Health benefits of Maple Syrup

and

the role of rare sugars

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UNIVERSITY OF TORONTO

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada — Canada

GUELPH RESEARCH AND DEVELOPMENT CENTRE
GUELPH, ONTARIO

OMSPA Summer Tour & Conference
North Bay, Canada
July 17th, 2024

St. Michael's
Inspired Care.
Inspiring Science.

Disclosures (36 months)

Research Support

– Canadian Institutes of Health Research (CIHR)

– National Honey Board USA

– Institute for the Advancement of Food and Nutrition Sciences (IAFNS) [Previously ILSI North America]

Honoraria or Speaker Fees

– IFIC (International Food Information Council)

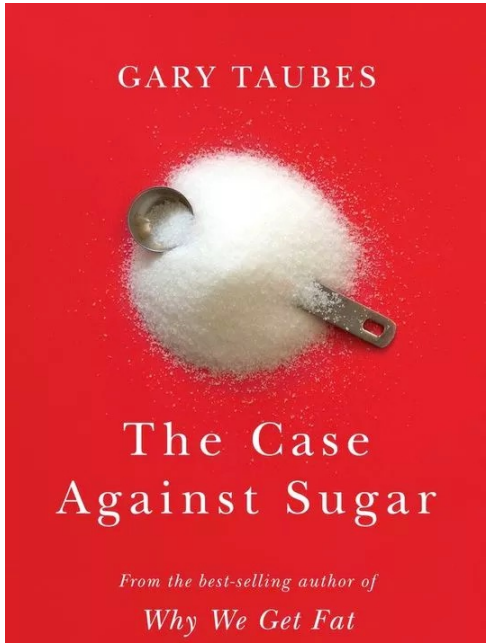
– IAFNS

– Arab Beverages Association

Advisory Board

— Nuradec

Sugar as the new public health concern!



Dietary and Public Health Guidelines

Health Canada Santé Canada

Canada's Dietary Guidelines

Canada.ca/FoodGuide

Free sugars: Less than 10% of total energy intake

World Health Organization

WHO recommends a maximum of 5 to 10 teaspoons of free sugars per day

WHO recommends reducing free sugar intake at all stages of life to under 10 percent of physical calories to reduce the risk of unhealthy weight gain and dental caries. This equals a maximum of 50 g of sugar per day (ca. 10 teaspoons) for the average adult (at a calorie intake of 2,000 kcal).

DGA Dietary Guidelines for Americans 2020 - 2025

Keep intake of **added sugars** to less than **10%** of their total daily **calories**. [<6% recommended by the DGAC)

Health Canada Santé Canada

Canada's Dietary Guidelines

Canada.ca/FoodGuide

Free sugars are monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook or consumer, and sugars naturally present in honey, **syrups**, fruit juices and fruit juice concentrates.

https://food-guide.canada.ca/en/guidelines/

World Health Organization

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https://www.who.int/publications/i/item/9789241549028

DGA Dietary Guidelines for Americans 2020 - 2025

Added sugars include sucrose, dextrose, table sugar, **syrups**, honey, and sugars from concentrated fruit or vegetable juices.

https://www.dietaryguidelines.gov/sites/default/files/2020-12/Dietary_Guidelines_for_Americans_2020-2025.pdf

DIABETES CANADA'S POSITION ON SUGARS

DIABETES CANADA

- MISSION
- HISTORY
- BANTING HOUSE
- FUNDING & ACCOUNTABILITY
- PUBLIC POLICY

Position statement

Diab

1.) intake. This is ased on a 2000-calorie
2. ace.
3. out life for overall health.

Limit free sugar <10%
Limit intake of SSBs

American Diabetes Association.

Myth: Eating too much sugar causes diabetes.

Fact: The answer i t trigger the onset of the disease; typ

Being overweight s from any source contributes to wei betes.

Limit calories from any source
Limit intake of SSBs

The American Diabetes Association recommends that people should avoid intake of sugar-sweetened beverages to help prevent diabetes. Sugar-sweetened beverages include beverages like:

http://www.diabetes.ca/about-cda/public-policy-position-statements/sugars

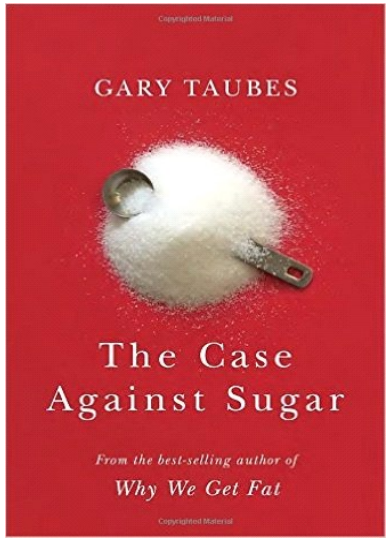
International Diabetes Federation

International Diabetes Federation Europe

Recommendation

"...revision of healthy eating guidelines to reduce consumption of foods with naturally high sugar content (e.g. certain fruits and fruit juices)."

http://www.idf.org/sugar



"…even an apple may not be a good thing… it may very well not be for people predisposed to gain weight easily or who are already obese and/or diabetic"

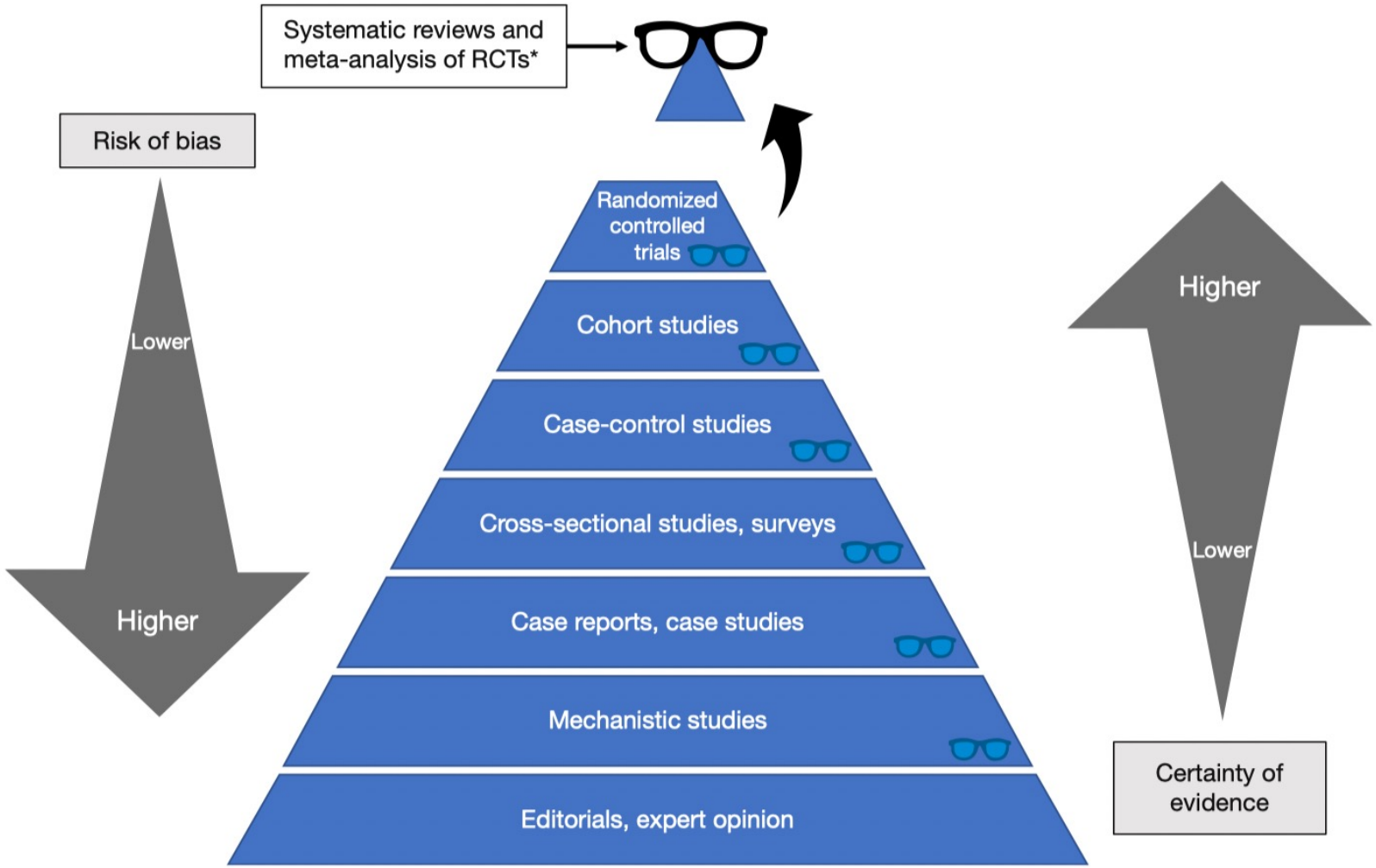
http://www.vox.com/science-and-health/2017/1/6/14167092/gary-taubes-case-against-sugar-book

Food sources of sugars

Can natural sources of sugars be an alternative to refined sugars!

Does source of of sugars matter?

Hierarchy of Evidence using GRADE Approach



https://gdt.gradepro.org/app/handbook/handbook.html

Search Strategy

MEDLINE U.S. National Library of Medicine

embase BIOMEDICAL ANSWERS

Cochrane Library

Exposures:

Sugar Sweetened Beverages

Fruit Drink

100% Fruit Juice

Fruits

Yogurt

Ice Cream

Cookies and Cakes, Chocolate

Breakfast Cereals

Jams, Jelly, Honey

Outcomes:

Incident Type 2 Diabetes

Design:

Prospective Observational Studies

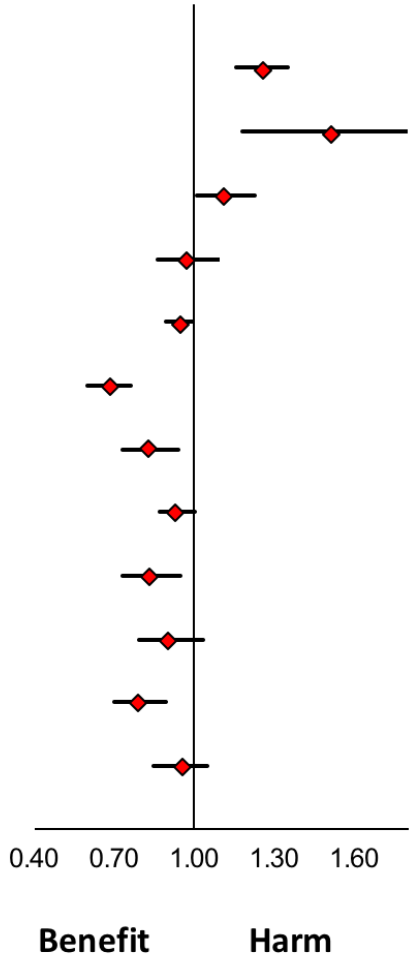
Follow-Up > 1 year
Free of diabetes at baseline

Based on NHANES list of food sources of sugars [Welsh et al. 2011]

Does source of sugars matter?

Systematic review and meta-analysis of 85 studies 4 million participants (Khan 2024 submitted)

Food source	Cohort comparisons	Cases	Subjects	Risk ratio [95% CIs]	Heterogeneity P	Heterogeneity I^2	Heterogeneity P
Sugar-sweetened beverages	16	26,884	411,739	1.25 [1.16, 1.35]	<0.0001	55%	0.005
Fruit drink	3	2,898	67,906	1.51 [1.18, 1.92]	0.001	50%	0.14
Mixed fruit juice	7	18,959	364,321	1.11 [1.01, 1.23]	0.033	75%	0.001
100% fruit juice	5	13,739	206,899	0.97 [0.86, 1.09]	0.62	0%	0.59
Fruit	21	65,989	1,847,583	0.94 [0.89, 0.99]	0.04	41%	0.038
Wholegrain breakfast cereals	3	3,491	216, 542	0.68 [0.60, 0.76]	0.013	78%	<0.001
Yoghurt	10	6,152	366,208	0.83 [0.73, 0.94]	0.008	58%	0.008
Jams, syrups, honey	4	993	27,847	0.93 [0.87, 1.0]	0.39	0%	0.39
Ice cream	2	1,499	150,477	0.83 [0.73, 0.95]	0.007	0%	0.37
Sherbet	2	1,548	172,015	0.90 [0.79, 1.03]	0.12	0%	0.6
Chocolate	5	1,630	26,737	0.79 [0.70, 0.89]	<0.0001	0%	0.83
Confectionary (biscuits, cakes, desserts)	3	837	23,531	0.95 [0.85, 1.05]	0.62	0%	0.95



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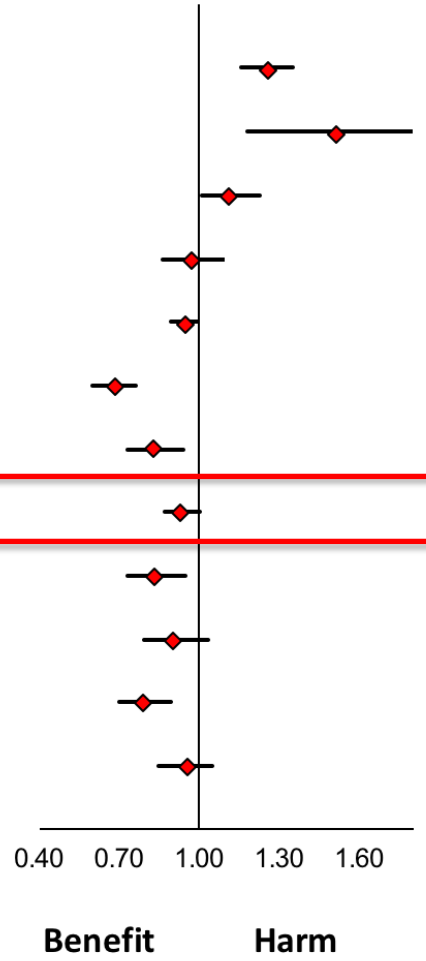

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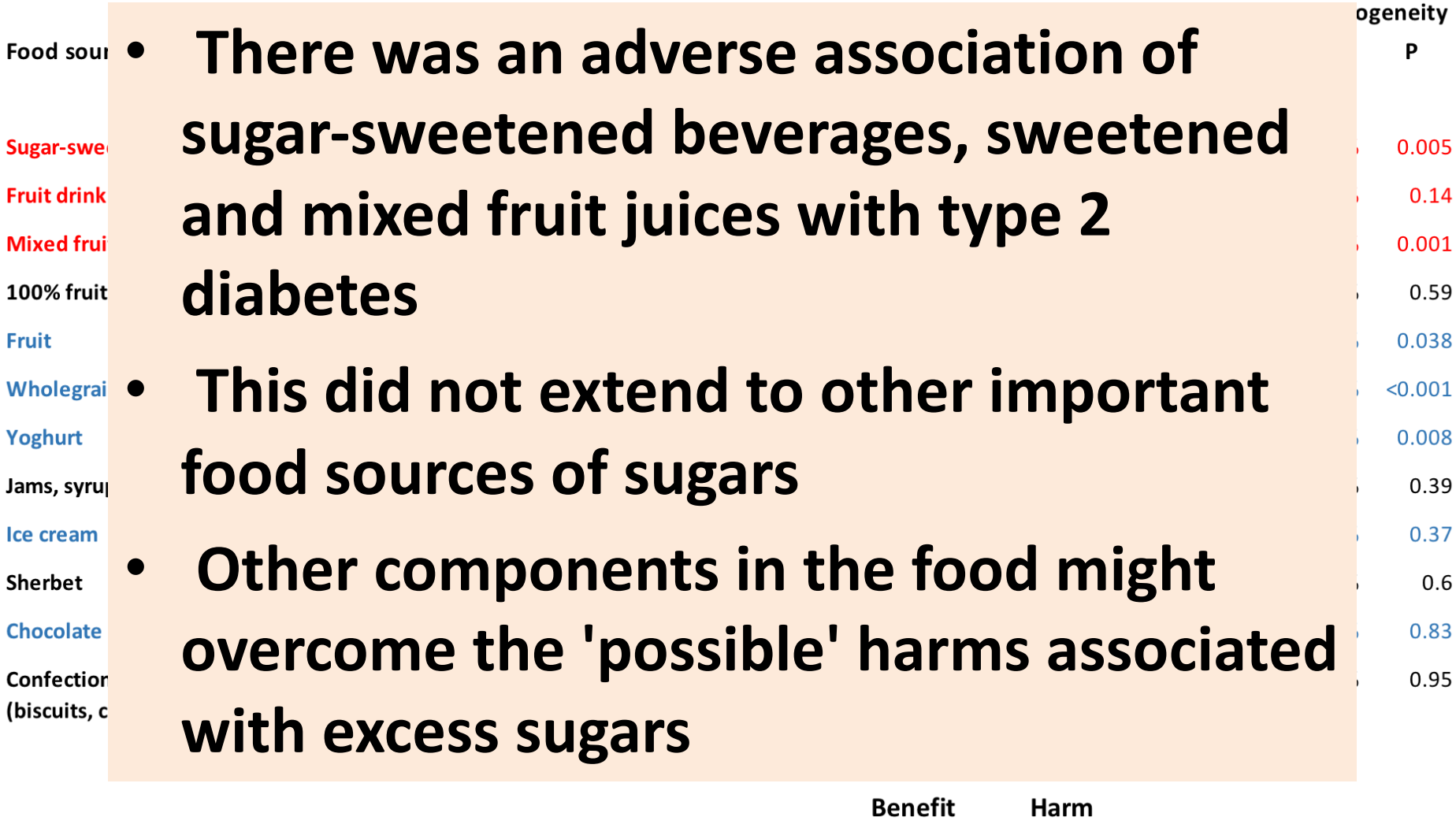
- **There was an adverse association of sugar-sweetened beverages, sweetened and mixed fruit juices with type 2 diabetes**
- **This did not extend to other important food sources of sugars**
- **Other components in the food might overcome the 'possible' harms associated with excess sugars**



Comparison of maple syrup to other natural sweeteners

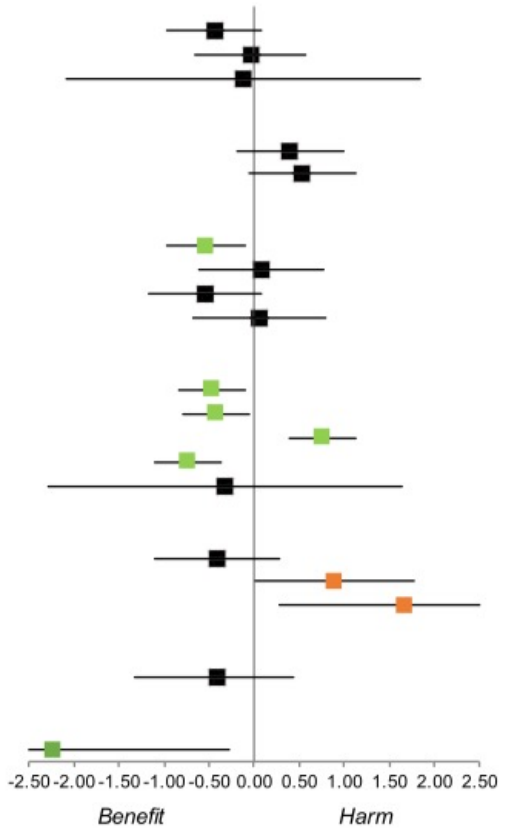
U.S. Department of Agriculture (USDA). FoodData Central. Retrieved from https://fdc.nal.usda.gov

Component	Maple Syrup	Honey	Agave Syrup	Refined Sugar
Primary Sugar	Sucrose (60-66%)	Fructose (38%)	Fructose (56-60%)	Sucrose (99.9%)
Secondary Sugars	Glucose, Fructose	Glucose (31%)	Glucose (20-24%)	None
Oligosaccharides/Rare Sugars	Small amounts of oligosaccharides	Oligosaccharides, Maltose	Small amounts of inulin	None
Calories (per 100g)	260	304	310	387
Calories (per teaspoon)	13 (4.2 gm)	21 (7 gm)	20 (6.8 gm)	16 (4.2 gm)
Calories (per tablespoon)	52 (14.3 gm)	64 (21 gm)	60 (20.4 g)	49! (12.6 g)
Vitamins	Riboflavin, Thiamin	Vitamin C, B6	Vitamin C, B6	None
Minerals	Calcium, Potassium, Manganese, Zinc	Calcium, Potassium, Iron, Magnesium	Calcium, Potassium	None
Glycemic Index	54	58	19-30	65
Water Content	32%	17%	25%	0%
Other Components	Amino acids, Antioxidants	Amino acids, Antioxidants, Enzymes	Saponins, Inulin	None

Honey and Cardiometabolic Outcomes

33 TRIAL COMPARISONS | N=1105 | MIXED HEALTH | 8 WEEKS
DOSE = 40 GRAM | COMPARATOR = OTHER CHO

Outcome	N trials	N	Summary Effect Estimates: MD (mmol/L) [95%CI]	Summary Effect Estimates: SMD (%) [95% CI]	P_{MD}	Heterogeneity: I^2	Heterogeneity: P_Q	GRADE: Downgrade: Risk of Bias	Downgrade: Inconsistency	Downgrade: Indirectness[a]	Downgrade: Imprecision	Downgrade: Publication Bias	GRADE: Upgrade: Dose-Response	Certainty of Evidence	Interpretation of Magnitude of Effect
Adiposity															
Body weight (kg)	14	374	-0.92 [-2.04, 0.19]	-0.43 [-0.96, 0.09]	0.105	0.0%	0.995	□	□	□	■	□	□	⊕⊕⊕○ MODERATE	No effect
BMI (kg/m^2)	10	457	0.00 [-0.06, 0.05]	-0.04 [-0.66, 0.58]	0.905	0.0%	0.999	□	□	□	□	□	□	⊕⊕⊕⊕ HIGH	No effect
Waist circumference (cm)	1	46	-0.30 [-4.90, 4.30]	-0.13 [-2.09, 1.83]	0.898	-	-	■	□	■	■	□	□	⊕○○○ VERY LOW	No effect
Blood Pressure															
SBP (mmHg)	11	278	1.00 [-0.50, 2.50]	0.39 [-0.20, 0.99]	0.190	6.6%	0.381	□	□	□	■	□	■	⊕⊕⊕⊕ HIGH	No effect
DBP (mmHg)	11	278	1.25 [-0.13, 2.64]	0.53 [-0.06, 1.13]	0.076	0.0%	0.797	□	□	□	■	□	□	⊕⊕⊕○ MODERATE	No effect
Glycemic Outcomes															
Fasting Glucose (mmol/L)	20	655	-0.20 [-0.37, -0.04]	-0.54 [-0.97, -0.10]	0.017	76.8%	<0.001	□	■	□	□	■	□	⊕⊕○○ LOW	Small
Fasting Insulin (uU/mL)	8	127	0.19 [-1.60, 1.99]	0.07 [-0.62, 0.77]	0.832	0.0%	0.972	□	□	□	■	□	□	⊕⊕⊕○ MODERATE	No effect
HbA1c (%)	10	162	-0.25 [-0.52, 0.04]	-0.54 [-1.16, 0.08]	0.086	63.0%	0.004	□	■	□	□	□	□	⊕⊕⊕○ MODERATE	No effect
HOMA-IR	7	101	0.03 [-0.35, 0.41]	0.06 [-0.68, 0.80]	0.872	0.0%	0.951	□	□	□	□	□	□	⊕⊕⊕⊕ HIGH	No effect
Cholesterol Outcomes															
Total Cholesterol (mmol/L)	29	992	-0.18 [-0.33, -0.04]	-0.47 [-0.84, -0.11]	0.011	65.1%	<0.001	□	■	□	■	□	□	⊕⊕○○ LOW	Small important
LDL (mmol/L)	29	992	-0.16 [-0.30, -0.02]	-0.42 [-0.78, -0.06]	0.024	73.8%	<0.001	□	■	□	■	□	□	⊕⊕○○ LOW	Small important
HDL (mmol/L)b	29	992	0.07 [0.04, 0.10]	0.76 [0.40, 1.13]	<0.001	33.0%	0.046	□	□	□	□	□	□	⊕⊕⊕⊕ HIGH	Small important
Fasting Triglycerides (mmol/L)	29	992	-0.13 [-0.20, -0.07]	-0.73 [-1.09, -0.37]	<0.001	63.4%	<0.001	□	■	□	■	□	□	⊕⊕○○ LOW	Small important
Apolipoprotein B (mg/dL)	1	30	-2.07 [-14.64, 10.50]	-0.32 [-2.28, 1.64]	0.747	-	-	□	□	■	■	□	□	⊕⊕○○ LOW	No effect
Markers of Inflammation															
hsCRP (mg/L)	8	247	-0.03 [-0.08, 0.02]	-0.42 [-1.11, 0.27]	0.236	0.0%	0.940	□	□	□	□	□	□	⊕⊕⊕⊕ HIGH	No effect
IL-6 (pg/mL)	5	119	0.37 [0.01, 0.74]	0.88 [0.02, 1.77]	0.046	0.0%	0.847	□	□	□	■	□	□	⊕⊕⊕○ MODERATE	Moderate
TNFα (pg/mL)	2	94	1.44 [0.24, 2.64]	1.66 [0.28, 3.05]	0.019	22.9%	0.255	□	□	□	■	□	□	⊕⊕⊕○ MODERATE	Large
Uric Acid															
Uric acid (mg/dL)	5	103	-0.07 [-0.21, 0.07]	-0.42 [-1.31, 0.44]	0.340	0.0%	0.997	□	□	□	■	□	□	⊕⊕⊕○ MODERATE	No effect
Markers of NAFLD															
Alanine aminotransferase (U/L)	1	72	-9.75 [-18.29, -1.21]	-2.24 [-4.20, -0.28]	0.025	-	-	□	□	■	■	□	□	⊕⊕○○ LOW	Moderate



Ahmed, Amna, et al. "Effect of honey on cardiometabolic risk factors: a systematic review and meta-analysis." Nutrition Reviews (2022).

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~~Apolipoprotein B (mg/dL)~~	~~1~~	~~30~~	~~2.07 [-14.64, 18.58]~~	~~0.32 [-2.28, 1.64]~~	~~0.747~~	-	-	□	□	■	■	□	□	⊕⊕○○ LOW	No effect
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TNFα (pg/mL)	2	94	1.44 [0.24, 2.64]	1.66 [0.28, 3.05]	0.019	22.9%	0.255	□	□	□	■	□	□	⊕⊕⊕○ MODERATE	Large
Uric Acid															
Uric acid (mg/dL)	5	103	-0.07 [-0.21, 0.07]	-0.42 [-1.31, 0.44]	0.340	0.0%	0.997	□	□	□	■	□	□	⊕⊕⊕○ MODERATE	No effect
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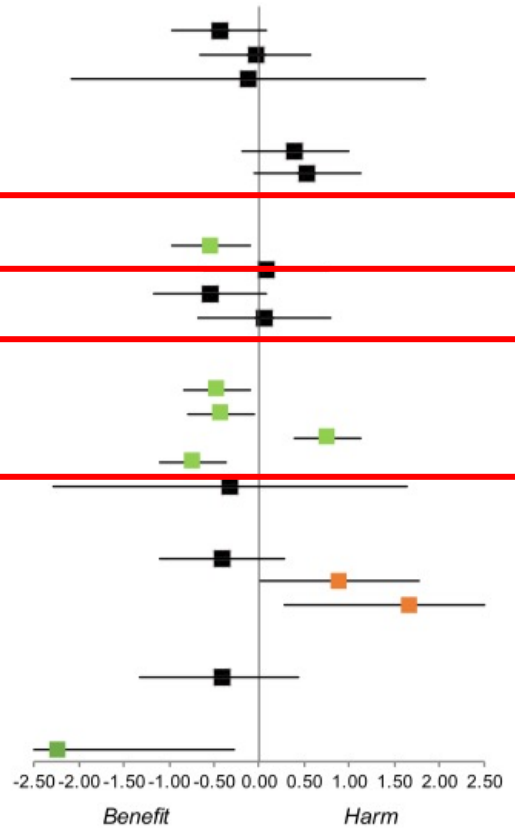

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FLORAL SOURCE OF HONEY

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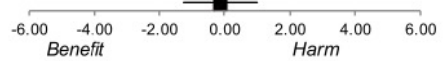
Cholesterol Outcomes																
Total Cholesterol (mmol/L)																
Clover Honey	3	47	-0.44 [-0.63, -0.26]	-2.69 [-3.85, -1.59]	<0.001	92.0%	<0.001							⊕⊕◯◯	LOW	Moderate
Robinia Honey	1	63	-0.52 [-0.78, -0.26]	-3.92 [-5.88, -1.96]	<0.001	-	-							⊕⊕◯◯	LOW	Large
Milk vetch honey	1	43	0.10 [-0.21, 0.41]	0.65 [-1.30, 2.62]	0.511	-	-							⊕⊕⊕◯	MODERATE	No effect
Polyfloral Honey	22	746	-0.07 [-0.22, 0.07]	-0.20 [-0.63, 0.20]	0.325	37.0	0.04							⊕⊕◯◯	LOW	No effect
LDL Cholesterol																
Clover Honey	3	47	-0.38 [-0.56, -0.20]	-2.39 [-3.52, -1.26]	<0.001	93.3%	<0.001							⊕⊕◯◯	LOW	Moderate
Robinia Honey	1	63	-0.69 [-1.04, -0.34]	-3.86 [-5.82, -1.90]	<0.001	-	-							⊕⊕◯◯	LOW	Large
Milk vetch honey	1	43	0.38 [0.15, 0.60]	3.33 [1.37, 5.29]	<0.001	-	-							⊕⊕◯◯	LOW	Moderate
Polyfloral Honey	22	746	-0.09 [-0.21, 0.02]	-0.33 [-0.76, 0.07]	0.117	41.9%	0.020							⊕⊕◯◯	LOW	No effect
HDL Cholesterol																
Clover Honey	3	47	0.08 [0.02, 0.15]	1.39 [0.35, 2.61]	0.011	86.5%	<0.001							⊕⊕◯◯	LOW	No effect
Robinia Honey	1	63	0.06 [-0.01, 0.13]	1.68 [-0.28, 3.64]	0.096	-	-							⊕⊕◯◯	LOW	No effect
Milk vetch honey	1	43	0.00 [-0.10, 0.09]	-0.06 [-2.01, 1.91]	0.957	-	-							⊕⊕◯◯	LOW	No effect
Polyfloral Honey	22	746	0.09 [0.06, 0.11]	1.50 [1.00, 1.84]	<0.001	0.00%	0.580							⊕⊕⊕◯	MODERATE	Small
Fasting Triglycerides																
Clover Honey	3	47	-0.31 [-0.39, -0.24]	-4.68 [-5.88, -3.62]	<0.001	88.36	<0.00							⊕⊕◯◯	LOW	Moderate
Robinia Honey	1	63	-0.20 [-0.37, -0.03]	-2.31 [-4.27, -0.35]	0.023	-	-							⊕⊕◯◯	LOW	Moderate
Milk vetch honey	1	43	-0.13 [-0.38, 0.13]	-0.98 [-2.94, 0.98]	0.328	-	-							⊕⊕◯◯	LOW	No effect
Polyfloral Honey	22	746	0.09 [0.06, 0.11]	1.50 [1.00, 1.84]										⊕⊕⊕◯	MODERATE	Small
Apolipoprotein B																
Polyfloral Honey	1	30	-2.07 [-14.64, 10.50]	-0.32 [-2.28, 1.64]	0.747	-	-							⊕⊕◯◯	LOW	No effect
Markers of Inflammation																
hsCRP (mg/L)																
Polyfloral Honey	6	149	0.43 [-0.35, 1.21]	0.44 [-0.36, 1.24]	0.277	0.00%	0.970							⊕⊕◯◯	MODERATE	No effect
IL-6 (pg/mL)																
Polyfloral Honey	5	119	0.37 [0.01, 0.74]	0.89 [0.02, 1.78]	0.046	0.00%	0.850							⊕⊕◯◯	MODERATE	Moderate
TNFalpha (pg/mL)																
Polyfloral Honey	2	94	1.44 [0.24, 2.64]	1.66 [0.28, 3.05]	0.029	22.920	0.250							⊕⊕⊕◯	MODERATE	Large
Uric Acid (mg/dL)																
Robinia Honey	2	8	-0.07 [-0.21, 0.07]	-0.69 [-2.08, 0.69]	0.353	0.000	0.690							⊕⊕⊕◯	MODERATE	No effect
Polyfloral Honey	3	95	-0.10 [-0.95, 0.75]	-0.13 [-1.26, 1.00]	0.818	0.000	0.999							⊕⊕⊕◯	MODERATE	No effect



Ahmed, Amna, et al. "Effect of honey on cardiometabolic risk factors: a systematic review and meta-analysis." Nutrition Reviews (2022).

What about health benefits of maple syrup

Can maple syrup, a natural sweetener, be used as a healthy alternative to refined sugars similar to honey!

Maple syrup composition highlights

- Maple syrup is a naturally sweet product with a distinctive flavor and nutritional benefits.
- It is produced by boiling the sap of mature maple trees to evaporate water and concentrate the sugar content to 66–67 °Brix, resulting in a thick, sweet syrup.
- Canada produced 17.4 million gallons of maple syrup in 2022, with a value of ~$650 million

Maple syrup composition highlights

- Maple syrup contains sugars, organic compounds, micronutrients, and phytochemicals — some of which are formed during the concentration process
- **Sugars**: sucrose, glucose, fructose, oligosaccharides (rare sugars), polysaccharides (inulin)
- **Organic acids:** Malic acid, fumaric acid, succinic acid (12 reported)
- **Amino acids:** alanine, valine, proline, serine, leucine (11 reported)
- **Vitamins**: Thiamine, niacin, riboflavin, folic acid, biotin, vit A, pyridoxine
- **Phenolic compounds**: Vanillin, galic acid, syringaldehyde … (~100s reported)
- **Minerals:** K, Ca, Na, Mg, Fe, Mn, Zn, Al etc
- **Total reported**: Exceed 200 chemical compounds

Mohammed F, Sibley P, Abdulwali N, Guillaume D. Nutritional, pharmacological, and sensory properties of maple syrup: A comprehensive review. Heliyon. 2023 Aug 21.

Maple Syrup Composition

	Maple Syrup
Solids	66-67%
pH	6.4
Carbohydrates	
Sucrose	66%
Glucose	0.7%
Fructose	0.4%
Oligosaccharides (rare sugars)	0.2%
Minerals	
Nitrogen	0.03%
Potassium	2026 mg/L
Calcium	775 mg/L
Magnesium	167 mg/L
Manganese	39.8 ppm
Sodium	36 ppm
Phosphorus, Iron, Zinc, Aluminium, Iron, Chl…	191.82 ppm
Organic Acids	
Malic acid	0.32%
Fumaric acid	0.13%
Succinic acid	0.26%

1. Ball DW. The chemical composition of maple syrup. Journal of Chemical Education. 2007 Oct;84(10):1647.
2. Perkins TD, van den Berg AK. Maple syrup—Production, composition, chemistry, and sensory characteristics. Advances in food and nutrition research. 2009 Jan 1;56:101-43.
3. Mohammed F, Sibley P, Abdulwali N, Guillaume D. Nutritional, pharmacological, and sensory properties of maple syrup: A comprehensive review. Heliyon. 2023 Aug 21.

U.S. Department of Agriculture (USDA). FoodData Central. Retrieved from https://fdc.nal.usda.gov

Component	Maple Syrup	Honey	Agave Syrup	Refined Sugar
Primary Sugar	Sucrose (60-66%)	Fructose (38%)	Fructose (56-60%)	Sucrose (99.9%)
Secondary Sugars	Glucose, Fructose	Glucose (31%)	Glucose (20-24%)	None
Oligosaccharides/Rare Sugars	Small amounts of oligosaccharides	Oligosaccharides, Maltose	Small amounts of inulin	None
Calories (per 100g)	260	304	310	387
Calories (per teaspoon)	17 (6.6 gm)	21 (7 gm)	20 (6.8 gm)	16 (4.2 gm)
Calories (per tablespoon)	51 (19.8 gm)	64 (21 gm)	60 (20.4 g)	49! (12.6 g)
Vitamins	Riboflavin, Thiamin	Vitamin C, B6	Vitamin C, B6	None
Minerals	Calcium, Potassium, Manganese, Zinc	Calcium, Potassium, Iron, Magnesium	Calcium, Potassium	None
Glycemic Index	54	58	19-30	65
Water Content	32%	17%	25%	0%
Other Components	Amino acids, Antioxidants	Amino acids, Antioxidants, Enzymes	Saponins, Inulin	None

Perception

TORONTO STAR

HEALTH

Here's why maple syrup is very good for your health

Good news for sweet tooths everywhere: that sticky syrup you love to pour on pancakes and waffles is not only bad for you — it might be good for you, too.

March 22, 2010 | 2 min read

Dr. Axe > Nutrition > Articles

✔ Fact Checked

Maple Syrup: the Most Versatile, Best Natural Sweetener?

By Jillian Levy, CHHC

December 11, 2023

food network's healthueats™

Healthy Eats Home | Healthy Recipes | News | Diets | Healthy Tips | Fitness & Wellness

Pour It On! Maple Syrup Is Good for You

By: Kiri Tannenbaum

McGill | Newsroom
Institutional Communications

Home

NEWS

Postmedia - Scientist sour on reported benefits of maple syrup

"This study is of academic interest, and that is all," Schwarcz told Postmedia News. "To suggest that maple syrup is healthy because it contains a number of phenolic compounds is rumpled thinking that needs to be straightened out. Phenolics are not rare -they are abundant in fruits and vegetables."

MENU | Diabetes Québec — The reference in diabetes | Give

Home | Diabetes | Diabetes management | Diet | Maple Syrup : not a miracle food

USA TODAY

TOP MOVIE, TV PICKS: ✍ SIGN Watch Party Newsle... | HEALTH BENEFITS EXPLAINED Apple cider vinegar | THE STARS DO IT Is Pilates for you?

U.S. | Elections | Sports | Entertainment | [Life] | Money | Tech | Travel | Opinion

HEALTH AND WELLNESS

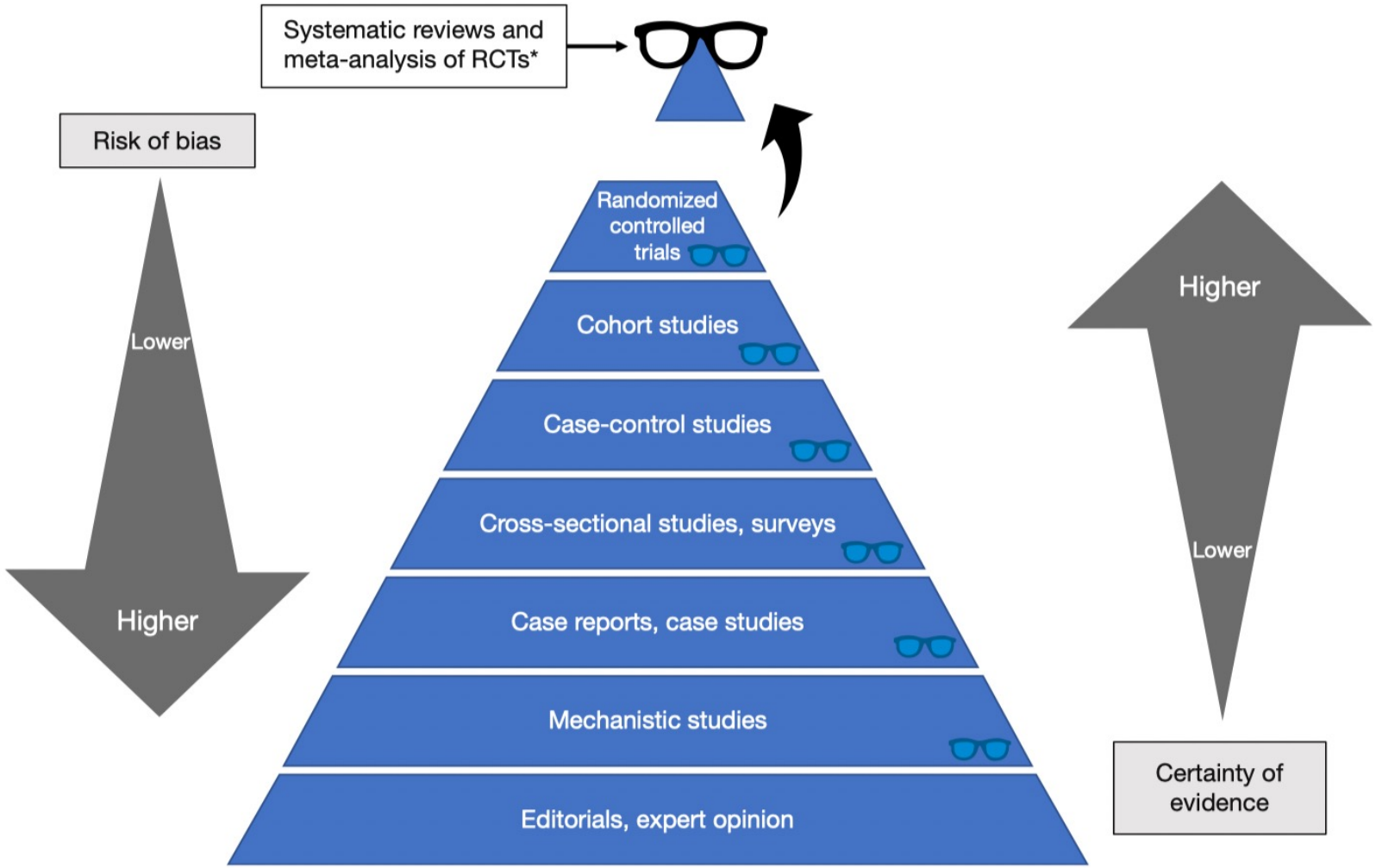
Maple syrup | Add Topic +

Maple syrup is a breakfast staple. Is it healthier for you than sugar?

Daryl Austin
USA TODAY

Published 5:02 a.m. ET Dec. 7, 2023 | **Updated 2:59 p.m. ET March 19, 2024**

Hierarchy of Evidence using GRADE Approach



https://gdt.gradepro.org/app/handbook/handbook.html

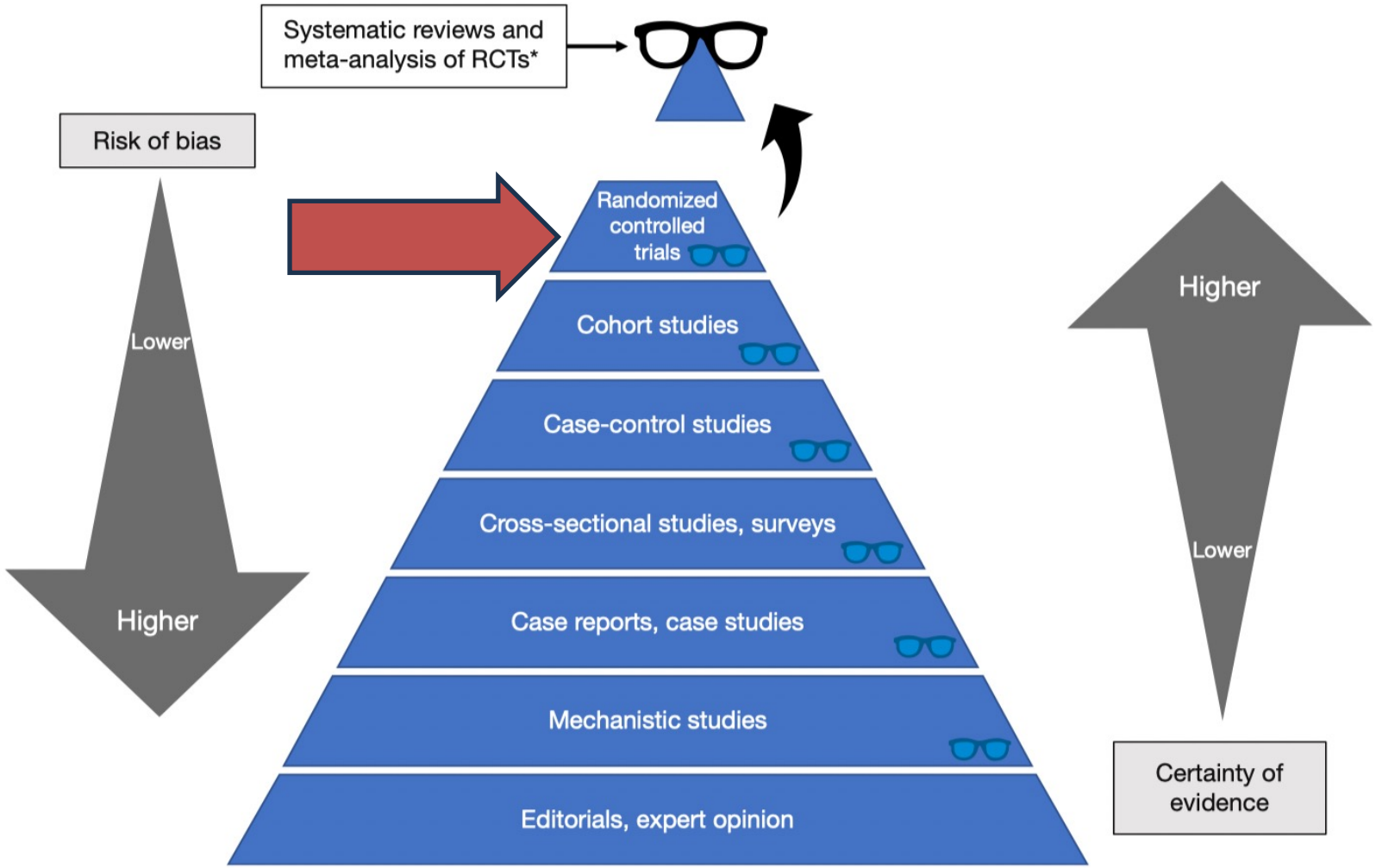
Current limitations of Maple Syrup research

Majority of studies have focused on cellular or animal models

Maple syrup extract is tested

Individual compounds in maple syrup are investigated

Hierarchy of Evidence using GRADE Approach



https://gdt.gradepro.org/app/handbook/handbook.html

WHAT IS THE EVIDENCE FROM RANDOMIZED CONTROLLED TRIALS (RCTS)?

nutrients

MDPI

Sports RCT

Article

Impact of Carbohydrate Ingestion on Cognitive Flexibility and Cerebral Oxygenation during High-Intensity Intermittent Exercise: A Comparison between Maple Products and Usual Carbohydrate Solutions

Olivier Dupuy [1,*] and Jonathan Tremblay [2]

1 Laboratoire MOVE (EA 6314), Faculté des Sciences du Sport, Université de Poitiers, 86000 Poitiers, France
2 École de kinésiologie et des sciences de l'activité physique, Faculté de Médecine, Université de Montréal, Montréal, QC H3T 1J4, Canada
* Correspondence: olivier.dupuy@univ-poitiers.fr

- Maple syrup sweetened carbohydrate (CHO) drink (6%) vs commercial sports drink, glucose, and control (water)
- 85 active healthy men
- Cognitive flexibility and cerebral oxygenation after HIIE

Results

- CHO ingestion, regardless of its type, tends to improve cognitive performance throughout exercise
- The ingestion of maple products and the commercial sports drink led to a lesser increase in glycemia than glucose ingestion.

Lavoie and Tremblay *Journal of the International Society of Sports Nutrition* (2020) 17:63
https://doi.org/10.1186/s12970-020-00384-3

Journal of the International Society of Sports Nutrition

RESEARCH ARTICLE Open Access

Ingestion of maple-based and other carbohydrate sports drinks: effect on sensory perceptions during prolonged exercise

Lorianne Lavoie and Jonathan Tremblay*

Sports RCT

- Maple water drink, maple syrup drink, glucose and commercial sports drink,
- 76 active healthy
- Perceive exertion (RPE), and appreciation schore

Results

- A sports drink containing maple syrup is well appreciated during prolonged exercise and appears to be a viable alternatives to more common sources of carbohydrates.

RCT in diseased individuals

OR14-05-23 Substituting Refined Sugars by Maple Syrup Decreases Key Cardiometabolic Risk Factors in Individuals With Mild Metabolic Alterations: A Double-Blind, Crossover RCT

André Marette[1], Geneviève Pilon[1], Arianne Morissette[1], Anne-Laure Agrinier[1], Théo Gignac[2], Lamia Ramadan[1], Julie Marois[3], Thibault Varin[1], Éric Larose[1], Claudia Gagnon[2], Benoit Arsenault[1], Jean-Pierre Després[1], Anne-Marie Carreau[2], Marie-Claude Vohl[3]

[1]Québec Heart and Lung Institute Université Laval
[2]Research Center Of CHU Université Laval
[3]Centre Nutrition, santé et société (NUTRISS), Institute of Nutrition and Functional Foods (INAF), Université Laval

Marette A, Pilon G, Morissette A, Agrinier AL, Gignac T, Ramadan L, Marois J, Varin T, Larose É, Gagnon C, Arsenault B. OR14-05-23 Substituting Refined Sugars by Maple Syrup Decreases Key Cardiometabolic Risk Factors in Individuals With Mild Metabolic Alterations: A Double-Blind, Crossover RCT. Current Developments in Nutrition. 2023 Jul 1;7.

Objective

- Test the impact of maple syrup consumption compared to an equivalent amount of refined sugar on cardiometabolic health.
- A double-blind cross-over trial

Marette A, Pilon G, Morissette A, Agrinier AL, Gignac T, Ramadan L, Marois J, Varin T, Larose É, Gagnon C, Arsenault B. OR14-05-23 Substituting Refined Sugars by Maple Syrup Decreases Key Cardiometabolic Risk Factors in Individuals With Mild Metabolic Alterations: A Double-Blind, Crossover RCT. Current Developments in Nutrition. 2023 Jul 1;7.

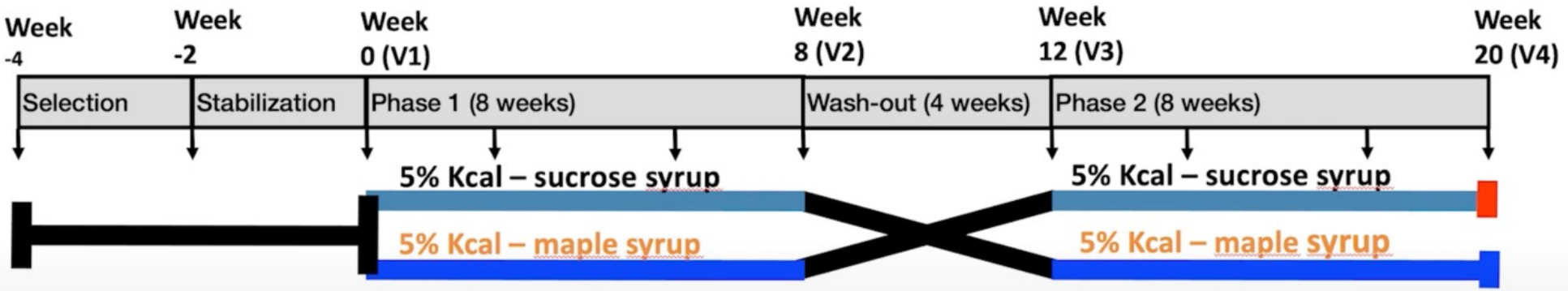
PICOT

- Population: 42 adults
  - With cardiometabolic alterations [at least one of the following criteria: fasting insulin > 42 pM/L, Fasting glucose: 5.6-6.9 mmol/L, HbA1c: 5.7-6.4%, or fasting triglycerides > 1.35 mmol/L]
- Intervention:
  - Substitute 5% of their total caloric intake provided by added sugars with a) maple syrup or b) artificially flavoured sucrose syrup
- Outcomes:
  - Cardiometabolic risk factors
  - Fecal microbiome
- Time: 8-week intervention [with 4 weeks washout period]

Objective

18-75 yrs-old, BMI 23-40kg/m^2 and at least one of the following criteria: FI > 42 pM, FG : 5.6-6.9 mM, HbA1c : 5.7-6.4%, or fasting TG > 1.35 mM

Randomized, double-blind, placebo-controlled crossover study



Sélection (V0)
Anthropometry
Blood samples
Questionnaires

24h-R

Visit 1 (V1)
Anthropometry
Blood samples
OGTT
Questionnaires
Fecal samples
MRI

24h-R

24h-R

Visit 2 (V2)
Anthropometry
Blood samples
OGTT
Questionnaires
Fecal samples
MRI

Visit 3 (V3)
Anthropometry
Blood samples
OGTT
Questionnaires
Fecal samples
MRI

24h-R

24h-R

Visit 4 (V4)
Anthropometry
Blood samples
OGTT
Questionnaires
Fecal samples
MRI

n=42, except for MRI analyses where N=27-28

Marette A, Pilon G, Morissette A, Agrinier AL, Gignac T, Ramadan L, Marois J, Varin T, Larose É, Gagnon C, Arsenault B. OR14-05-23 Substituting Refined Sugars by Maple Syrup Decreases Key Cardiometabolic Risk Factors in Individuals With Mild Metabolic Alterations: A Double-Blind, Crossover RCT. Current Developments in Nutrition. 2023 Jul 1;7.

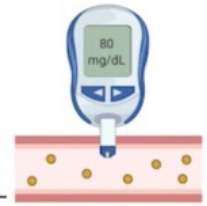
Results

- Maple syrup decreased abundance of *Bacteroides Pectinophilus* and *Klebsiella* in the fecal microbiome of participants.
- Maple syrup improved:
  - Systolic blood pressure (p =0.03)
  - Abdominal fat mass (p=0.02)
  - Glucose iAUC (p=0.05)

Marette A, Pilon G, Morissette A, Agrinier AL, Gignac T, Ramadan L, Marois J, Varin T, Larose É, Gagnon C, Arsenault B. OR14-05-23 Substituting Refined Sugars by Maple Syrup Decreases Key Cardiometabolic Risk Factors in Individuals With Mild Metabolic Alterations: A Double-Blind, Crossover RCT. Current Developments in Nutrition. 2023 Jul 1;7.

Overall results

When comparing the impact of maple syrup vs an equivalent amount of calories from sucrose alone:

	Maple syrup vs Sucrose	Implications
	↓ AUC glucose (OGTT)	Less deleterious impact on glucose homeostasis
	↓ systolic pressure ↓ diastolic pressure*	Reduced impact on blood pressure
	↓ android fat	Less abdominal fat accumulation

Marette A, Pilon G, Morissette A, Agrinier AL, Gignac T, Ramadan L, Marois J, Varin T, Larose É, Gagnon C, Arsenault B. OR14-05-23 Substituting Refined Sugars by Maple Syrup Decreases Key Cardiometabolic Risk Factors in Individuals With Mild Metabolic Alterations: A Double-Blind, Crossover RCT. Current Developments in Nutrition. 2023 Jul 1;7.

Conclusion

- In this clinical study, replacing refined sugars with the same quantity of maple syrup for 5% of daily energy intake [2 tablespoons] resulted in
  - Improved glucose control
  - Lower blood pressure
  - Reduced abdominal fat
- These results suggest that using maple syrup as a preferred source of added sugar ***improves*** [less deleterious] metabolic health compared to refined sugars, and was associated with changes in the gut microbiota composition

Glycemic Index (GI)

- Classify carbohydrate foods according to their effect on postprandial plasma glucose response — property of food
- Relative measure — GI is iAUC response relative to equivalent glucose or white bread
- Low GI foods release their carbohydrate slowly and elicit a lower glycemic response [low GI ≤55; medium 56-69; high GI ≥ 70]
- Benefits: weight maintenance, weight loss, benefits for glucose control, diabetes, and heart disease.

THE UNIVERSITY OF SYDNEY

Maple Syrup GI

GI Search

Food Name	GI	Serving Size (g)	Average carbohydrate portion (g)	GL (based on average carbohydrate potion)
maple syrup	Search GI	Search Serving Size (g)	Search Average carbohydra	Search GL (based on avera
Maple flavored syrup	68		5	3
Maple syrup, pure Canadian	54		5	3

Showing 1 to 2 of 2 entries (filtered from 4,249 total entries)

Previous 1 Next

= Glycemic index (GI) values and glycemic load (GL) values determined in studies with method deviations from ISO 26642:2010 or values showing wide variability.

Low GI foods and drinks have a GI value less than or equal to 55 and are characterised by a smaller rise and fall in blood glucose.

High GI foods and drinks have a GI value greater than or equal to 70 and are characterised by faster and higher peaks and troughs in blood glucose levels.

Medium GI foods and drinks have a GI value between 56 and 69.

https://glycemicindex.com/gi-search/?food_name=maple+syrup

Comparison of maple syrup to other natural sweeteners

U.S. Department of Agriculture (USDA). FoodData Central. Retrieved from https://fdc.nal.usda.gov

Component	Maple Syrup	Honey	Agave Syrup	Refined Sugar
Primary Sugar	Sucrose (60-66%)	Fructose (38%)	Fructose (56-60%)	Sucrose (99.9%)
Secondary Sugars	Glucose, Fructose	Glucose (31%)	Glucose (20-24%)	None
Oligosaccharides/Rare Sugars	Small amounts of oligosaccharides	Oligosaccharides, Maltose	Small amounts of inulin	None
Calories (per 100g)	260	304	310	387
Calories (per teaspoon)	17 (6.6 gm)	21 (7 gm)	20 (6.8 gm)	16 (4.2 gm)
Calories (per tablespoon)	51 (19.8 gm)	64 (21 gm)	60 (20.4 g)	49! (12.6 g)
Vitamins	Riboflavin, Thiamin	Vitamin C, B6	Vitamin C, B6	None
Minerals	Calcium, Potassium, Manganese, Zinc	Calcium, Potassium, Iron, Magnesium	Calcium, Potassium	None
Glycemic Index	54	58	19-30	65
Water Content	32%	17%	25%	0%
Other Components	Amino acids, Antioxidants	Amino acids, Antioxidants, Enzymes	Saponins, Inulin	None

Glycemic index of maple syrup

Actual

GI = 54 (low GI)

Predicted

eGI = 64 (medium GI)

Mechanism: Inhibition of glucosidase activity and/or glucose transporters!

https://glycemicindex.com/
Sydney University's Glycemic Index Research Service (Sydney, Australi

$$GI = \frac{\sum_{i=1}^{m} x_i a_i GI_i}{\sum_{i=1}^{m} x_i + \sum_{j=1}^{n} x_j b_j}$$ (Rytz 2019)

Other studies (animal or cellular)

- Improved glucose metabolism though
  - Inhibition of alpha-glucosidase [limit glucose absorption]
  - Affects gastic inhibitory peptide (GIP) [affects glucose and lipid metabolism] and glucagon-like peptide (GLP-1) [improves satiety]
  - Possible inhibition of intestinal glucose transporters SGLT1 and GLUT2, this preventing glucose absorption

What is the mechanism?

- Active functional molecules!
  - Polyphenols
  - Organic acids
  - Vitamins
  - Minerals
  - Phytohormones (e.g. abscisic acid (ABA))
  - Sugars

St-Pierre P, Pilon G, Dumais V, Dion C, Dubois MJ, Dubé P, Desjardins Y, Marette A. Comparative analysis of maple syrup to other natural sweeteners and evaluation of their metabolic responses in healthy rats. Journal of Functional Foods. 2014 Nov 1;11:460-71.

Table 1 – Carbohydrate content of different sweeteners in g/L.

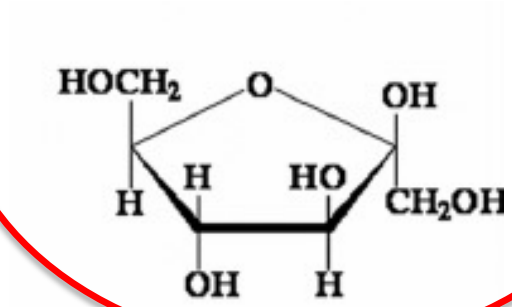
	Polysaccharides	Oligosaccharides	Sucrose	Glucose	Fructose	Total carbohydrates	Variation (%)
Maple	14 ± 0.6 (2%)	2 ± 3.8 (0%)	860 ± 4.9 (97%)	8 ± 1.8 (1%)	<BDL	884 (100%)	0.2
Molasses	45 ± 0.1 (4%)	72 ± 1.2 (7%)	439 ± 1.8 (43%)	251 ± 2.2 (24%)	222 ± 2.6 (22%)	1029 (100%)	1.6
Brown rice	197 ± 14.3 (22%)	184 ± 0.5 (21%)	364 ± 1.9 (42%)	132 ± 0.1 (15%)	<BDL	877 (100%)	1.1
Agave	<BDL	<BDL	30 ± 0.3 (3%)	106 ± 0.2 (10%)	917 ± 3.7 (87%)	1053 (100%)	0.1
Corn	228 ± 3.5 (33%)	112 ± 0.4 (16%)	127 ± 0.4 (19%)	212 ± 0.4 (31%)	7 ± 0.5 (1%)	686 (100%)	1.4
Honey	3 ± 0.0 (0%)	7 ± 0.1 (1%)	35 ± 0.1 (3%)	528 ± 8.6 (47%)	553 ± 8.3 (49%)	1126 (100%)	0.8

<BDL, below detection limit (1 g/L).
Measurements done in triplicate.

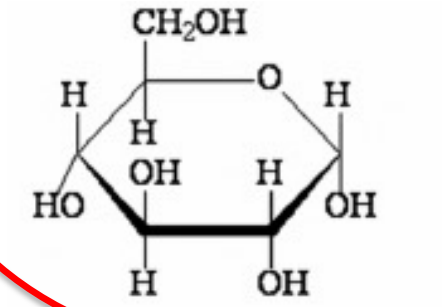
St-Pierre P, Pilon G, Dumais V, Dion C, Dubois MJ, Dubé P, Desjardins Y, Marette A. Comparative analysis of maple syrup to other natural sweeteners and evaluation of their metabolic responses in healthy rats. Journal of Functional Foods. 2014 Nov 1;11:460-71.

Common Sugars

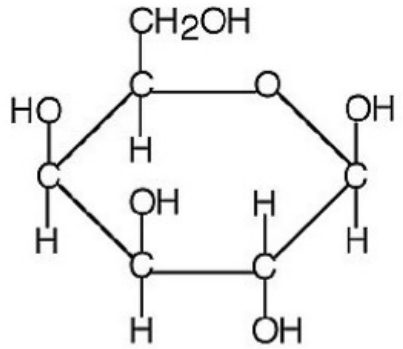
- Fructose (fruit)



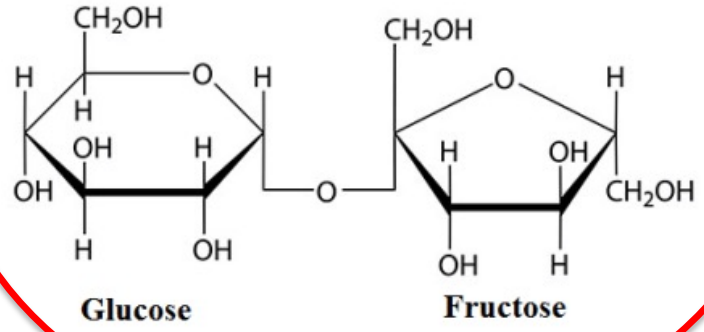
- Glucose (fruit)



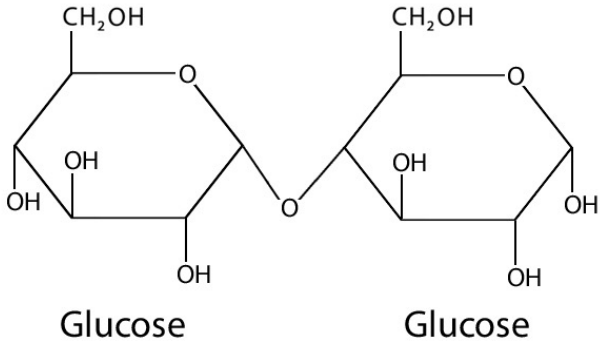
- Galactose (dairy)



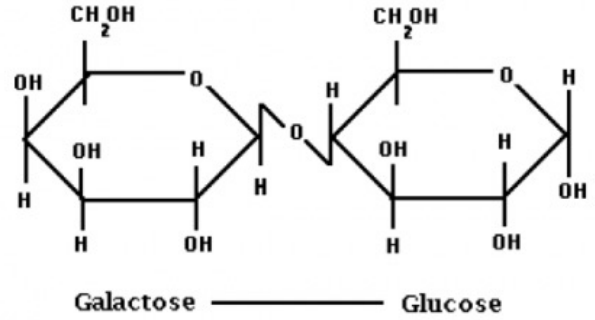
- Sucrose (table sugar, maple syrup)



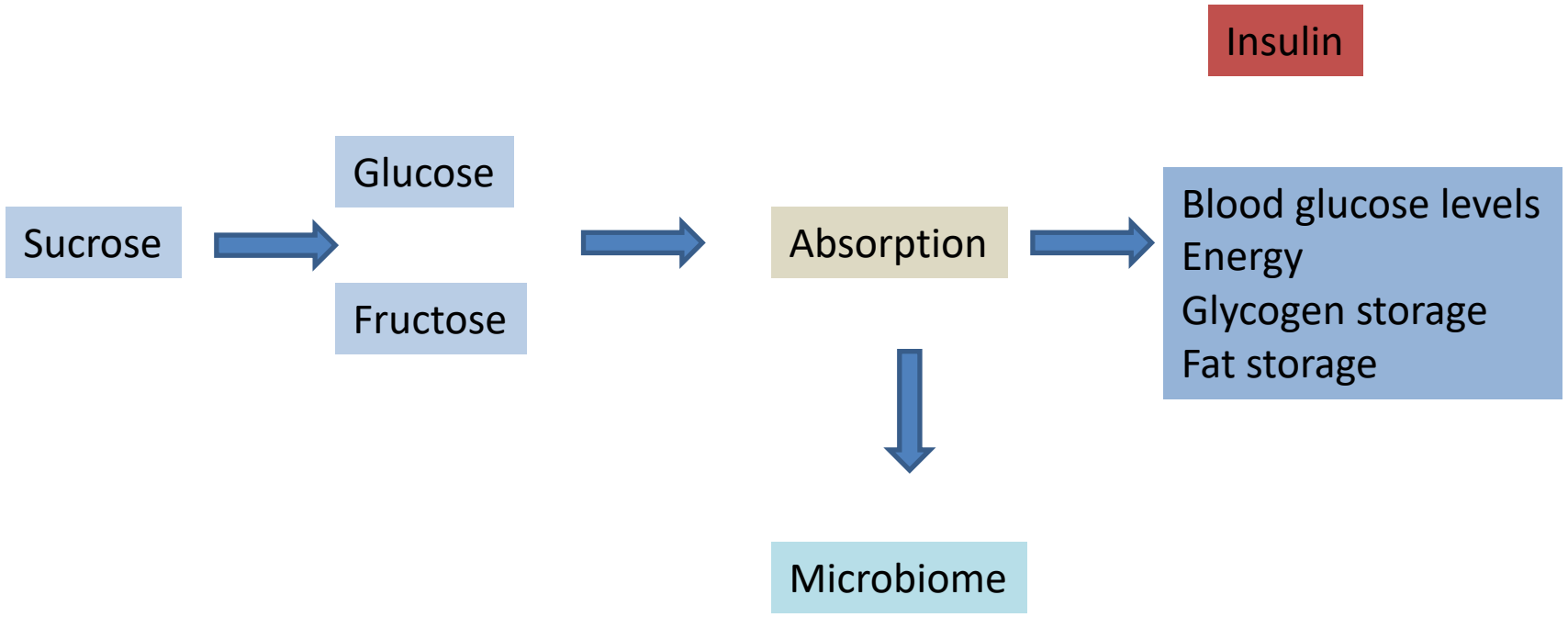
- Maltose (grains)



- Lactose (dairy)

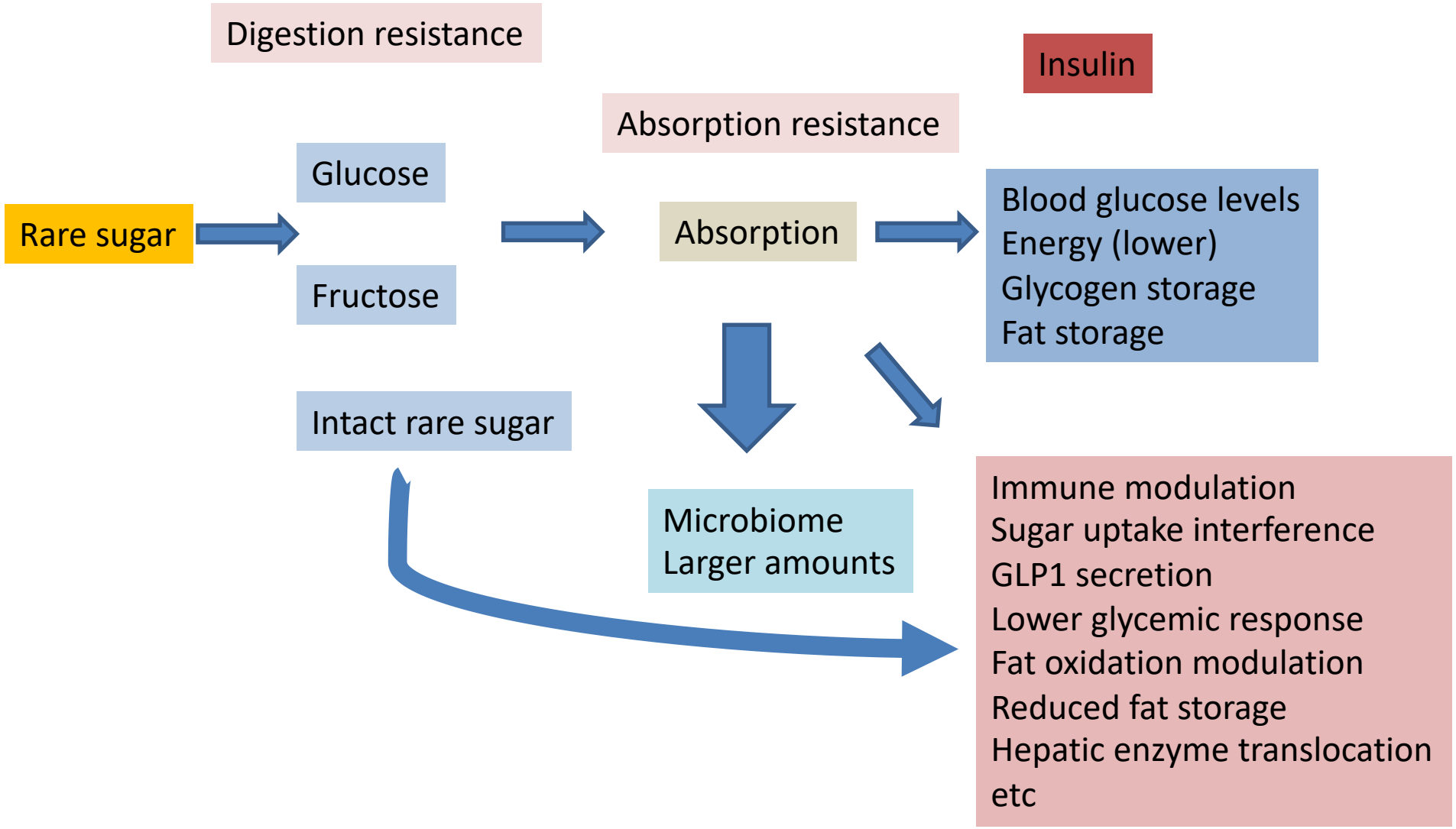


Common sugar effects



Ahmed, A., Khan, T. A., Dan Ramdath, D., Kendall, C. W. C. & Sievenpiper, J. L. Rare sugars and their health effects in humans: a systematic review and narrative synthesis of the evidence from human trials. *Nutrition Reviews* (2021) doi:10.1093/nutrit/nuab012.

Rare sugar effects



Ahmed, A., Khan, T. A., Dan Ramdath, D., Kendall, C. W. C. & Sievenpiper, J. L. Rare sugars and their health effects in humans: a systematic review and narrative synthesis of the evidence from human trials. *Nutrition Reviews* (2021) doi:10.1093/nutrit/nuab012.

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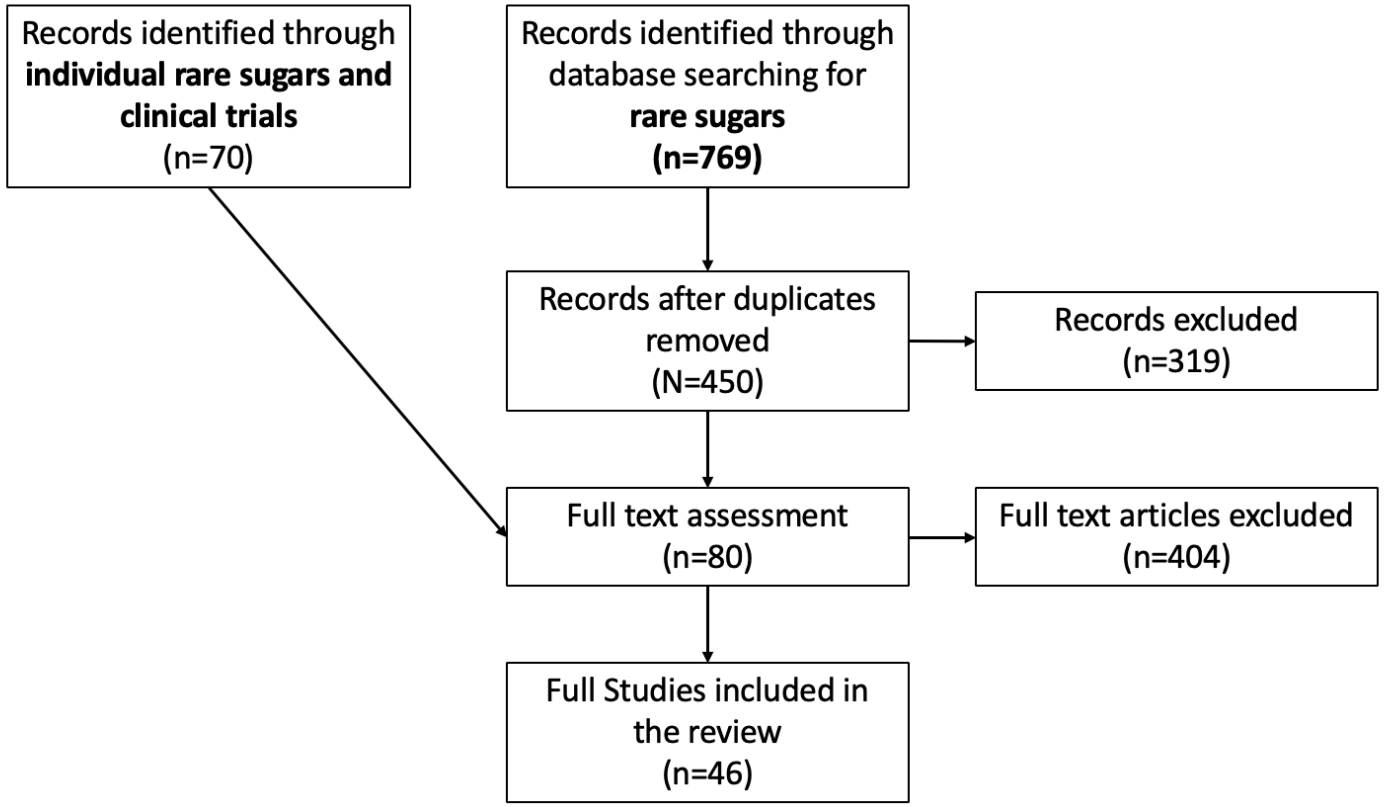
Special Article

Rare sugars and their health effects in humans: a systematic review and narrative synthesis of the evidence from human trials

Amna Ahmed, Tauseef A. Khan, D. Dan Ramdath, Cyril W.C. Kendall, and John L. Sievenpiper

Rare sugars and their potential effects in human studies – Systematic Review and Meta-Analysis

Literature flowchart



Rare Sugars

- *'Monosaccharides and their derivatives that are present in limited quantities in nature.'* Hayashi et al. 2014

Rare Monosaccharides

- Allose
- Tagatose
- Allulose
- Sorbose

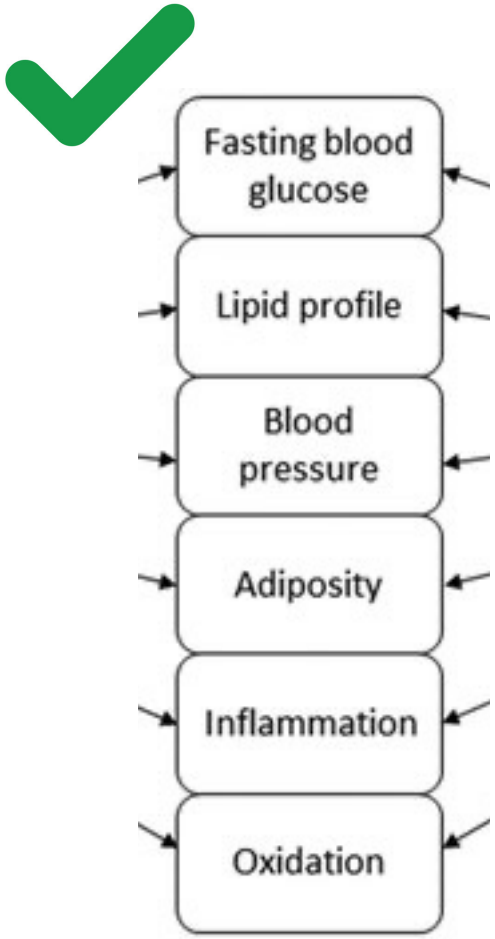
Rare Disaccharides

- Trehalose
- Turanose
- Leucrose
- Isomaltulose (palatinose)
- Kojibose
- Nigerose
- Etc.

Rare Trisaccharides

- Erlose
- Panose
- Isopanose
- Maltotriose
- Theanderose
- Melezitose
- Isomaltotriose
- Etc.

5 Rare Sugars of Focus



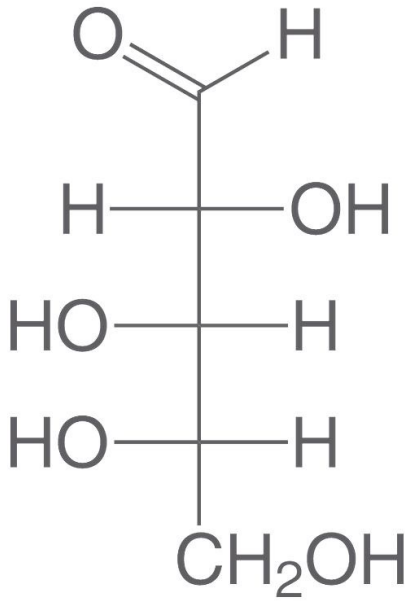
- Allulose
- L-Arabinose
- D-Tagatose
- Trehalose
- Isomaltulose (Palatinose)

Additional Sugars of Interest

- Allose
- Kojibiose
- Sorbose

L-Arabinose

- Food sources: grains, plant gums, maple syrup
- Sweetness (compared to sucrose): 50%
- Caloric content: 0 kcal/g (non-nutritive)
- Structure: monosaccharide, aldopentose

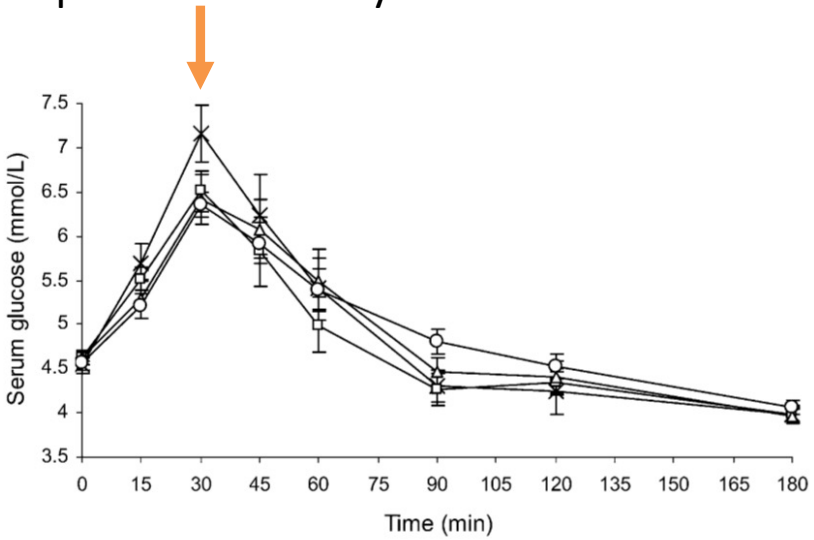


Sweetness of sucrose and none of the calories

L-Arabinose: acute effects - glycemic control

Patient type	Interventi on	Compar ator	Time	Setting
15 H	1, 2, or 3 g arabinose	Sucrose	Acute	Denmark

Population: Healthy individuals



Reduction in the glucose peak when given prior to a test meal compared to sucrose in health individuals

Krog-Mikkelsen et al. 2011

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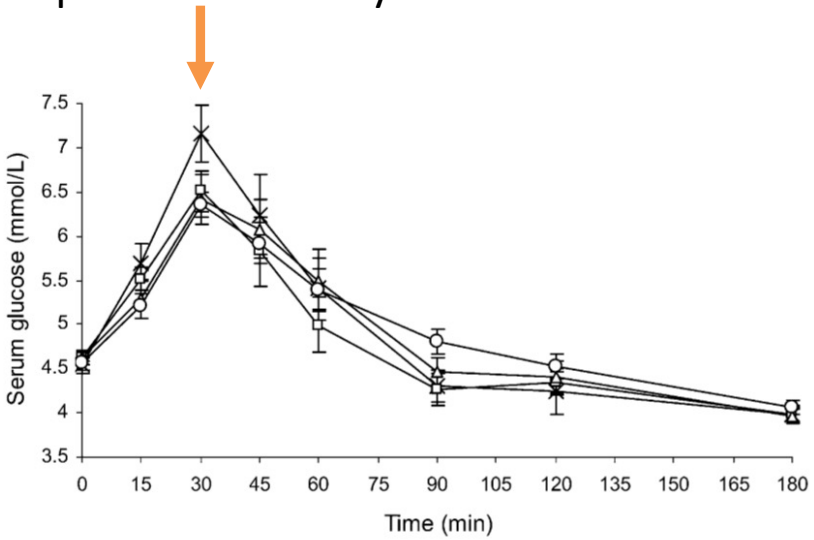


Reduction in the glucose peak when given prior to a test meal compared to sucrose in health individuals

Krog-Mikkelsen et al. 2011

Patient type	Intervention	Comparator	Time	Setting
21 H	2g arabinose	Sucrose	Acute	Japan

Population: Healthy individuals

Table 4 Highest Δblood glucose values and area under the curves (AUC) after ingestion of the test or control meal, or sucrose-load meal by healthy adults ($n = 21$)

Meal	Highest Δblood glucose (mg/dL)	AUC (mg min/dL)
After ingestion of test or control meal		
Control meal	63.8 ± 17.9	2,680 ± 1,020
Test meal	40.3 ± 17.8*	2,070 ± 1,140*
After ingestion of sucrose-load meal		
Control meal	65.0 ± 17.7	3,680 ± 1,340
Test meal	53.8 ± 19.7*	2,680 ± 1,310*

Mean ± SD ($n = 21$), * Significant different, $p < 0.05$

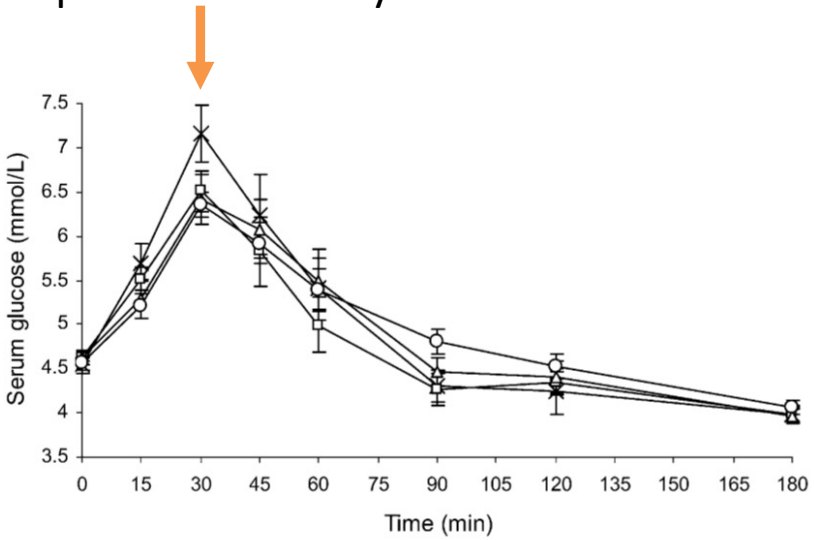
L-arabinose given prior to test meal or 40g of sucrose led to reduced blood glucose levels compared to water

Shibanuma et al. 2010

L-Arabinose: acute effects - glycemic control

Patient type	Intervention	Comparator	Time	Setting
15 H	1, 2, or 3 g arabinose	Sucrose	Acute	Denmark

Population: Healthy individuals



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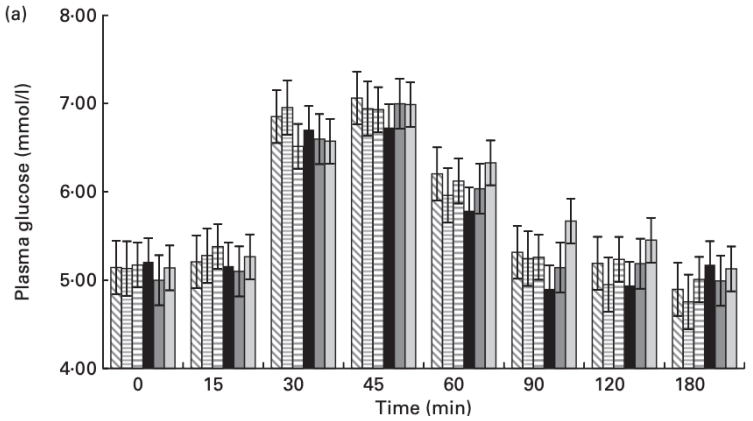
Shibanuma et al. 2010

Patient type	Intervention	Comparator	Time	Setting
17 H	5 or 10% arabinose meal	Sucrose	Acute	Denmark

Population: Healthy individuals



Did not see this effect when L-arabinose supplemented breakfast meal

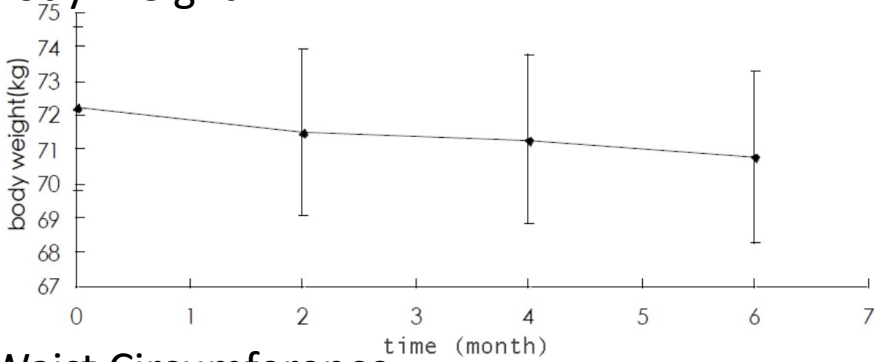
Halschou-Jensen et al. 2015

L-Arabinose: longer term effects

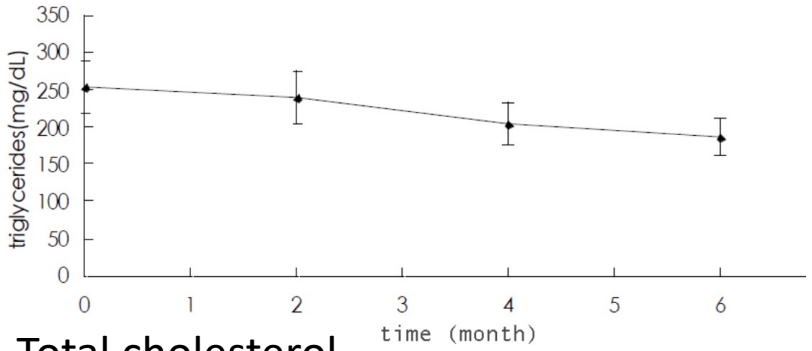
Benefit to individuals with metabolic syndrome

Patient type	Intervention	Comparator	Time	Setting
30 MetS	40-45g arabinose	None	6mo	China

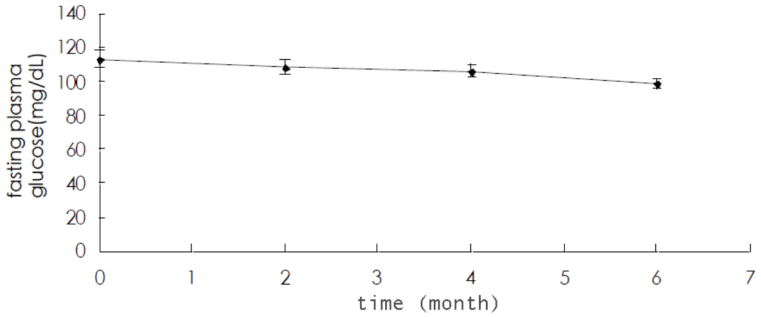
Body Weight



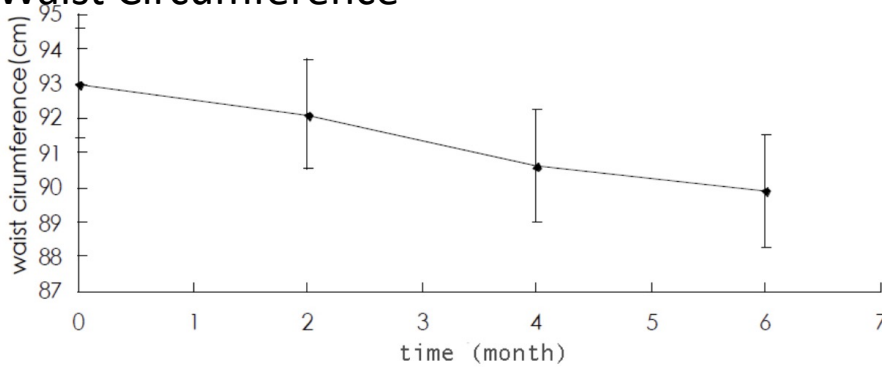
Triglycerides



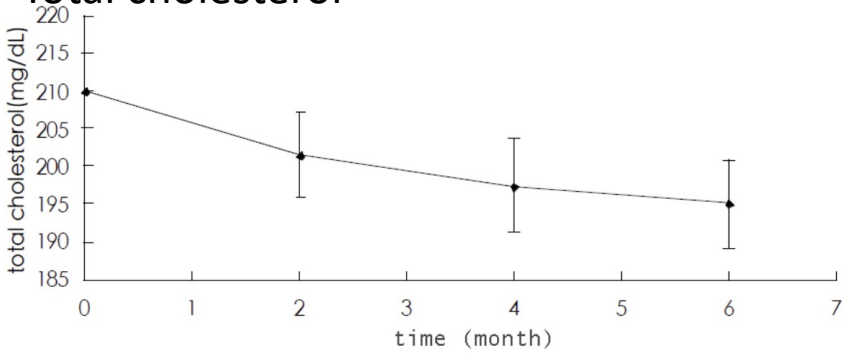
Fasting plasma glucose



Waist Circumference



Total cholesterol



Yang et al. 2013

6-month arabinose supplementation in individuals with metabolic syndrome showed decreased body weight, waist circumference, triglycerides, total cholesterol, and fasting plasma glucose

Summary

Rare sugar	Healthy individuals	Obese/overweight individuals	Individuals with type 2 diabetes	Side effects
L-Arabinose	**Acute** - reduced insulin and glucose peak post-test meal	**Longer term** - reduced waist circumference - reduced total cholesterol - reduced fasting plasma glucose	—	Nausea, abdominal pain, diarrhea

L-Arabinose: possible mechanism

- Potential mechanism: inhibits brush border enzyme **sucrase** *which can reduce glucose absorption and contribute to the effect seen.*

1. Mariette A, Kang HS, Heazlewood JL, Persson S, Ebert B, Lampugnani ER. Not just a simple sugar: arabinose metabolism and function in plants. Plant and Cell Physiology. 2021 Dec 1;62(12):1791-812.

Rare sugars in honey (29+ in literature)

Monosaccharides	
Fructose	⊕
Glucose	⊕

Disaccharides (15)	
Sucrose isomers	
Trehahulose (D-glucose 1-1 D-fructose)	
Sucrose (D-glucose 1-2 D-Fructose)	⊕
Turanose (D-glucose 1-3 D-fructose)	
Maltulose (D-glucose 1-4 D-fructose)	
Leucrose (D-glucose 1-5 D-fructose)	
Isomaltulose (palatinose) (D-glucose 1-6 D-fructose)	⊕
α-glucobioses (α-glucose disaccharides)	
Trehalose (D-glucose 1-1 D-glucose)	⊕
Kojibiose (D-glucose 1-2 D-glucose)	
Nigerose (D-glucose 1-3 D-glucose)	
Maltose (D-glucose 1-4 D-glucose)	⊕
Isomaltose (D-glucose 1-6 D-glucose)	
β-glucobioses (β-glucose disaccharides)	
Laminaribiose (β-D-glucose 1-3 D-glucose)	
Cellobiose (β-D-glucose 1-4 D-glucose)	
Gentiobiose (β-D-glucose 1-6 D-glucose)	
Melibiose (D-galactose 1-6 D-glucose)!	

Trisaccharides (12)	
Sucrose-containing trisaccharides	
Melezitose (D-glucose 1-3 β-D-fructose 2-1 D-glucose)	
Raffinose (β-D-fructose - α-D-glucose 1-6 D-galactose)!	
1-Kestose (D-glucose 1-2 β-D-fuctose 1-2 β-D-fructose)	
6-Kestose (D-glucose 1-2 β-D-fuctose 2-6 β-D-fructose)	
Erlose (D-glucose 1-4 D-glucose 1-2 β-D-fructose)	
Neokestose (β-D-fructose 1-2 D-glucose 1-6 β-D-fructose)	
Theanderose (D-glucose 1-6 D-glucose 1-2 β-D-fructose)	
Glucose trisaccharides	
Centose (D-glucose 1-4 D-glucose 1-2 D-glucose)	
Panose (D-glucose 1-6 D-glucose 1-4 D-glucose)	
Isopanose (D-glucose 1-4 D-glucose 1-6 D-glucose)	
Maltotriose (D-glucose 1-4 D-glucose 1-4 D-glucose)	
Isomaltotriose (D-glucose 1-6 D-glucose 1-6 D-glucose)	

Tetrasaccharides/oligosaccharides (3)	
Maltotetraose	
Isomaltotetraose	
Isomaltopentaose	

Evidence Map of Rare Sugars in Maple Syrup: Identification, Abundance and benefits to cardiometabolic health

Frass Chaudhary, BHSc student
McMaster University
University of Toronto (summer student)

- On going study

Sugars/rare sugars in Maple Syrup

Monosaccharides
- Glucose
- Fructose
- Galactose
- Rhamnose
- Arabinose
- Xylose

Disaccharides
- Sucrose
- Maplebiose 1
- Several unknowns

Trisaccharides
- Raffinose
- 1-Kestose
- 1-Nystose
- Neokestose
- Mapletriose 1
- Mapletriose 2
- Mapletriose 3

Tetrasaccharide
- Nystose

Polysaccharides
- Inulin

17 sugars in maple syrup with 14 can be considered rare sugars

References
- *Adams 1959*
- *Alli 1992*
- *Sato 2019*
- *Sun 2016*
- *Mohammed 2023*
- *Brochu 2019*
- *Mellado 2016*
- *Taga 2012*

Search - Medline

Keywords

Terms connected by **OR**	**AND**	Terms connected by **OR**	**AND**	Terms connected by **OR**
Sugars [MeSH] **OR** Rare Sugars **OR** Sucrose **OR** Fructose **OR** Glucose **OR** *Saccharide **OR** *Rhamnose **OR** *Arabinose **OR** *Xylose **OR** *Blastose **OR** *Raffinose **OR** Maplebiose* **OR** *Kestose **OR** Fructo-oligosaccharides **OR** Mapletriose* **OR** Neokestose **OR** *Nystose **OR** *Inulin		Maple Syrups **OR** "Maple Syrup" **NOT** Maple Syrup Urine Disease		EMPTY

MeSH terms are underline
No LIMITS were used

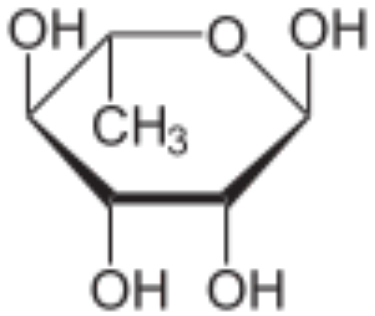
21 February 2024

Flowchart


58 studies imported for screening
Hide sources
33 MEDLINE
25 Embase
1 duplicate identified manually
18 duplicates identified by Covidence
39 studies screened
24 studies irrelevant
15 full-text studies assessed for eligibility
2 studies excluded
Hide reasons
1 Conference Abstract
1 Wrong outcomes
0 studies ongoing
0 studies awaiting classification
13 studies included

Rare sugars in Maple Syrup – Some preliminary results

L-Rhamnose



Structure: Methyl-pentose Deoxy Sugar

Maple Syrup Composition: Concentration compared to other saccharides is unknown. In sap not present in its it's monosaccharide form, but rather found in various polysaccharides such as arabinogalactins.

Digestion: Resists digestion and absorption before reaching colon.

Metabolic Effects

- **Skin Anti-aging:** Rhamnose benefits two key areas of skin aging: the papillary dermis and the dermal-epidermal junction.
- **Prebiotic**: L-Rhamnose is a prebiotic and can help support healthy gut bacteria
- **Lipogenic affects**: Varying data suggests L-Rhamnose affects lipid profile, but no consistency on the direction of effect.
- **Anti-cancer potential**: Suppressed tumour growth in mice
- **Appetite:** Reduced plasma insulin without affecting appetite.

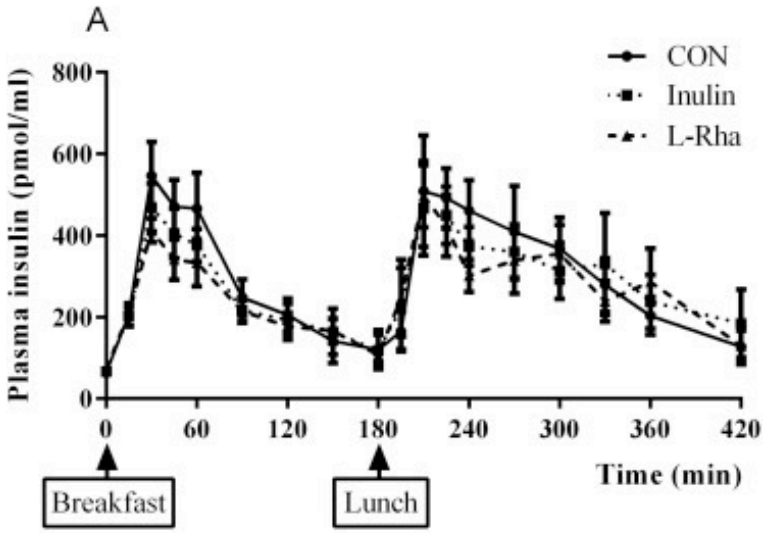
1. Adams GA, Bishop CT. Constitution of an arabinogalactan from maple sap. Canadian Journal of Chemistry. 1960 Dec 1;38(12):2380-6.
2. Pageon H, Azouaoui A, Zucchi H, Ricois S, Tran C, Asselineau D. Potentially beneficial effects of rhamnose on skin ageing: an in vitro and in vivo study. International Journal of Cosmetic Science. 2019 Jun;41(3):213-20.
3. Davani-Davari D, Negahdaripour M, Karimzadeh I, Seifan M, Mohkam M, Masoumi SJ, Berenjian A, Ghasemi Y. Prebiotics: definition, types, sources, mechanisms, and clinical applications. Foods. 2019 Mar 9;8(3):92.
4. Darzi J, Frost GS, Swann JR, Costabile A, Robertson MD. L-rhamnose as a source of colonic propionate inhibits insulin secretion but does not influence measures of appetite or food intake. Appetite. 2016 Mar 1;98:142-9.

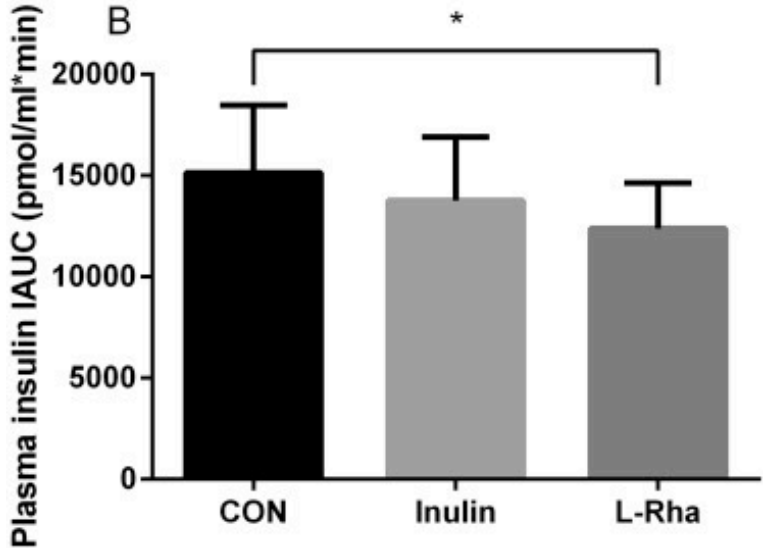
L-Rhamnose

- 13 healthy men and women
- L-Rhamnose vs control
- Reduced plasma insulin without affecting appetite in mixed breakfast and lunch

Mechanism

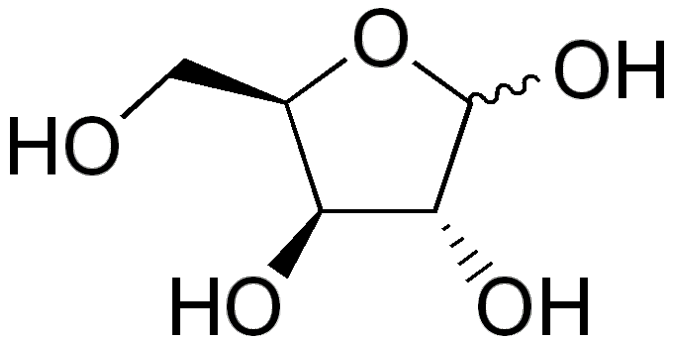
- Possibly via short-chain fatty acid (propionate) activated PYY and GLP-1 production
- Can possibly reduce adiposity





Darzi J, Frost GS, Swann JR, Costabile A, Robertson MD. L-rhamnose as a source of colonic propionate inhibits insulin secretion but does not influence measures of appetite or food intake. Appetite. 2016 Mar 1;98:142-9.

Xylose



Structure: Pentose Sugar – 5 carbon sugar

Found in: Typically found in wood and straw. Studied extensively in pigs and other livestock.

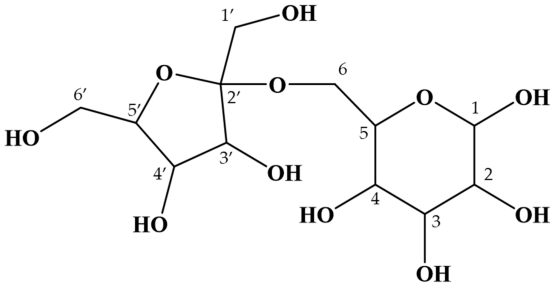
Maple Syrup Composition: [TBD]

Metabolic Effects:

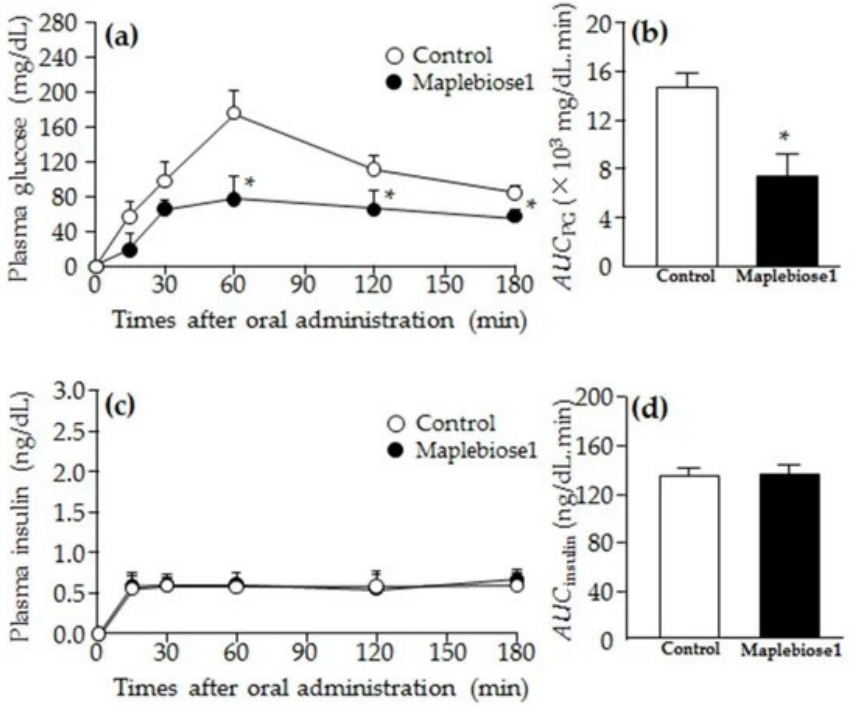
- Lower calories than sucrose
- Prebiotic, promoting growth of beneficial gut bacteria such as Bifidobacteria and Lactobacilli
- Low glycemic index — improved Postprandial glycemic response by inhibiting sucrase enzyme
- Anti-oxidative and anti-inflammatory properties
- Improved lipid profile by reducing total cholesterol and LDL-Cholesterol

1. Mellado-Mojica E, Seeram NP, López MG. Comparative analysis of maple syrups and natural sweeteners: Carbohydrates composition and classification (differentiation) by HPAEC-PAD and FTIR spectroscopy-chemometrics. Journal of Food Composition and Analysis. 2016 Sep 1;52:1-8.

Maplebiose 1/Blastose

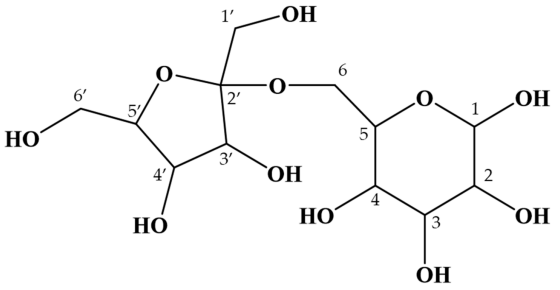


- **Structure**: A disaccharide of 6-glucose - 2-fructose [blastose]
- **Found in**: Maple syrup
- **Maple Syrup composition: [TBD]**
- **Metabolic effect**
  - In OLETF (fatty) rats, Maplebiose 1 lowered the AUCPG over 3 hours after sucrose intake compared to controls, with no significant difference in insulin levels.

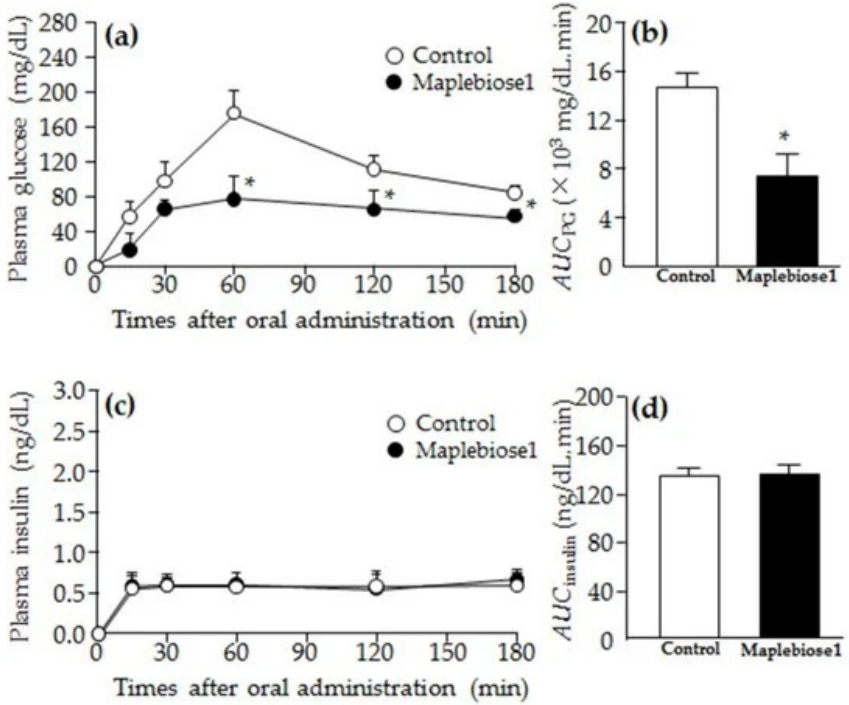


1. Sato K, Nagai N, Yamamoto T, Mitamura K, Taga A. Identification of a Functional Oligosaccharide in Maple Syrup as a Potential Alternative Saccharide for Diabetes Mellitus Patients. International Journal of Molecular Sciences. 2019 Oct 11;20(20):5041.

Maplebiose 1/Blastose



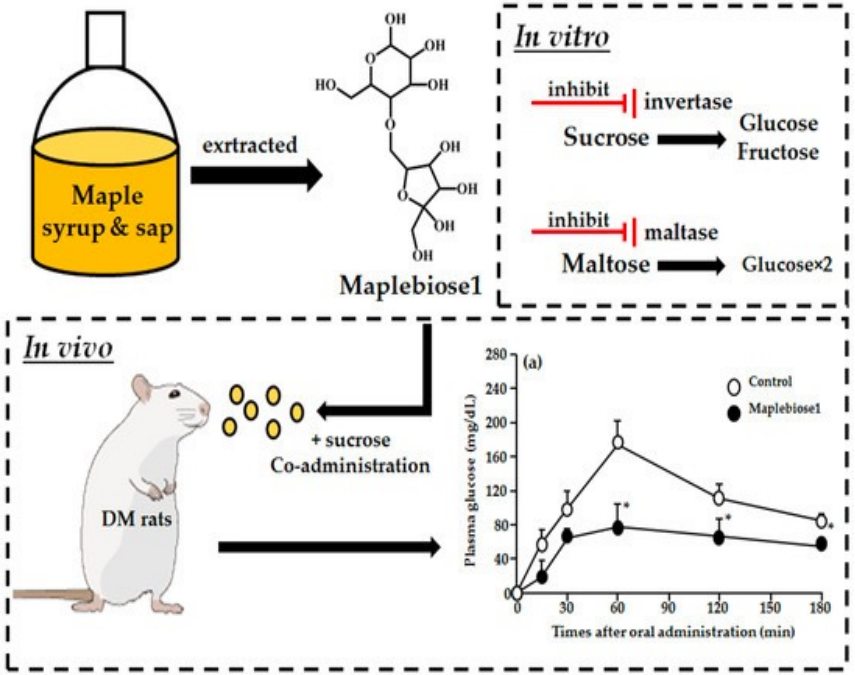
- **Structure**: A disaccharide of 6-glucose - 2-fructose [blastose]
- **Found in**: Maple syrup
- **Maple Syrup composition: [TBD]**
- **Metabolic effect**
  - In OLETF (fatty) rats, Maplebiose 1 lowered the post-prandial glucose over 3 hours after sucrose intake compared to controls, with no significant difference in insulin levels.



Mechanism

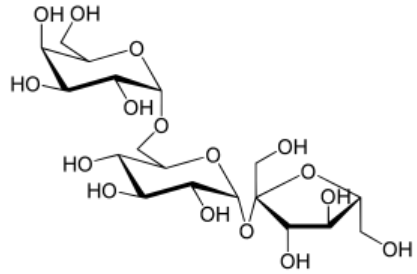
- Inhibits invertase, maltase, and isomaltase

- Reduces glucose absorption across small intestine



Sato K, Nagai N, Yamamoto T, Mitamura K, Taga A. Identification of a Functional Oligosaccharide in Maple Syrup as a Potential Alternative Saccharide for Diabetes Mellitus Patients. International Journal of Molecular Sciences. 2019 Oct 11;20(20):5041.

Raffinose

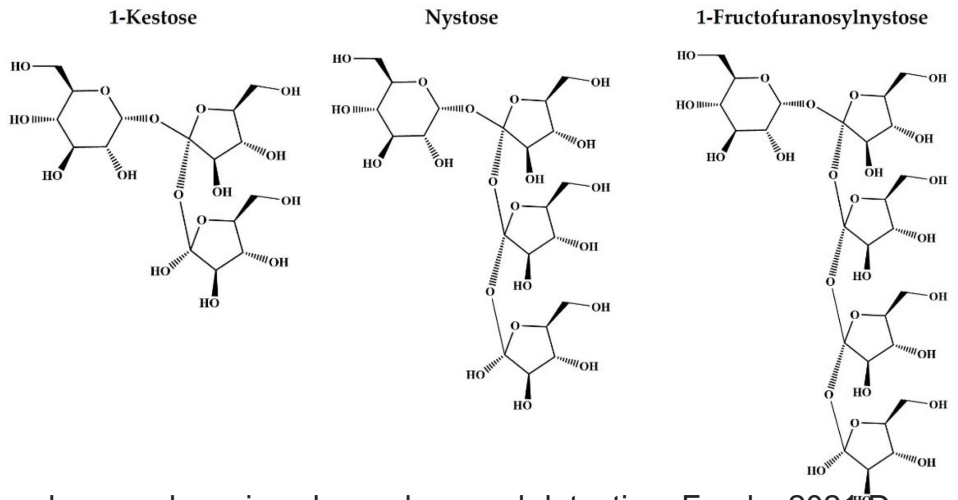


- **Structure**: A trisaccharide of galactose, glucose and fructose.
- **Found in**: beans, cabbage, broccoli, asparagus, maple syrup
- **Maple Syrup composition**: 5.05 - 25.3 µg/mg depending on grade of Maple Syrup (highest in dark)
- **Metabolic effect**
  - Prebiotic – promotes growth of beneficial bacteria in gut
  - Low glycemic index — helps manage blood pressure
  - Satiety — dietary fibre

1. Elango D, Rajendran K, Van der Laan L, Sebastiar S, Raigne J, Thaiparambil NA, El Haddad N, Raja B, Wang W, Ferela A, Chiteri KO. Raffinose family oligosaccharides: friend or foe for human and plant health?. Frontiers in Plant Science. 2022 Feb 17;13:829118.
2. Dou Y, Yu X, Luo Y, Chen B, Ma D, Zhu J. Effect of fructooligosaccharides supplementation on the gut microbiota in human: a systematic review and meta-analysis. Nutrients. 2022 Aug 12;14(16):3298.

FOS - fructosyl oligosaccharides

- Saccharides (sugars) such as fructosyl oligosaccharides (FOS) now popular
- Function as indigestibility and prebiotics, which are beneficial to human health
- In maple syrup
  - 1-kestose,
  - Nystose,
  - 1-fructofuranosylnystose



- Sato K, Yamamoto T, Mitamura K, Taga A. Separation of fructosyl oligosaccharides in maple syrup by using charged aerosol detection. Foods. 2021 Dec 20;10(12):3160.

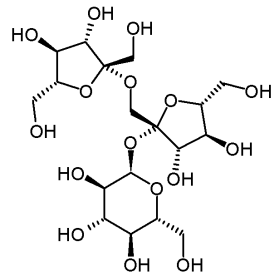
The concentration of saccharides in all grades of maple syrup under investigation

Variables	Golden	Amber	Dark	Very Dark
Fructose (μg/10 mg)	21.3 ± 0.146	41.7 ± 0.295	65.6 ± 0.442	163 ± 1.46
Glucose (μg/10 mg)	31.6 ± 0.152	55.1 ± 0.396	83.3 ± 0.464	198 ± 2.12
Sucrose (mg/10 mg)	5.98 ± 0.159	5.94 ± 0.138	6.04 ± 0.115	5.49 ± 0.0506
Mapletriose1 (*) (μg/10 mg)	20.6 ± 1.23	19.6 ± 0.474	31.2 ± 0.491	40.6 ± 0.573
1-Kestose (μg/10 mg)	5.05 ± 0.357	10.1 ± 0.383	13.6 ± 0.142	25.3 ± 0.510
Nystose (μg/10 mg)	0.244 ± 0.0155	0.593 ± 0.00395	1.45 ± 0.0191	3.08 ± 0.0483

Data are presented as mean ± S.D. (*) The concentration of mapletriose1 was predicted using the calibration curve of 1-kestose.

1. Sato K, Yamamoto T, Mitamura K, Taga A. Separation of fructosyl oligosaccharides in maple syrup by using charged aerosol detection. Foods. 2021 Dec 20;10(12):3160.

1-Kestose



- **Structure**: A trisaccharide of glucose and two fructose molecules.
- **Found in**: garlic, onions, asparagus, and banana, maple syrup, honey
- **Maple Syrup composition**: 5.05 - 25.3 µg/mg depending on grade of Maple Syrup (highest in Very Dark)
- **Metabolic effect**
  - Prebiotic for gut health
  - Lower glycemic index
  - Does not promote tooth decay

1. Watanabe A, Tochio T, Kadota Y, Takahashi M, Kitaura Y, Ishikawa H, Yasutake T, Nakano M, Shinohara H, Kudo T, Nishimoto Y. Supplementation of 1-kestose modulates the gut microbiota composition to ameliorate glucose metabolism in obesity-prone hosts. Nutrients. 2021 Aug 27;13(9):2983.

Mapletriose 1/Neokestose

- **Structure**: A trisaccharide of glucose and two fructose molecules.
- **Found in**: maple syrup,
- **Maple Syrup composition**: Mapletriose 1 is the 4th most abundant saccharide observed in maple syrup chromatograms, after sucrose, glucose and fructose. It is found at a concentration of 20.6 - 40.6 µg/mg
- **Metabolic effect**
  - Similar benefits to maplebiose 1
  - Prebiotic
  - Affect on human melanoma cells

1. Sato K, Yamamoto T, Mitamura K, Taga A. Separation of fructosyl oligosaccharides in maple syrup by using charged aerosol detection. Foods. 2021 Dec 20;10(12):3160.
2. Wu JS, Chang JY, Chen CW, Lin MT, Sheu DC, Lee SM. Neokestose suppresses the growth of human melanoma A2058 cells via inhibition of the nuclear factor-κB signaling pathway. Molecular Medicine Reports. 2017 Jul 1;16(1):295-300.

Conclusion

1. Maple syrup is not a simple sugar
2. Maple syrup exerts metabolic benefits when replacing refined sugar
3. Maple syrup has lower than expected glycemic index and can be beneficial for those who with glucose intolerance
4. These benefits can possibly be explained by the rare sugar content of maple syrup
5. More human studies are needed on maple syrup to replicate its cardiometabolic effects.
6. The effects of novel rare sugars in maple syrup needs further evaluation

4 grades - https://inspection.canada.ca/about-cfia/acts-and-regulations/list-of-acts-and-regulations/documents-incorporated-by-reference/canadian-grade-compendium-volume-7/eng/1521118355767/1521118356469?chap=0

Thank you

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