Fructose Fiasco

How a Sweet Little Molecule Hijacked Our Health

"IT'S NOT NICE TO FOOL <u>WITH</u> MOTHER NATURE"

FROM FRUIT... TO THE LAB...

TO PROCESSED FOODS...

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FRUCTOSE – WHAT IT IS

 FRUCTOSE IS A NATURALLY OCCURRING SIMPLE SUGAR
 (MONOSACCHARIDE), CHEMICALLY CLASSIFIED ALONGSIDE GLUCOSE AND GALACTOSE AS ONE OF THE THREE BASIC BUILDING BLOCKS OF
 CARBOHYDRATES. OFTEN REFERRED TO AS "FRUIT SUGAR," FRUCTOSE IS
 FOUND NATURALLY IN FRUITS, HONEY, AND ROOT VEGETABLES. IT IS THE
 SWEETEST OF ALL NATURALLY OCCURRING SUGARS — ABOUT 1.2 TO 1.8
 TIMES SWEETER THAN SUCROSE (TABLE SUGAR).

CHEMICAL STRUCTURE

- A SIX-CARBON SUGAR (HEXOSE) WITH THE MOLECULAR FORMULA C₆H₁₂O₆.
- STRUCTURALLY DISTINCT FROM GLUCOSE: FRUCTOSE IS A KETOSE SUGAR (IT HAS A KETONE GROUP), WHILE GLUCOSE IS AN ALDOSE SUGAR (IT HAS AN ALDEHYDE GROUP).
- IN AQUEOUS SOLUTIONS, FRUCTOSE EXISTS IN SEVERAL FORMS (LINEAR AND CYCLIC), BUT PRIMARILY AS A FIVE-MEMBERED RING (FURANOSE FORM).





NATURAL SOURCES

• FRUITS (ESPECIALLY APPLES, PEARS, GRAPES, WATERMELON)

• HONEY

• SOME ROOT VEGETABLES (LIKE BEETS AND SWEET POTATOES)

• SMALL AMOUNTS IN OTHER FOODS (SOME NUTS, GRAINS)

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COMMERCIAL PROCESSED FORMS

- HIGH-FRUCTOSE CORN SYRUP (HFCS) INDUSTRIALLY MANUFACTURED FROM CORN STARCH.
- CRYSTALLINE FRUCTOSE HIGHLY PURIFIED AND USED AS A SWEETENER IN SOME PROCESSED FOODS AND BEVERAGES.



KEY PHYSIOLOGICAL NOTE

UNLIKE GLUCOSE, **FRUCTOSE IS METABOLIZED ALMOST ENTIRELY BY THE LIVER**. WHEN CONSUMED IN SMALL AMOUNTS FROM NATURAL FOODS, THIS POSES NO PROBLEM. HOWEVER, WHEN CONSUMED IN LARGE QUANTITIES (ESPECIALLY IN THE FORM OF PROCESSED SWEETENERS), THE LIVER BECOMES OVERWHELMED, WHICH HAS PROFOUND METABOLIC CONSEQUENCES — A TOPIC WE WILL EXPLORE SHORTLY.



LET'S TAKE A LOOK BACK!

FRUCTOSE BECAME AVAILABLE AS A LIQUID IN THE 1970S

IN THE EARLY 1970S, THE FOOD INDUSTRY UNLOCKED A NEW CHAPTER IN HUMAN SUGAR CONSUMPTION: LIQUID FRUCTOSE.

PRIOR TO THIS TIME, FRUCTOSE INTAKE CAME ALMOST EXCLUSIVELY FROM WHOLE FOODS LIKE FRUITS AND HONEY. THE AVERAGE AMERICAN CONSUMED ABOUT 5 GRAMS OF FRUCTOSE PER DAY — A SMALL, NATURAL AMOUNT THAT THE LIVER COULD EASILY HANDLE.

WITH THE ADVENT OF INDUSTRIAL FOOD PROCESSING TECHNOLOGIES, HOWEVER, THE ABILITY TO ISOLATE, CONCENTRATE, AND DISSOLVE FRUCTOSE INTO LIQUID FORM OPENED THE FLOODGATES.



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EARLY DEVELOPMENTS

Advances in enzymatic processing techniques allowed manufacturers to hydrolyze fructose from sources like sugar beets, sugar cane, and cornstarch. • LIQUID FRUCTOSE SYRUPS (**NOT YET "HIGH-FRUCTOSE CORN SYRUP"**) BECAME ATTRACTIVE TO FOOD COMPANIES BECAUSE:

• THEY WERE **SWEETER THAN SUCROSE**.

THEY **DISSOLVED EASILY** IN BEVERAGES AND PROCESSED FOODS.

THEY HAD A LONG SHELF LIFE AND PREVENTED
 CRYSTALLIZATION IN PRODUCTS LIKE SOFT DRINKS AND
 BAKED GOODS.



RISE IN CONSUMPTION

• WITH LIQUID FRUCTOSE NOW CHEAP AND READILY AVAILABLE, IT STARTED BEING HEAVILY ADDED TO SODAS, CANDIES, PASTRIES, AND OTHER PROCESSED FOODS.

• AS A RESULT, AVERAGE DAILY FRUCTOSE CONSUMPTION IN THE U.S. SKYROCKETED FROM ABOUT 5 GRAMS TO 33 GRAMS PER PERSON PER DAY DURING THE 1970S.

KEY POINT

This early surge was not due to high-fructose corn syrup (HFCS). It was **pure fructose** or **liquid fructose syrup**, distinct from HFCS, which contains a mixture of glucose and fructose.

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INDUSTRY MOTIVATION

• THE POST-WORLD WAR II ERA SAW **EXPLOSIVE GROWTH IN PACKAGED** FOODS AND MASS MARKETING OF SOFT DRINKS.

• FOOD COMPANIES WERE SEARCHING FOR CHEAPER, MORE SHELF-STABLE SWEETENERS THAT COULD ALSO APPEAL TO EVOLVING AMERICAN TASTES (TOWARD SWEETER FOODS).

• FRUCTOSE FIT THE BILL: IT WAS CHEAP TO PRODUCE, CHEMICALLY STABLE, AND INCREDIBLY SWEET EVEN AT LOWER CONCENTRATIONS.





SETTING THE STAGE

THE BROADER CULTURAL BACKDROP OF THE 1970S — WITH AN ECONOMIC EMPHASIS ON EFFICIENCY, MASS PRODUCTION, AND COST-CUTTING IN FOOD MANUFACTURING — CREATED A PERFECT STORM FOR THE PROLIFERATION OF LIQUID FRUCTOSE. CONSUMERS WERE LARGELY UNAWARE THAT THE METABOLIC IMPACT OF FRUCTOSE DIFFERED DRAMATICALLY FROM GLUCOSE OR SUCROSE, SETTING THE STAGE FOR DECADES OF RISING CHRONIC DISEASE.



THE INTRODUCTION OF HIGH-FRUCTOSE CORN SYRUP (HFCS)

AS IF THE RISE OF LIQUID FRUCTOSE WASN'T ENOUGH, THE FOOD INDUSTRY FOUND A WAY TO TAKE THINGS EVEN FURTHER: ENTER HIGH-FRUCTOSE CORN SYRUP (HFCS).

HFCS WAS NOT MERELY ANOTHER LIQUID SUGAR; IT WAS A **CHEMICALLY ENGINEERED SWEETENER** DESIGNED TO BE CHEAP, VERSATILE, AND MORE ADDICTIVE — AND IT CHANGED THE LANDSCAPE OF AMERICAN (AND EVENTUALLY GLOBAL) HEALTH.

DEVELOPMENT



In the late 1950s and early 1960s, Japanese researchers developed a process using **glucose isomerase** enzymes to convert glucose from cornstarch into fructose.



By tweaking the ratios, manufacturers could create syrups with varying concentrations of fructose and glucose.



In **1967**, HFCS was first introduced commercially in the U.S.

Mass adoption came shortly after — especially into soft drinks and processed foods — by the early to mid-1970s.

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COMPOSITION

Unlike pure liquid fructose, HFCS is a blend:

Structurally similar to table sugar (sucrose), but in HFCS, **the glucose and fructose are free-floating** (unbound), whereas in sucrose they are chemically bonded.

Common forms:

HFCS-42: ~42% fructose, 53% glucose (used in baked goods).
HFCS-55: ~55% fructose, 42% glucose (used in soft drinks).

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This matters because free fructose and glucose are **absorbed faster,** spiking blood sugar and overloading the liver even more aggressively.



WHY HFCS BECAME SO POPULAR

COST: CORN SUBSIDIES MADE HFCS CHEAPER THAN CANE SUGAR.

CONVENIENCE: HFCS IS LIQUID — EASY TO BLEND INTO BEVERAGES AND PROCESSED FOODS WITHOUT CRYSTALLIZING.

SHELF STABILITY: HFCS EXTENDS THE SHELF LIFE OF MANY PROCESSED PRODUCTS.

• SWEETNESS: COMPARABLE (OR SLIGHTLY HIGHER) SWEETNESS TO SUCROSE AT A LOWER COST.



CONSUMPTION EXPLOSION!

BY THE 1980S AND 1990S, HFCS WAS **EVERYWHERE** — SOFT DRINKS, SALAD DRESSINGS, KETCHUP, YOGURT, BREAD, SOUPS, "HEALTH BARS," AND MORE.

AT ITS PEAK, HFCS ACCOUNTED FOR **MORE THAN** 40% OF ALL CALORIC SWEETENERS ADDED TO FOODS AND BEVERAGES IN THE UNITED STATES.



SWEET DEAL OR TICKING TIME BOMB?

"HIGH-FRUCTOSE CORN SYRUP WASN'T JUST A SWEET DEAL FOR MANUFACTURERS — IT WAS A TICKING TIME BOMB FOR PUBLIC HEALTH."

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TIMELINE OF EVENTS

Year	Event	
Late 1950s–Early 1960s	Enzymatic process to make HFCS developed	
1967	HFCS enters U.S. market	
Early 1970s	HFCS begins replacing cane sugar in processed foods	
Late 1970s	Major soda companies switch from sucrose to HFCS	
1980s—1990s	HFCS consumption peaks in U.S. diet	

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WHERE HFCS IS FOUND

WHEN HIGH-FRUCTOSE CORN SYRUP TOOK HOLD IN THE AMERICAN FOOD SUPPLY, IT WASN'T JUST ADDED TO OBVIOUS SWEETS LIKE CANDY AND SODA.

IT RAPIDLY INFILTRATED **NEARLY EVERY CATEGORY OF PROCESSED FOOD**, OFTEN IN PLACES WHERE CONSUMERS WOULDN'T EXPECT TO FIND ADDED SUGARS AT ALL.

THIS WIDESPREAD INCORPORATION MEANT THAT EVEN INDIVIDUALS TRYING TO EAT "SAVORY" OR "LOW-FAT" FOODS WERE OFTEN UNKNOWINGLY CONSUMING SIGNIFICANT AMOUNTS OF FRUCTOSE.



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BEVERAGES

- REGULAR SODAS (E.G., COCA-COLA, PEPSI)
- SWEETENED TEAS
- FRUIT PUNCHES AND "FRUIT-FLAVORED" DRINKS
- SPORTS DRINKS AND ENERGY DRINKS

CONDIMENTS & DRESSINGS

- KETCHUP
- BARBECUE SAUCE
- SALAD DRESSINGS (ESPECIALLY "LOW-FAT" VERSIONS)
- SWEET AND SOUR SAUCE
- TERIYAKI SAUCE





BAKED GOODS & SNACK FOODS

- COMMERCIAL BREADS AND HAMBURGER BUNS
- MUFFINS, DONUTS, PASTRIES
- BREAKFAST CEREALS AND CEREAL BARS
- GRANOLA BARS
- CRACKERS (EVEN "SAVORY" ONES)

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DAIRY & DAIRY ALTERNATIVES

- FLAVORED YOGURTS
- PUDDING CUPS
- COFFEE CREAMERS





- CANNED SOUPS (ESPECIALLY TOMATO SOUP)
- CANNED FRUITS (PACKED IN SYRUP)
- FROZEN DINNERS
- "HEALTHY" FROZEN ENTREES AND DIET MEALS
- MEAL REPLACEMENT SHAKES



SOME SURPRISING SOURCES

- PEANUT BUTTER (NON-NATURAL VERSIONS)
- JAMS AND JELLIES
- PICKLES (SWEET PICKLES AND RELISHES)
- BAKED BEANS
- FAST FOOD ITEMS (BUNS, SAUCES, EVEN SOME FRIES!)

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"BY THE LATE 20TH CENTURY, HFCS WASN'T JUST A SWEETENER — IT WAS PRACTICALLY A FOOD GROUP."

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HEALTH EFFECTS OF HFCS CONSUMPTION

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THE MASSIVE INCREASE IN FRUCTOSE CONSUMPTION FOODS — HAS HAD **PROFOUND AND** DEVASTATING IMPACTS ON PUBLIC HEALTH. UNLIKE GLUCOSE, WHICH THE BODY USES WIDELY FOR IMMEDIATE ENERGY NEEDS, **EXCESS FRUCTOSE IS** PRIMARILY HANDLED BY THE LIVER, OVERWHELMING ITS CAPACITY AND TRIGGERING A CASCADE OF METABOLIC DYSFUNCTIONS.





- MECHANISM:
 - FRUCTOSE IS RAPIDLY SHUNTED INTO DE NOVO LIPOGENESIS — THE CREATION OF FAT — IN THE LIVER.
 - WHEN THE LIVER CAN'T EXPORT THE FAT FAST ENOUGH, IT ACCUMULATES WITHIN LIVER CELLS, LEADING TO FATTY LIVER.
- WHY IT MATTERS:
 - NAFLD CAN PROGRESS TO STEATOHEPATITIS, FIBROSIS, CIRRHOSIS, AND EVEN LIVER CANCER — WITHOUT A DROP OF ALCOHOL BEING CONSUMED.
 - FRUCTOSE IS NOW RECOGNIZED AS ONE
 OF THE **PRIMARY DRIVERS** BEHIND THE
 EPIDEMIC OF NAFLD.

INSULIN RESISTANCE & TYPE 2 DIABETES

- MECHANISM:
- CHRONIC LIVER FAT ACCUMULATION INTERFERES WITH INSULIN SIGNALING.
- FRUCTOSE INCREASES HEPATIC INSULIN RESISTANCE EVEN BEFORE
 SYSTEMIC BLOOD SUGAR CHANGES ARE OBVIOUS.
- WHY IT MATTERS:
- INSULIN RESISTANCE LAYS THE GROUNDWORK FOR **TYPE 2 DIABETES**,
 METABOLIC SYNDROME, AND **CARDIOVASCULAR DISEASE**.



Obesity



OBESITY & C VISCERAL FAT ACCUMULATION

MECHANISM:

- FRUCTOSE CONSUMPTION INCREASES
 VISCERAL FAT THE FAT
 SURROUNDING INTERNAL ORGANS
 FAR MORE EFFICIENTLY THAN
 GLUCOSE.
- FRUCTOSE ALSO FAILS TO TRIGGER SATIETY HORMONES (LIKE LEPTIN) PROPERLY, PROMOTING OVEREATING.
- WHY IT MATTERS:
 - VISCERAL FAT IS HIGHLY
 INFLAMMATORY AND STRONGLY
 CORRELATED WITH HEART DISEASE,
 STROKE, CANCER, AND ALZHEIMER'S
 DISEASE.

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"GLUCOSE FEEDS YOUR MUSCLES. FRUCTOSE FEEDS YOUR FAT CELLS."

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ELEVATED URIC ACID & GOUT

• MECHANISM:

- FRUCTOSE METABOLISM GENERATES URIC ACID AS A BYPRODUCT.
- WHY IT MATTERS:
 - ELEVATED URIC ACID IS LINKED TO GOUT, A PAINFUL FORM OF INFLAMMATORY ARTHRITIS.
- IT ALSO CONTRIBUTES TO HYPERTENSION, KIDNEY DISEASE, AND ENDOTHELIAL DYSFUNCTION (DAMAGED BLOOD VESSELS).



INCREASED OXIDATIVE STRESS & INFLAMMATION

MECHANISM:

- FRUCTOSE METABOLISM DEPLETES INTRACELLULAR ATP (ENERGY CURRENCY), LEADING TO MITOCHONDRIAL DYSFUNCTION.
- IT PROMOTES FORMATION OF REACTIVE OXYGEN SPECIES (ROS) AND ADVANCED GLYCATION END PRODUCTS (AGES) — BOTH OF WHICH DRIVE INFLAMMATION AND CELLULAR AGING.

WHY IT MATTERS:

•

 THIS OXIDATIVE BURDEN CONTRIBUTES TO THE DEVELOPMENT OF NEURODEGENERATIVE DISEASES, ATHEROSCLEROSIS, CANCER, AND ACCELERATED AGING.

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DYSLIPIDEMIA

- MECHANISM:
 - FRUCTOSE BOOSTS PRODUCTION OF VLDL (VERY-LOW-DENSITY LIPOPROTEIN) PARTICLES IN THE LIVER.
- WHY IT MATTERS:
 - THIS LEADS TO HIGH
 TRIGLYCERIDES, SMALL, DENSE LDL
 PARTICLES (THE MOST
 ATHEROGENIC FORM), AND LOWER
 HDL CHOLESTEROL A PERFECT
 STORM FOR HEART DISEASE.

Health Effect

Fatty liver

Fructose Role

Drives fat production in the liver

insulin signaling

Insulin resistance

Obesity

Promotes visceral fat, fails to trigger satiety

Increases liver fat, disrupts

Gout & hypertension Elevates uric acid production

Oxidative stress Generates ROS and AGEs

Heart disease risk

Raises VLDL, triglycerides, and small dense LDL

QUICK CHART SUMMARY

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"FRUCTOSE ACTS LIKE A STEALTH BOMBER — IT BYPASSES NORMAL METABOLIC DEFENSES, BOMBARDS THE LIVER, FUELS FAT GAIN, RAISES URIC ACID, INFLAMES THE BODY, AND SETS FIRE TO THE MITOCHONDRIA."

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RECOVERY AND SOLUTIONS: HEALING FROM THE FRUCTOSE FALLOUT

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THE GOOD NEWS?

WHILE CHRONIC HIGH-FRUCTOSE INTAKE WREAKS HAVOC ON THE BODY, **THE DAMAGE IS LARGELY REVERSIBLE** — *IF* CAUGHT EARLY AND ADDRESSED CONSISTENTLY. BY REMOVING THE EXCESS FRUCTOSE BURDEN AND SUPPORTING MITOCHONDRIAL AND LIVER RECOVERY, THE BODY HAS A REMARKABLE ABILITY TO HEAL ITSELF.



DRASTICALLY REDUCE INTAKE

Primary Step:

• Eliminate or minimize foods containing **high-fructose corn syrup** and **added fructose**.

How:

- Replace processed foods with whole, minimally processed options.
- Check labels HFCS hides in surprising places (condiments, bread, yogurt, canned goods).
- Minimize soft drinks, fruit punches, energy drinks, sweetened teas, and commercial smoothies.

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"IF IT COMES WITH A NUTRITION LABEL, READ IT LIKE YOU'RE HUNTING FOR BURIED TREASURE — AND HFCS IS THE BOOBY TRAP."

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MODERATE NATURAL FRUCTOSE FROM FRUITS

KEY POINT:

- WHOLE FRUITS ARE NOT THE ENEMY.
- THEY DELIVER FRUCTOSE ENCASED IN FIBER, WATER, VITAMINS, MINERALS, AND POLYPHENOLS, ALL OF WHICH SLOW ABSORPTION AND PROTECT THE BODY.

HOW:

- FOCUS ON LOWER-FRUCTOSE FRUITS WHEN HEALING, SUCH AS:
 - o BERRIES (STRAWBERRIES, BLUEBERRIES, RASPBERRIES)
 - CITRUS FRUITS (LEMONS, LIMES, GRAPEFRUITS)
 - AVOCADOS (VERY LOW SUGAR)
- LIMIT OR TEMPORARILY REDUCE **HIGHER-FRUCTOSE FRUITS** LIKE APPLES, GRAPES, WATERMELON, AND MANGOES DURING INTENSIVE HEALING PHASES.

SPECIAL NOTE:

• FRUIT JUICES ARE NOT EQUIVALENT TO WHOLE FRUITS — THEY ACT MORE LIKE SOFT DRINKS DUE TO THEIR CONCENTRATED, FIBERLESS FRUCTOSE HIT.



SUPPORT LIVER & MITOCHONDRIAL ENERGY

NUTRITIONAL ALLIES:

- **CHOLINE** (EGGS, LIVER, SUNFLOWER LECITHIN) CRITICAL FOR FAT EXPORT FROM THE LIVER.
- **OMEGA-3 FATTY ACIDS** (WILD SALMON, SARDINES, FLAXSEED) REDUCE LIVER INFLAMMATION.
- **ANTIOXIDANTS** (ESPECIALLY GLUTATHIONE BOOSTERS LIKE NAC, ALPHA-LIPOIC ACID, AND VITAMIN C AND/OR S-ACETYL-L-GLUTATHIONE) HELP QUENCH OXIDATIVE STRESS.
- MAGNESIUM CRUCIAL FOR MITOCHONDRIAL ENERGY PRODUCTION AND INSULIN SENSITIVITY.
- **B VITAMINS** NEEDED FOR MITOCHONDRIAL ENZYMES TO FUNCTION OPTIMALLY.

LIFESTYLE STRATEGIES

TIME-RESTRICTED EATING (E.G., 12-16 HOUR FASTS) — GIVES THE LIVER TIME TO "DETOXIFY" AND CLEAR EXCESS FAT.

PHYSICAL ACTIVITY — ESPECIALLY STRENGTH TRAINING AND BRISK WALKING
 — ENHANCES INSULIN SENSITIVITY AND BURNS LIVER FAT.

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"THINK OF YOUR LIVER LIKE A KITCHEN — IT NEEDS TIME TO CLEAN UP THE MESS BEFORE YOU BRING IN MORE GROCERIES."

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CHOOSE SAFER SWEETENERS

IF SWEETENERS ARE DESIRED, THESE ARE FAR BETTER OPTIONS:

- **STEVIA** (NATURAL, ZERO-CALORIE, DOES NOT IMPACT BLOOD SUGAR)
- MONK FRUIT EXTRACT (NATURAL, ANTIOXIDANT-RICH, NO FRUCTOSE)
- ERYTHRITOL (A SUGAR ALCOHOL
 WITH MINIMAL GUT FERMENTATION)
- RAW LOCAL HONEY (IN MODERATION — THOUGH IT CONTAINS FRUCTOSE, IT'S PAIRED WITH ANTIOXIDANTS AND USED SPARINGLY IN WHOLE-FOOD DIETS) Rebecca Roentsch Montrone, BS - Wondrous Roots, Inc.





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"THE GOAL IS NOT JUST TO SWAP ONE SWEETENER FOR ANOTHER, BUT TO RESET YOUR TASTE BUDS TOWARD ENJOYING LESS SWEETNESS OVERALL."



00	Goal	Action Step	
¢	Cut fructose sources	Eliminate HFCS and limit processed foods	TIME "
S	Support liver	Eat choline-rich foods, omega-3s, antioxidants	
F	leal mitochondria	Prioritize magnesium, B vitamins, glutathione	
R tl	Reset sweetness hreshold	Use stevia, monk fruit if needed	
E	ncourage repair	Practice time-restricted eating and daily movement	A 11/VL.



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