

FROM CRAVINGS TO CARCINOGENESIS: A REVIEW OF SUGAR’S DUAL
ROLE IN ADDICTION AND CANCER

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Abstract

Keywords:

Sugar,Carcinogenesis, calories

Received on 15 February, 2026

Accepted on 04 April, 2026

Published on 22 April, 2026

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Today, the primary global health concern is the excessive intake of added sugars, which surpasses obesity and diabetes. This report aims to bring together the facts on sugar, both as a potentially addictive substance and as a factor that may contribute to the development of cancer. The report highlights the neurobiological mechanisms by which refined sugars can serve as super stimuli for dopamine reward pathways in the mesolimbic system. Consequently, it produces neuroadaptations that are indistinguishable from those caused by drug addiction resulting in down regulation

of dopamine receptors, impairment of the prefrontal cortex, and loss of control over intake. Eventually, this results in compulsive overeating, as this addictive feedback loop

maintains prolonged and excessive exposure over time. Additionally, the key oncogenic mechanisms driven by this long-term high exposure include; 1) the high glucose supply leading to Warburg effect in neoplastic cells, 2) hyperinsulinemia and high IGF 1 activity which activates proliferative pathways such as PI3K Akt mTOR, 3) oxidative stress and inflammation leading to genotoxicity, and 4) obesity, which itself is a carcinogen. We propose that the carcinogenic and addictive effects of sugar are mutually reinforcing and thereby, generate a destructive feedback loop of self-perpetuation. Therefore, cessation of sugar consumption should be identified as a primary preventative measure against carcinoma, aligning with established oncological and health advisories that recommend minimizing sugar intake to reduce its carcinogenic potential.

INTRODUCTION

We are living in that world where an average person is consuming 40 pc sugar of their body weight annually. Global sugar use has gone up a lot, and right now, people are eating more than 25 kilograms of added sugar each year.[1] That's over 65 grams—or 16 teaspoons—of sugar every day. This isn't just about the sugar you add to your coffee. It's about sugar that's hidden in your food. [2] Added sugars are everywhere in the modern food system, and they're in about 74% of all packaged foods you see in stores. The sweetness comes in many names:

· Sucrose, which is regular table sugar
· High-Fructose Corn Syrup (HFCS), which is a common sweetener in processed foods. A lot of "natural" syrups and concentrates that, even though they sound healthy, still give your body the same sugars: glucose and fructose you eat a lot of added sugar but you don't eat the naturally ones. Intrinsic sugars are sugars naturally found within the cell structure of fresh foods such as fruits, vegetables,

and dairy. They are a very important part to a healthy diet because they are filled with the fiber, vitamins, minerals, and phytonutrients that they need to regulate their absorption. Public health here talks only about sugar that is put in while making or cooking food and drinks. This means added sugars, like white sugar, syrup made from corn with high-fructose, and other sweet things with calories. These are all put into food and drinks when they are made or mixed. They promote excessive intake, which, statistically, is linked to health issues, and supply calorie consumption with no nutritional value. Therefore, this investigation will evaluate the hypothesis that sustained consumption of excessive added sugars sustains a metabolic and inflammatory state favorable for pathway activation and carcinogenesis, thereby increasing the likelihood of tumor development.[3]

Because of this risk, big global health groups have set clear limits. The World Health Organization (WHO) says that added or 'free' sugars should be less than 10% of all the energy we get from food each day. They also suggest going even lower, to under 5%, which is about 25 grams or 6 teaspoons, if we want more health benefits. But right now, people are eating a lot more than these limits—often double or even triple them.[4]

The big problem is how much sugar we're eating. A single serving of a popular breakfast cereal can already have 5 teaspoons of sugar before you even start your day. A regular bottle of sweetened tea or a flavored yogurt can have 8 to 10 teaspoons. This is creating a global problem where people are eating two or three times the maximum daily limit of 25 grams, as recommended by health experts. This constant, daily flood of sugar isn't just a simple choice. It's like a long-term experiment on the body.

And now, the human brain and body are showing signs of that. The first and most dangerous effect is on the brain itself—the part that decides whether you want to eat more.

The Neurobiological Underpinnings of Sugar Consumption: An Addiction Framework

It's not only your mouth that feels it when you eat lots of sugar. It also has a lot to do with the way your brain operates like the way it reacts to addictive stuff. Scientific evidence supports the assertion that white sugar genuinely stimulates the brain's reward systems due to its ability to trigger significant responses in these areas. It can mess with your head, make you crave & like stuff - and it's been proven in lots of experiments by loads of different teams, just that it's got the same effect on your brain as a drug, really scary to think about.[5]

1. How the Sugar Make you feel good and a bit of Dopamine.

It begins with the feel good stuff - the way sugar gives you that high of pleasure is primarily occurring in the brain's reward circuitry, primarily within the mesolimbic dopamine pathway. The second you eat something sweet your brain pretty fast releases a bunch of dopamine. And it happens in a little bit of a brain called the nucleus accumbens. This part helps you feel joy and is key to what makes you want things. This dopamine message is telling the brain that sugar feels good and now we are more interested in sugar in the future. It's more of an impact because sugar can make your blood sugar go up and down really fast and it can make you hungry really fast but complex carbs don't do this to your brain. Modern consumables with elevated sugar levels enhance its addictiveness beyond historical levels. It's no longer only sugar, but in ultra-processed foods with refined sugar and a lot of salt, bad fats and flavour enhancers.[6] This synthesis produces what is known as hyperpalatability, a state in which the palatability of the food is enhanced to a degree that it activates a reward response within neural pathways that exceeds the response generated by sucrose consumption alone. They have very little fiber

and are low in digestibility and so produce rapid rises in blood glucose and insulin.[7]This quick change in how the body works makes you want more food.and that is why the food that we eat today is very sugary its not just that they just want us to not feel full and they just want us to keep eating that why its so hard to not go over and go to the limit without even trying to be more aware and make better choice

2 Neuroadaptive Responses and the Emergence of Tolerance:

The reward system undergoes compensatory neuroadaptations as a result of prolonged, sporadic exposure to high sugar concentrations. [8]The downregulation of postsynaptic dopamine D2 receptors in the striatum and NAc is a major adaptation. This receptor reduction is a type of pharmacological tolerance in which the dopaminergic response is gradually reduced at a given sucrose dose.[9] As a result, in order to reach the antecedent level of reward perception, larger amounts or more frequent ingestion are needed, which feeds the cycle of increasing consumption. A hallmark of the development of addictive diseases is this neurochemical tolerance.

3. Prolonged Withdrawal Syndrome Symptoms:

When long-term exposure to sugar is stopped, reward homeostasis dysregulation becomes apparent. When a high-sugar diet is stopped, preclinical models consistently show a behavioral withdrawal syndrome marked by anxiety-like behaviors, locomotor agitation, and anhedonia. Similar, but frequently subjectively described, symptoms in humans include intense cravings, irritability, cognitive exhaustion, and dysphoric mood following dietary sugar restriction. A hypodopaminergic state and dysregulation of endogenous opioid and corticotropin-releasing factor (CRF) systems in extended

amygdala regions are the neurobiological underpinnings of this state, which is similar to the unpleasant affective state of drug withdrawal[10]

4. Loss of Inhibitory Control and Dysfunction of the Prefrontal Cortex

The top-down control of appetitive impulses depends on executive function, which is primarily controlled by the prefrontal cortex (PFC). Chronic high-sugar diets are linked to reduced PFC function, according to convergent data from behavioral and neuroimaging investigations. This shows up as decreased gray matter volume in areas linked to self-regulation and decreased activity during activities demanding delayed gratification. Impulsive and compulsive consumption patterns are facilitated by a neurobiological situation where hyperactivated subcortical drive for reward is met with insufficient cortical restriction due to the resulting weakness in inhibitory control.[11]

According to a 2023 study published in Cell Metabolism, long-term high sugar consumption literally rewires taste perception in addition to causing cravings. The brain's sweet taste cortex was less active in mice on a high-sugar diet. This is a biological trap more than just a lack of self-control since the brain itself gets less sensitive to sweetness, which may lead people to seek out progressively more intense sweetness to register the same amount of reward.

5. The Endogenous Opioid System's Concurrent Involvement

Sugar's reinforcing qualities are not limited to dopaminergic pathways. Endogenous opioids are also released when sweet foods are consumed, especially in the NAc and ventral pallidum. Different from dopaminergic "wanting" or motivation, this opioid activity mediates the consummatory pleasure or "liking" aspect of the event. The palatability of

sweet solutions is diminished by antagonistic opioid receptors, and long-term exposure results in opioid system dependency, the sudden cessation of which greatly exacerbates the unpleasant state associated with sugar abstinence.[12]

From Craving to Crisis: The Systemic Toll of Sugar

First, the sugar affect to our brain is just start, after a long time of consume way too much sugar, a lot of bad things happen to our body and it can be turn to a health emergency.They all think that it ' s a metabolic issue that is making them eat such a lot of sugar.the liver, where it induces the body to generate higher levels of adipose tissue this process, termed de novo lipogenesis, constitutes a critical aspect of

Non-Alcoholic Fatty Liver Disease (NAFLD):

NAFLD constitutes the most prevalent liver disorder globally, as reported by the World Health Organization (WHO).Additionally, they indicated that in 2022, overconsumption of sugary beverages became a significant preventable factor linked to this condition.Metabolic syndrome: Hypertension, hyperglycemia, excessive abdominal fat, and high low-density lipoprotein levels may be classified as a syndrome.The World Health Organization recognizes excess free sugar intake as a separate risk factor for this syndrome.the best connection between food and diabetes, why sugar is the number one cause of type 2 diabetes.the organism is under to much metabolic stress, because of the excess sugar intake which lowers insulin sensitivity of tissue.The Cardiac Health Diet: Effects of sugar intake on cardiac health.[13]

Sugar and Your Heart

Most of us eat sugar each day. But eating too much sugar can be bad for your heart. If you eat or drink a lot of sweet things, it may hurt your heart and blood. Why Too Much Sugar Is Bad If you eat more sugar, it can make you gain weight. More weight can make your heart work too hard. Too much sugar can raise blood levels, which is not good for your heart. Your body can be at risk for heart disease if there is too much sugar.

So, this process sets off many bad things in the cells. It leads to more insulin in the blood, stress for the cells, and it also makes more bad sugar proteins called AGEs. They also set off a long, slow burn in the body that can hurt the walls inside your blood tubes. This steady kind of swelling chips away at the smooth layer in your veins, signifies a critical initial phase in atherosclerosis progression. Data analysis indicates a statistical association between high sugar consumption and increased blood pressure, triglycerides, decreased high-density lipoprotein cholesterol, and elevated C-reactive protein. [14]

The Chain of Negativity:

eating large amounts of sugar for a long time period can overwhelm both our liver and pancreas because of lipogenesis in liver and constant need to insulin release from pancreas. Excess sugar is stored as visceral fats leading to obesity. secondly constant insulin release for years can result in insulin resistance leading to hyperinsulinemia and type 2 diabetes. The effects aren't just limited to this, other effects like high blood pressure, high blood sugar, high triglycerides are also observed. so in short obesity can worsen insulin resistance which can worsen the metabolic syndrome leading to heart problems and inflammation further increasing the chances of tumors and cancer

The Oncogenic Engine: Mechanistic Pathways Linking Dietary Sugar to Carcinogenesis

The hypothesis that sugar consumption may contribute to carcinogenesis is not a recent development. sort of like our system in our body just rip us apart. Overconsumption of high-sugar foods is unnecessary and places additional strain on bodily metabolic processes. These alterations influence cellular energy dynamics, endocrine regulation, and broader physiological systems. It Starts, It Sends, It Matters.

1. Changing How Cells Use Energy and Supporting the Warburg Effect

the very first thing that cancer cell do is warburg effect. so even if you have oxygen around you use glycolysis to make energy. not really good but it help the cell build the parts that it need to grow fast and subdivide that what the parts you need to make the new dna or the parts you need to make the new protein

Nutritional Consumption: High intake of refined sugar results in sustained hyperglycemia. This keeps a steady flow of sugar for cells to make power and build key things.

Getting More Sugar In: Cancer cells have a higher concentration of specific proteins categorized as glucose transporters, facilitating sugar intake. This elevated sugar consumption preference can also be statistically associated with various signs of neoplastic activity in the organism, establishing a positive feedback mechanism where increased glucose intake further facilitates neoplastic proliferation. [15]

2. The Environment That Promotes Inflammation

High sugar consumption results in a persistent, low-level systemic inflammatory response, contributing to carcinogenesis.

Cytokine Storm: Continuous secretion of pro-inflammatory cytokines (e.g., TNF-, IL-6, IL-1) is observed under conditions of hyperglycemia and hyperinsulinemia, which activate critical inflammatory transcription factors (e.g., NF-

B).Tumor-Permissive Conditions: These cytokines create a tumor-permissive environment by stimulating angiogenesis, disrupting normal tissue architecture, and impeding anti-tumor immune responses. Initiator cells can use inflammation as a persistent wound healing signal.

3. Genomic Instability: Oxidative Stress and Glycation

When the cell uses glucose in the mitochondria, it makes things called reactive oxygen species (ROS). These molecules generally facilitate intercellular communication; however, an overabundance of them causes DNA damage. This mutation can cause the gene to either turn on the oncogenes or turn off the tumor suppressor genes. AGEs are the products of non enzymatic reactions between proteins, lipids and reducing sugars. While endogenously generated during hyperglycemia and consumed in processed foods, these abnormal molecules bind to their receptor (RAGE). The AGE-RAGE path also brings more harm to the body's proteins and genes. It does this by keeping stress from oxygen high, causing swelling in tissues, and by making cell signals go wrong.[16]

4. Obesity: The link between sugar and cancer

This is how sugar gives you cancer obesity. Adipose tissue, particularly in the abdominal region, functions not only as a fat storage site but also as an endocrine organ.

In certain individuals categorized as obese, adipose tissue releases harmful hormones. It raises a hormone called leptin that may promote cell growth and inflammation, and it reduces a hormone called adiponectin that reduces inflammation and improves insulin sensitivity. Pathological Intersection: Weight excess is associated with a multitude of cancer-related conditions. It causes these fat cells to cause the inflammation for the rest

of your life, the high insulin levels due to insulin resistance, and the sex hormone changes. It illustrates the possibility that sugar-facilitated metabolic disturbances can contribute to systemic health issues, thereby increasing the risk of neoplastic transformations across multiple organs.

5. Gut health gets knocked off track by barrier dysfunction & a gut microbiome that's gone haywire

The food we eat has a strong tie to how our body works. This is linked to the groups of tiny life forms that live in our gut. The mix of these small bugs shapes what food does for us. The way this works is not simple, but it all comes down to what is inside us. and if you 're eating a diet that 's all high in sugar, well, you 're basically starving the good guys while giving the bad guys an all you can eat buffet.

You might ask yourself is your brain the only reason you cant get enough of the sweet stuff after all a pretty interesting theory popped up in a 2024 review in BioEssays that sugarloving gut microbes can get themselves in charge of the whole gut & brain connection and start nudging our behaviour to feed them.

What happens when your gut isn 't balanced: all this can lead to leaky gut where the lining of your intestines gets compromised, your body starts churning out carcinogenic chemicals & it makes less of the helpful butyrate your gut really needs.[17]

when you open up the gut it makes it possible for nasty bacterial stuff to get into your blood stream. And when this takes place, it can start strong swelling in your body. This may hurt your liver and can make it more likely for you to get cancer, not just in your gut but in other parts too.

6. Epidemiological Correlates: Particular Associations with Cancer

The correlations are derived from epidemiological data related to human health; however, biological mechanistic explanations provide logical justification. The most direct connection between excessive sugar consumption and increased risk pertains to particular cancers that are directly related to metabolic or hormonal dysregulation: Factors contributing to colorectal neoplasia encompass microbiome dysbiosis and increased luminal fructose levels affecting colonic epithelial tissue. Insulin resistance, hyperinsulinemia, and abnormal estrogen metabolism are associated with breast and endometrial carcinomas, notably in women past reproductive age. Pancreatic cancer because the pancreas is the main source of insulin production glucose, a sugar, is produced by the pancreas, therefore it is exposed to high concentrations of glucose, thus undergoes predominantly stressed conditions. Hepatocellular carcinoma this is very tightly coupled to hepatic fructose metabolism and sugar nash formation, which most often occur in the setting of non alcoholic fatty liver nash.

In conclusion, dietary sugar acts as a worldwide endocrine and metabolic disruptor rather than a traditional carcinogen. When many built-in checks that stop cells from turning into cancer cells go away, the body changes. More cells start to grow fast, swelling does not stop, and genes become less stable. This condition facilitates neoplastic development in the organism.[18]

IV. Synthesis, Implications, and Future Horizons

The earlie discussion shows a dangerous conection. Substance dependencies are regulated by neural mechanisms involving dopaminergic pathways, including the prefrontal cortex and tolerance zones characterized by diminished regulatory input, resulting in an increased behavioral output: excessive human intake of sugar. This long

term state on the body causes a very bad inner world which is having to much insulin, swelling all over your body, and stress from bad form of oxygen. This isn ' t just a problem just a different one it ' s the one big problem that you can ' t seem to get your body away from the food addictions that keep your body in a state that helps cancer grow very fast, the inflammation and blood sugar spikes you ' re giving yourself that can just keep feeding your addiction and leaving you more reward starved. This loop gets much worse when there is more stress in the body. High cortisol causes the body to require additional sugar. it causes swelling and hurts the body more. Therefore, what effect does sugar have for cancer there are two of dual effects: intake and the response you get or you have done, which is a feedback. Potential areas of investigation include: 1) longitudinal observational studies monitoring glucose intake in humans over time and its relation to cancer development; 2) experimental approaches to determine if breaking the sugar addiction cycle, via behavioral or pharmacological interventions, can yield risk reduction; 3) population-level research assessing whether altering gut microbiota or genetic modifications in dopamine pathways impact the correlation; 4) policy initiatives designed to systematically disrupt this cycle.[19]

V. Navigating the Evidence: Challenges and Real-World Paths Forward

Most of this comes from studies that look at many people. These can show links, but they can't say one thing causes another. Other things like what you eat, how your body is made, and how much you move can also play a part in what is seen. These things make it hard to tell what the main cause is, because they add more details and make it less simple. Also it's hard to keep on how much sugar people are taking in for a long term because you've got to remember how much sugar you had that day and say. Also the cancer is very

different from one part of the body to the other, what happen in the cell of pancreas when the cell contact with the sugar is not the same what happen in the cell of breast, that why there no clear evidence in human being, but that doesn't mean the biological reasons we have found are not strong and consistent.

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3007-2387

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