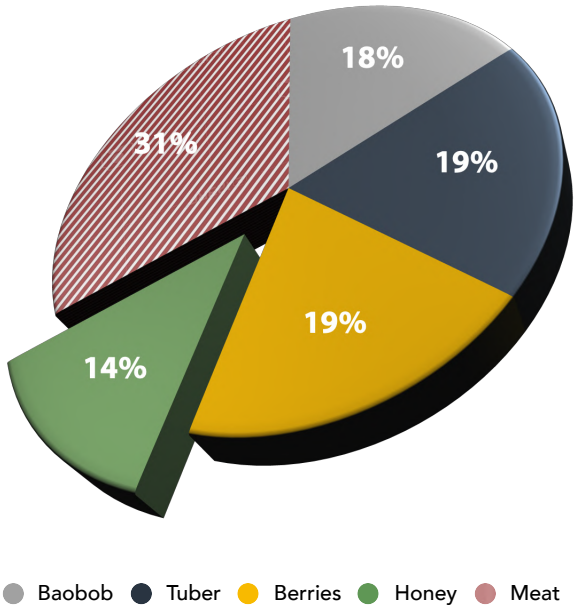


Figure 7. A. Percentage of kg of honey in the Hazda diet. **B**. Percentage of calories in the Hazda diet. Marlowe, F.W., et al., Honey, Hadza, hunter-gatherers, and human evolution, *Journal of Human Evolution* (2014). [75].

Figure 8. Honey Consumption in Hunter Gatherer Societies Worldwide. Marlowe, F.W., et al., Honey, Hadza, hunter-gatherers, and human evolution, *Journal of Human Evolution* (2014). [75].

3 | EXPERT INPUT

Robb Wolf is a former research biochemist and a 2x New York Times and Wall Street Journal best-selling author of "The Paleo Solution" and "Wired To Eat," and is credited with transforming the lives of millions of people around the world with his US, top-ranked iTunes podcast, books, and seminars. He has served as a review editor for the *Journal of Nutrition* and *Metabolism* and *Journal of Evolutionary Health*, and is recognized as the world's leading expert on Paleo nutrition [80] .

When asked the question "Is sugar cane juice, or water extracted from the sugar cane by crushing, boiling, or chewing, Paleo?" by the Paleo Foundation, Wolf quickly responded with "In my opinion, yeah, [sugar cane juice] is Paleo. Yes, it's sugar, but it's minimally processed, and also highly sustainable."

(Karen Pendergrass, personal communication, September 17, 2019)

4 | DISCUSSION

Of the five Community Arguments levied against the inclusion of sugar cane juice in the Paleo Diet, the glycemic index argument (3), the argument regarding sugar cane juice being nutritionally void (4), and the low-carbohydrate / sugary foods argument (5) appear to be the most prolific.

However, these arguments are simply false. Yet these are common belief sets leading to the majority opposition within the Paleo Community. We posit that these observations may be a function of the Illusory Truth Effect [Appendix] in action, as these false claims are often made without citation, taken as a common knowledge statement of fact, and appear to be prevalent on many community sites and discussion boards.

5 | CONCLUSION

While sugar cane juice extracted with minimal processing meets the basic tenets of the Paleo Diet, the Paleo Community is most likely to respond with extreme opposition to its inclusion in the Paleo Diet given community polls. Promoting the acceptability of sugar cane juice warrants additional education efforts.

Despite the opposition sugar cane juice may receive from the Paleo community, The Paleo Foundation will support the inclusion of unrefined sugar cane juice into the Certified Paleo Standards, as it meets the ruling requirements based on Weighted Input as outlined on page 4.

6 | CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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8 | APPENDIX

Paleolithic Era

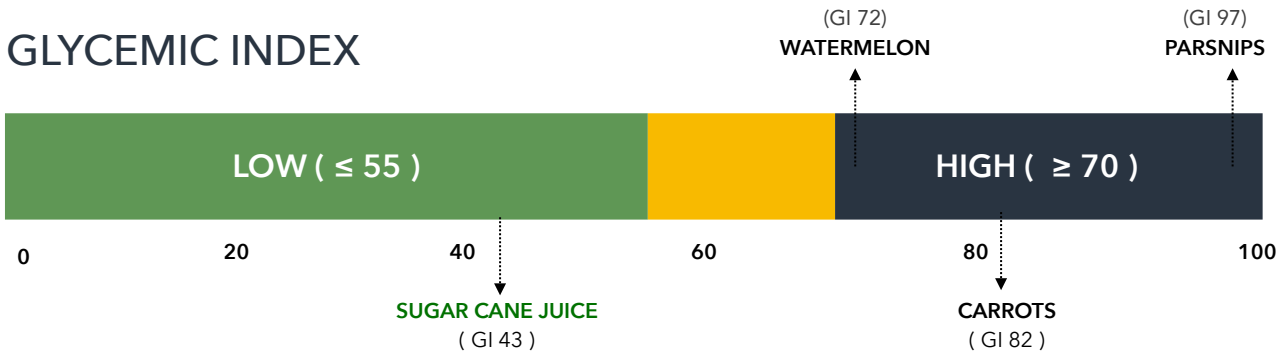
While there is some disagreement among archaeologists about when the Paleolithic period began and ended, estimates suggest that it started around 750,000 B.C. to 500,000 B.C., and ended approximately around 10,000 B.C. to 8,000 B.C. when the Neolithic period began, hallmarked by the advent of agriculture. However, this transition point is heavily debated, as different parts of the world achieved the Neolithic stage at different times.

Paleo Diet

The Paleo diet is an abstract, theoretical template, based on the foods presumed to be eaten by individuals during the Paleolithic era, before the advent of agriculture. These foods included meat and seafood, nuts and seeds, roots and tubers, and fruits and berries. The diet of our ancient Paleolithic ancestors presumably excluded dairy, grains, and highly refined foods.

Glycemic Index

The Glycemic Index (GI) is a number from 0 to 100 assigned to a food, with pure glucose assigned the value of 100, which represents how quickly the carbohydrate content of a particular food item will be broken down into glucose.



Logical Truth

All of philosophical logic aims to provide accounts of logical truth and logical consequence. A logical truth is a statement which remains true given all interpretations of its components other than its logical constants. Logical truths are considered to be necessarily true.

Necessary Truth

A statement is considered necessarily true if it is impossible for the statement to be true. In other words, no scenario exists that would cause the statement to be false. Thus, a logical truth must be true in every sense, and no situation could arise which would cause a rejection of its logical truth without committing a logical fallacy.

Fallacy

A fallacy is the use of an invalid or faulty reason in the construction of an argument. A fallacious argument may be committed intentionally to manipulate, while others may be committed unintentionally, due to ignorance, carelessness, and poor understanding of logical constructs.

Modal Scope Fallacy

Modal logic studies ways in which a proposition may be true or false. Some propositions are necessarily true or false while others are possibly true/ false. A modal scope fallacy is a type of fallacy that occurs in modal logic, when a proposition is placed in the wrong modal scope in an argument, leading one to infer that because something is true, it is inherently or necessarily true. This renders the argument invalid by confusing the scope of what may actually be a possible truth as a necessary truth.

Example:
"Sugar can juice is unhealthy because it contains sugar."

This is not a necessary truth, as there are many documented circumstances where sugar cane juice is healthy. The more accurate modal scope is that it is a possible truth, as there may be instances where sugar cane juice is both healthy, and unhealthy.

Illusory Truth Effect

The illusory truth effect or reiteration effect is the tendency to believe false information to be correct after repeated exposure. This Illusory Truth Effect phenomenon was first identified in a 1977 study at Villanova University and Temple University.

COMPOUNDS IDENTIFIED IN SUGAR CANE

Policosanols:

- Tetracosanol
- Hexacosanol
- Heptacosanol
- Octacosanol
- Triacontanol
- Dotriacontanol
- Tetratriacontanol
- Hexacosanoic

Long-chain aliphatic fatty acids:

- Hexacosanoic acid
- Heptacosanoic acid
- Octacosanoic acid
- Nonacosaoic acid
- Triacontanoic acid
- Hentriacontanoic acid
- Dotriacontanoic acid
- Tritriacontanoic acid
- Pentratriacontanoic acid
- Hexacotriacontanoic acid

Phytosterols :

- brassicasterol
- campesterol
- betasitosterol
- stigmasterol

Keto Steroids:

- methylcholest-3,6-dione
- ethylcholest-3,6-dione
- ethylcholest 22en–3,6-dione

Higher Terpenoids:

- Hydroxycampest-4-en-3-one
- Hydroxystigmast-4-en-3-one
- Hydroxystigmast-4,22-dien-3-one

COMPOUNDS IDENTIFIED IN SUGAR CANE JUICE

Phenolic Compounds:

- chlorogenic acid
- cinnamic acid
- hydroxycinnamic acid
- sinapic acid
- caffeic acid

Flavones:

- apigenin
- luteolin
- tricin

Flavone Glycosides:

- 4′,5′- dimethoxy-luteoline-8-C-glucoside
- tricin-7-O-rhamnosylgalacturonide
- tricin-7-O-glucoside
- schaftoside
- isoschaftoside
- vitexin
- orientin

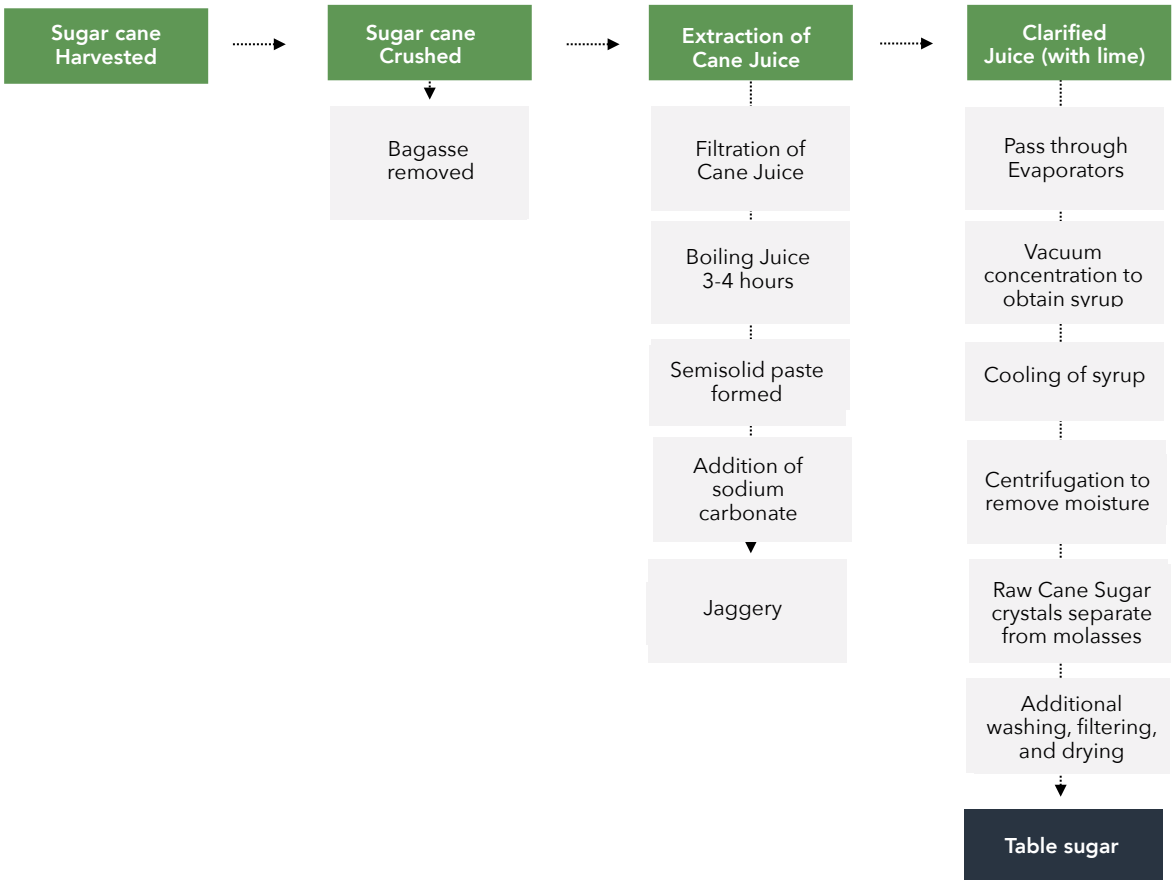
Jaggery

The prehistoric production of jaggery would have been possible with the natural mineral form of sodium carbonate, nahcolite. Nahcolite is a component of the mineral natron and is found in many mineral springs.

Bagasse

Bagasse is the dry, pulpy, fibrous matter that is left after the extraction of juice from sugar cane.

Cane sugar production process [81]:



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Can Sugar Cane Juice Without Additional Refinement be Certified Paleo? Paleo Foundation Consensus Report. (2019)

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