

PLANT-BASED DIETS FOR TYPE 2 DIABETES

PREVENTION & TREATMENT

Michelle McMacken, MD
 Assistant Professor of Medicine, NYU School of Medicine
 Director, Bellevue Hospital Weight Management Program
 Attending Physician, Bellevue Adult Primary Care Center

Michelle.McMacken@nyumc.org

Disclosure of Financial Relationships

Michelle McMacken, MD

Has disclosed relationships with an entity producing, marketing, re-selling, or distributing health care goods or services consumed by, or used on, patients.

<u>Advisory Board/Stock Options</u>	<u>Royalties/Faculty</u>
Nutrinic, Inc.	A Sustainable Diet, Inc.


****Also...I love vegetables.**



What I'll cover...

- What is a plant-based diet?
- Guidelines & nutrient considerations
- Prevention of type 2 diabetes
- Treatment of type 2 diabetes
- Reduction of diabetes-related complications
- Mechanisms of action
- Practical applications & resources

3





Types of plant-based diets

Vegetarian	No red meat, poultry, or seafood. May include dairy and/or eggs, refined grains, added sugar, & oils.
Vegan	No animal products. Only plant foods. May include refined grains, added sugar, & oils.
Whole-foods, plant-based	No animal products. Only plant foods. Minimizes refined grains, added sugar, & oils.

5 NYU Langone

Whole-foods, plant-based diet

Food group	Recommended servings per day
Vegetables, all types, including starchy	Ad libitum, with a variety of colors represented
Fruits, all types	2-4 servings (1 serving = 1 medium piece or 1/2 cup)
Whole grains (eg, quinoa, brown rice, oats)	6-11 servings (1 serving = 1/2 cup cooked or 1 slice whole grain bread)
Legumes (beans, peas, lentils, soy foods)	2-3 servings (1 serving = 1/2 cup cooked)
Leafy green vegetables (eg, kale, lettuce, broccoli)	At least 2-3 servings (1 serving = 1 cup raw or 1/2 cup cooked)
Nuts (eg, walnuts, almonds, pistachios)	1-2 ounces
Seeds (eg, chia, hemp, and flax seeds)	1-3 tablespoons
Fortified plant milks (eg, soy, almond, cashew)	Optional, 2-3 cups
Fresh herbs and spices	Optional, ad libitum

6 Hever J., Plant-based diets: A Physician's Guide, Permanente J 2016 NYU Langone

Plant-based diets in guideline recommendations


Dietary Guidelines for Americans, 2015

“Overall nutrition, as assessed by the Alternative Healthy Eating Index, is typically better on vegetarian and vegan diets compared with omnivorous diets.”

Melina et al. Position of the Academy of Nutrition and Dietetics: Vegetarian Diets. J Acad Nutr Diet 2016 Dec;116(12):1970-1980.


“All patients with type 2 diabetes should strive to attain and maintain an optimal weight through a primarily plant-based meal plan...”

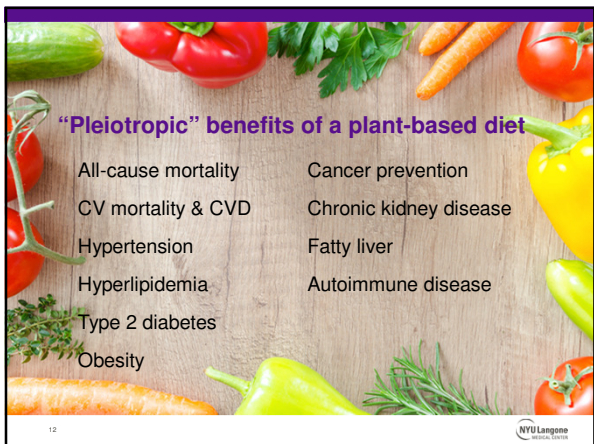
Canadian Diabetes Association, 2013
 “A vegan or vegetarian diet may be used in people with type 2 diabetes to improve glycemic control.”

10 

Nutrients to consider on a plant-based diet


- **B12:** Recommend supplementation
- **Protein:**
 - Intake typically meets or exceeds recommendations when calories adequate
 - No need to combine proteins; variety of plant foods eaten throughout day will supply all essential amino acids if calorie intake adequate
- **Iron:** Vegetarians not more likely to be anemic; iron stores lower but but absorption increased via adaptation
- **Calcium:** Intake varies in fully plant-based diet & can fall below recommendations if not considered; absorption high (>50%) from low-oxalate vegetables
- **Others to consider:** vitamin D, omega 3 fatty acids, zinc, iodine

11 Melina et al. Position of the Academy of Nutrition and Dietetics: Vegetarian Diets. J Acad Nutr Diet 2016 Dec;116(12):1970-1980. 




“Pleiotropic” benefits of a plant-based diet

All-cause mortality	Cancer prevention
CV mortality & CVD	Chronic kidney disease
Hypertension	Fatty liver
Hyperlipidemia	Autoimmune disease
Type 2 diabetes	
Obesity	

12 

What I'll cover...

- ✓ • What is a plant-based diet?
- ✓ • Guidelines & nutrient considerations
 - Prevention of type 2 diabetes ←
 - Treatment of type 2 diabetes
 - Reduction of diabetes-related complications
 - Mechanisms of action
 - Practical applications & resources

13 

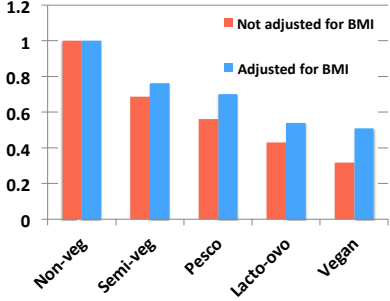
Prevention of type 2 diabetes

Observational studies <ul style="list-style-type: none">• Adventist Health Studies• Taiwanese Buddhists• Nurses Health Study & Health Professionals Follow-Up Study	Foods and diabetes risk <ul style="list-style-type: none">• Underlying mechanisms• Foods that increase risk• Protective foods• Macronutrients (carbs/protein/fat)
--	---




14 

Odds of having type 2 diabetes, Adventist Health Study 2



Diet Type	Not adjusted for BMI	Adjusted for BMI
Non-veg	1.0	1.0
Semi-veg	~0.7	~0.8
Pesco	~0.55	~0.7
Lacto-ovo	~0.45	~0.55
Vegan	~0.35	~0.5


Tonistad S et al. Type of vegetarian diet, body weight, and prevalence of type 2 diabetes. Diabetes Care 2009 May;32(5):791-6 

Incidence of type 2 diabetes, Adventist cohorts

Tonstad et al
n=41,387; 2 years
Vegans:
62% decreased risk of DM2 vs omnivores
*Adjusted for BMI

Tonstad S et al. Vegetarian diets and incidence of diabetes in the Adventist Health Study-2. *Nutr Metab Cardiovasc Dis* 2013 Apr;23(4):292-9.

Vang A et al. Meats, processed meats, obesity, weight gain and occurrence of diabetes among adults: findings from Adventist Health Studies. *Ann Nutr Metab* 2008;52(2):96-104




Incidence of type 2 diabetes, Adventist cohorts

Tonstad et al	Vang et al
n=41,387; 2 years	n=8401; 17 years
Vegans:	Omnivores eating meat \geq once a week:
62% decreased risk of DM2 vs omnivores	34% <u>increased</u> risk of DM2 vs vegans
*Adjusted for BMI	*Adjusted for BMI

Tonstad S et al. Vegetarian diets and incidence of diabetes in the Adventist Health Study-2. *Nutr Metab Cardiovasc Dis* 2013 Apr;23(4):292-9.

Vang A et al. Meats, processed meats, obesity, weight gain and occurrence of diabetes among adults: findings from Adventist Health Studies. *Ann Nutr Metab* 2008;52(2):96-104



OPEN ACCESS Freely available online


PLOS ONE

Taiwanese Vegetarians and Omnivores: Dietary Composition, Prevalence of Diabetes and IFG

Tina H. T. Chiu^{1,2}, Hui-Ya Huang³, Yen-Feng Chiu⁴, Wen-Harn Pan^{2,5}, Hui-Yi Kao⁶, Jason P. C. Chiu⁶, Ming-Nan Lin^{3,7*}, Chin-Lon Lin^{1,8,9}

- Prevalence study of 4384 Taiwanese Buddhists
- Vegetarians had significantly lower odds of having diabetes & impaired fasting glucose
 - OR for diabetes: 0.49 men, 0.26 premenopausal women, 0.25 menopausal women
 - OR for IFG: 0.66 men, 0.60 premenopausal women, 0.73 menopausal women
- Adjusted for age, BMI, fam hx, education, physical activity, smoking, alcohol

Chiu TH et al. Taiwanese vegetarians and omnivores: dietary composition, prevalence of diabetes and IFG. *PLoS One*. 2014 Feb 11;9(2):e88547



ARTICLE Open Access

Vegetarian diet, change in dietary patterns, and diabetes risk: a prospective study

Tina H. T. Chiu^{1,2,3}, Wen-Han Pan^{2,4}, Ming-Nan Lin^{1,6} and Chin-Lon Lin^{7,8}

- Prospective study of 2918 Taiwanese Buddhists; 5-year follow-up
- Vegetarian diet, & changing to vegetarian diet, highly protective:
 - Consistent vegetarian diet: 35% ↓ risk of type 2 diabetes vs omnivores
 - Changing from omnivore to vegetarian: 53% ↓ risk vs not changing
- Adjusted for age, gender, BMI, fam hx, education, physical activity, & use of lipid-lowering meds. (No participants smoked or drank alcohol.)

19 Chiu TH et al. Vegetarian diet, change in dietary patterns, and diabetes risk: a prospective study. *Nutr Diabetes*. 2018 Mar 9;8(1):12




RESEARCH ARTICLE

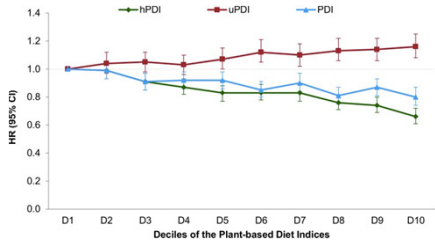
Plant-Based Dietary Patterns and Incidence of Type 2 Diabetes in US Men and Women: Results from Three Prospective Cohort Studies

Ambika Satija^{1,2*}, Shilpa N. Dhupathiraju¹, Eric B. Rimm^{1,2,3}, Donna Spiegelman^{1,2,3,4,5}, Stephanie E. Chiuve^{1,2,6}, Lea Borgi⁷, Walter C. Willett^{1,2,8}, JoAnn E. Manson^{9,10}, Qi Sun^{1,2}, Frank B. Hu^{1,2,3}

- Nurses' Health Study 1 & 2, Health Professionals Follow-Up Study; 4.1 million person-years of follow-up
- Plant-based diet index (PDI): high in all plant foods, low in animal foods
 - **Healthy PDI**: high in whole grains, fruits, vegetables, nuts, legumes, vegetable oils, tea & coffee
 - **Unhealthy PDI**: high in fruit juice, refined grains, fried potatoes & chips, sugar-sweetened beverages, sweets/desserts

Satija et al. Plant-Based Dietary Patterns and Incidence of Type 2 Diabetes in US Men and Women: Results from Three Prospective Cohort Studies. *PLoS Med*. 2016 Jun 14;13(6):e1002039






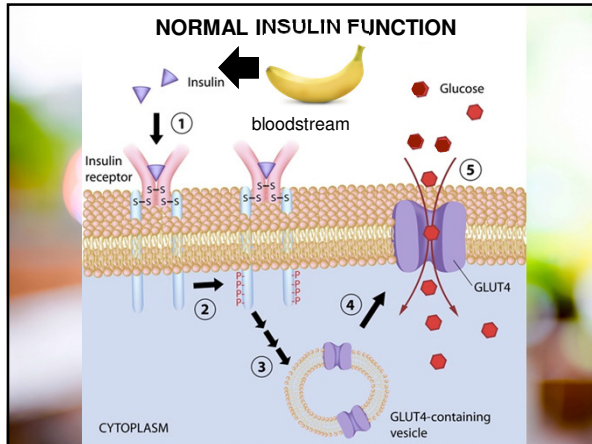
Risk of type 2 diabetes*

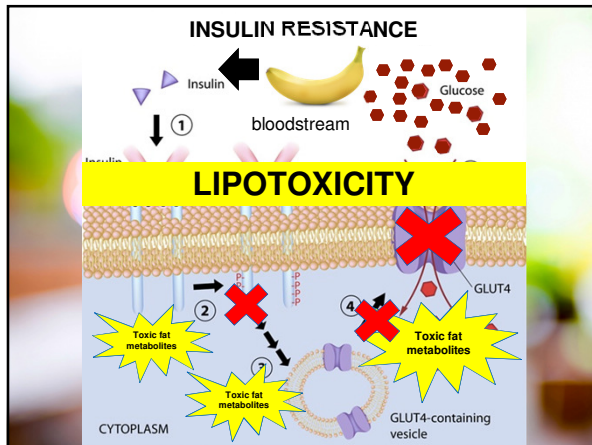
- OVERALL plant-based pattern: **20% ↓ risk**
- Healthy plant-based pattern: **34% ↓ risk**
- Unhealthy plant-based pattern: **16% ↑ risk**

*Multivariate adjusted model, including BMI, age, smoking, exercise, alcohol, fam hx, energy intake & other risk factors

Satija et al. Plant-Based Dietary Patterns and Incidence of Type 2 Diabetes in US Men and Women: Results from Three Prospective Cohort Studies. *PLoS Med*. 2016 Jun 14;13(6):e1002039







THE NEW ENGLAND JOURNAL OF MEDICINE

REVIEW ARTICLE

Dan L. Longo, M.D., Editor

Ectopic Fat in Insulin Resistance, Dyslipidemia, and Cardiometabolic Disease

Gerald I. Shulman, M.D., Ph.D.

Fat accumulation in skeletal muscle & liver cells (ectopic fat) is a primary cause of insulin resistance

- Skeletal muscle: decreased glucose uptake
- Liver: decreased glycogen synthesis, increased gluconeogenesis

24 Shulman GI. Ectopic fat in insulin resistance, dyslipidemia, and cardiometabolic disease. *N Engl J Med*. 2014 Sep 18;371(12):1131-41.

THE NEW ENGLAND JOURNAL OF MEDICINE

REVIEW ARTICLE

Dan L. Longo, M.D., Editor

Ectopic Fat in Insulin Resistance, Dyslipidemia, and Cardiometabolic Disease

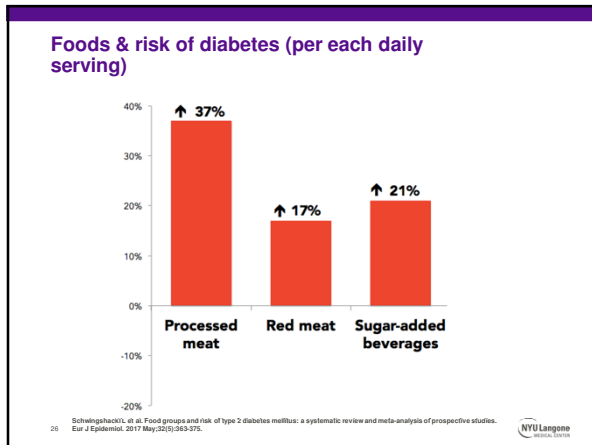
Gerald I. Shulman, M.D.

Fat accumulation in skeletal muscle and liver is a primary cause of insulin resistance and dyslipidemia.

- Skeletal muscle: decreased glucose uptake
- Liver: decreased glycogen synthesis and gluconeogenesis

Adiposity
Excess calories
Excess dietary fat
Inflammation
Oxidative stress
Mitochondrial dysfunction

25 Shulman GI. Ectopic fat in insulin resistance, dyslipidemia, and cardiometabolic disease. *N Engl J Med*. 2014 Sep 18;371(12):1311-41. NYU Langone Medical Center



Red meat consumption and risk of type 2 diabetes: 3 cohorts of US adults and an updated meta-analysis¹⁻³ *Am J Clin Nutr* 2011

An Pan, Qi Sun, Adam M Bernstein, Matthias B Schulz, Johan E Manson, Walter C Willet, and Frank B Hu

Meat Consumption as a Risk Factor for Type 2 Diabetes

Neal Barnard¹, Susan Levin^{2*} and Caroline Trapp² *Nutrients* 2014, 6, 897-910

Associations between red meat intake and biomarkers of inflammation and glucose metabolism in women¹⁻³ *Am J Clin Nutr* 2014

Sylvia H Lee, Qi Sun, Walter C Willett, A Heather Eliasson, Kiana Wu, An Pan, Fran Grodstein, and Frank B Hu

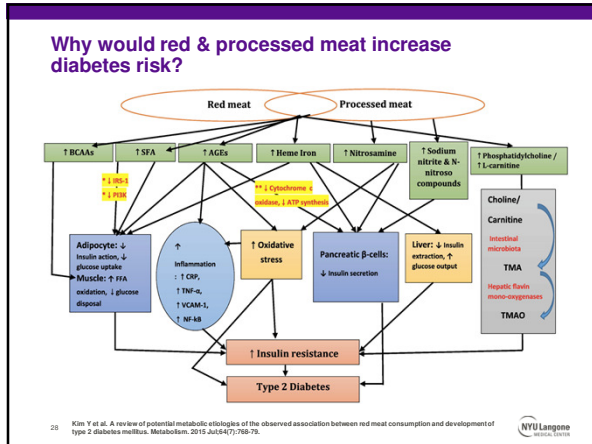
Meat consumption and the risk of type 2 diabetes: a systematic review and meta-analysis of cohort studies

D. Anne C. Ursin¹, M. R. Veierød² *Diabetologia* 2009

Original Investigation
Changes in Red Meat Consumption and Subsequent Risk of Type 2 Diabetes Mellitus: Three Cohorts of US Men and Women
JAMA Int Med 2013

Association between dietary meat consumption and incident type 2 diabetes: the EPIC-InterAct study
Diabetologia 2013

The InterAct Consortium NYU Langone Medical Center



Dietary Protein Intake and Incidence of Type 2 Diabetes in Europe: The EPIC-InterAct Case-Cohort Study

- 22% increased risk for highest quintile of protein intake (109g/day), adjusted for BMI & other risk factors
- Association attributed to animal protein

Van Heelen M et al. Dietary protein intake and incidence of type 2 diabetes in Europe: the EPIC-INTERACT case-cohort study. *Diabetes Care* 2014 Jul;37(7):1854-62. NYU Langone

American Journal of Epidemiology
 © The Author 2016. Published by Oxford University Press on behalf of the Johns Hopkins Bloomberg School of Public Health. All rights reserved. For permissions, please email: journals.permissions@oup.com
 Vol. 183, No. 8
 DOI: 10.1093/aje/kwv268
 Advance Access publication: March 28, 2016

Original Contribution

Dietary Protein Intake and Risk of Type 2 Diabetes in US Men and Women
 Vasanti S. Malik*, Yanping Li, Deirdre K. Tobias, An Pan, and Frank B. Hu


- 4.1 million person-years of follow up
- Highest quintile of animal protein: 13% ↑ risk of diabetes
- Substituting 5% of calories from plant protein in lieu of animal protein: 23% ↓ risk of diabetes

Malik VS. Dietary Protein Intake and Risk of Type 2 Diabetes in US Men and Women. *Am J Epidemiol*. 2016 Apr 15;183(8):715-28. NYU Langone

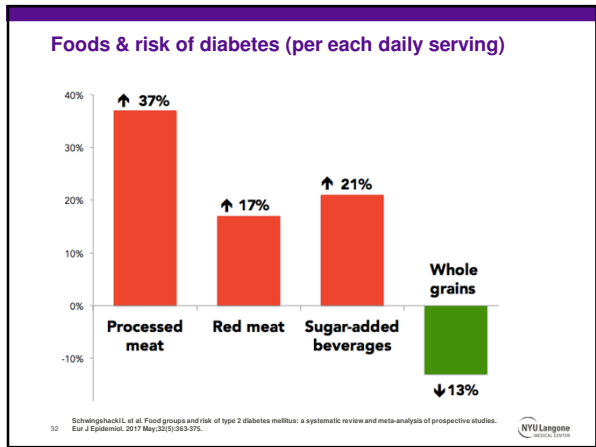
Effect of Replacing Animal Protein with Plant Protein on Glycemic Control in Diabetes: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

Effie Vigiouliouk^{1,2}, Sarah E. Stewart^{1,2}, Viranda H. Jayalath^{1,3,4}, Alena Praneet Ng¹, Arash Mirrahimi^{1,5}, Russell J. de Souza^{1,2,6}, Anthony J. Hanley^{2,7,8,9}, Richard P. Bazinet², Sonia Blanco Mejia^{1,2}, Lawrence A. Leiter^{1,2,8,10,11}, Robert G. Josse^{1,2,8,10,11}, Cyril W.C. Kendall^{1,2,12}, David J.A. Jenkins^{1,2,9,10,11} and John L. Sievenpiper^{1,2,10,11,*}

In patients with diabetes:
 Replacing ≈35% of total protein with plant instead of animal protein **significantly lowered HbA1c, fasting glucose, & fasting insulin** compared to control arms.




Vigiouliouk E et al. Effect of Replacing Animal Protein with Plant Protein on Glycemic Control in Diabetes: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Nutrients. 2018 Dec 1;7(12):2004-24.



Whole grains lower diabetes risk: effect of cereal fiber

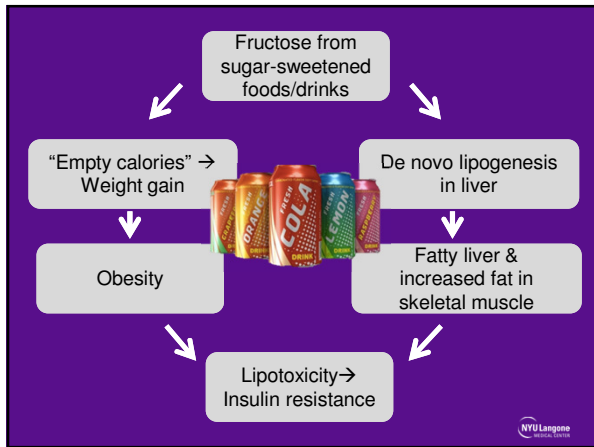
Improves postprandial glucose response
 Lowers calorie density
 Increases satiety
 Metabolized by gut bacteria to form *short-chain fatty acids*

- > Increase GLP1
- > Increase insulin sensitivity
- > Regulate cytokines to decrease inflammation
- > Improve mitochondrial function



NYU Langone Medical Center






RESEARCH ARTICLE

Fresh fruit consumption in relation to incident diabetes and diabetic vascular complications: A 7-y prospective study of 0.5 million Chinese adults

Huaidong Du^{1,2*}, Liming Li^{3,4*}, Derrick Bennett², Yu Guo⁵, Iain Turnbull⁶, Ling Yang^{1,2}, Fiona Bragg⁷, Zheng Bian¹, Yiping Chen^{1,2}, Junshi Chen⁸, Iona Y. Millwood^{1,2}, Sam Sansome², Liangcai Ma⁹, Ying Huang⁹, Ningmei Zhang², Xiangyang Zheng¹, Qiang Sun¹⁰, Timothy J. Key¹¹, Rory Collins², Richard Peto², Zhengming Chen², China Kadoorie Biobank study¹

- >500,000 adults followed for 7 yrs
- Daily fruit consumption: 12% lower risk of diabetes
- In those who had diabetes at baseline, 3x/wk fruit **lowered**
 - All-cause mortality by 17%
 - Microvascular complications by 28%
 - Macrovascular complications by 13%




Du H et al. Fresh fruit consumption in relation to incident diabetes and diabetic vascular complications: A 7-y prospective study of 0.5 million Chinese adults. *PLoS Med*. 2017 Apr 11;14(4):e1002276.



Macronutrients & risk of diabetes

- Carbohydrates: tend to be highly protective in whole or minimally processed foods (whole grains, legumes, whole fruits, root vegetables)
- Protein: plant sources protective, animal sources increase risk
- Fats: saturated fats promote insulin resistance; unsaturated fats decrease risk compared with saturated fats

38 

Low-carb diets can *increase* the risk of diabetes...

- Bao et al, Diabetes Care 2016
- de Koning et al, Am J Clin Nutr 2011
- Schulze et al, Br J Nutr 2008



...and do not improve glycemic control over the long-term

- Snorgaard et al, BMJ Open Diabetes Res Care 2017
- van Wyk et al, Diabet Med 2016



What I'll cover...

- ✓ • What is a plant-based diet?
- ✓ • Guidelines & nutrient considerations
- ✓ • Prevention of type 2 diabetes
- Treatment of type 2 diabetes ←
- Reduction of diabetes-related complications
- Mechanisms of action
- Practical applications & resources

NYU Langone

High-carbohydrate, high-fiber diet for insulin-treated men with diabetes mellitus^{1, 2}

James W. Anderson, M.D. and Kylene Ward, R.D.

ABSTRACT The effects of high-carbohydrate, high-fiber diet on the lipid metabolism of 20 lean men receiving insulin therapy on a metabolic ward. All men received control diets for 16 days, followed by a high-carbohydrate, high-fiber diet for an average of 16 days. Diets were designed to provide similar energy and protein but with significant alterations in body weight. The daily dose of insulin was reduced on the HCF diet than on the control diet. The average insulin dose (mean ± SEM) on the control diets to 11 ± 3 (P < 0.05) insulin therapy could be discontinued in nine patients receiving 32 units/day. Fasting and 3-hr postprandial glucose levels were lower in most patients on the HCF diets than on the control diets. Cholesterol values dropped from 206 ± 10 mg/dl on the control diet to 147 ± 5 mg/dl on the HCF diet; average fasting serum triglyceride values were not significantly altered on the HCF diet. These studies suggest that HCF diets may be the dietary therapy of choice for certain patients with the maturity-onset type of diabetes. *Am. J. Clin. Nutr.* 32: 2312-2321, 1979.

Key findings:

- 20 men with T2DM on insulin
- Metabolic ward: vegetarian diet x 16 days
 - high carb, low fat, high fiber (65g/day)
- 9 of 20 patients stopped insulin
- Insulin reduced: 26 ± 3 units/day → 11 ± 3 units / day
- Fasting & post prandial glucose levels decreased significantly
- Cholesterol 206 ± 10 mg/dL → 147 ± 5

NYU Langone

A Low-Fat Vegan Diet Improves Glycemic Control and Cardiovascular Risk Factors in a Randomized Clinical Trial in Individuals With Type 2 Diabetes

Niall D. Barnard, MD^{1,2}, Bruce J. Bantle, MD¹, Jennifer Conroy, MD¹, David J.A. Jenkins, MD, PhD³, Corbett E. Tanabe-McCarty, MS, RD⁴, Lisa Goette, MS, RD⁵, Bruce J. Bantle, MD¹, Ross S. Klein, MD, PhD¹, Anitha A. Gurusamy, MD¹, Stanley H. Taylor, MD¹

22-wk RCT; 99 patients with type 2 diabetes, a1c 6.5-10.5%

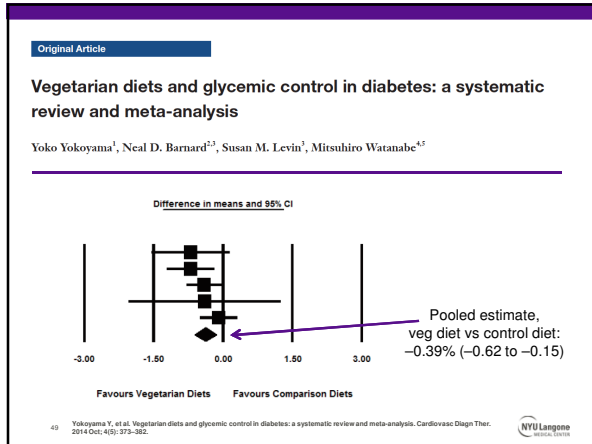
Intervention diet: vegetables, fruits, grains, legumes

- 10% fat, 15% protein, 75% carbohydrate
- Avoid animal products and added fats
- Favor low-glycemic index foods (green vegetables, legumes); no energy/portion restriction

Control diet: conventional diet based on 2003 ADA guidelines

- <7% saturated fat; 15-20% protein, 60-70% carbohydrate
- Individualized based on body weight; prescribed deficit of 500-1000kcal/day

NYU Langone



A Story from My Practice...

Jaime, 42 years old
Poorly controlled type 2 diabetes
BMI 23

A1c 12.7
LDL cholesterol 145

A Story from My Practice...

After 4 months of a whole-food plant-based diet:

A1c 12.7→6.9
LDL 145→105

What I'll cover...

- ✓ • What is a plant-based diet?
- ✓ • Guidelines & nutrient considerations
- ✓ • Prevention of type 2 diabetes
- ✓ • Treatment of type 2 diabetes
 - Reduction of diabetes-related complications ←
 - Mechanisms of action
 - Practical applications & resources

NYU Langone

A plant-based diet reduces cardiovascular risk

	Ischemic Heart Disease (vs nonvegetarians)
Key et al (Am J Clin Nutr 1999, n>76,000)	↓ 24% (mortality)
Huang et al (Ann Nutr Metab 2012, n>124,000)	↓ 29% (mortality)
Crowe et al (Am J Clin Nutr 2013, n>44,000)	↓ 32% (incident cases)

Clin Nutr 1999;79:630-635
Huang T et al. Cardiovascular disease mortality and cancer incidence in vegetarians: a meta-analysis and systematic review. Ann Nutr Metab 2012;20:222-231
Crowe FL, Appleby PN, Travis RC, Key TJ. Risk of hospitalization or death from ischemic heart disease among British vegetarians and nonvegetarians: Results from the EPIC-Oxford cohort study. Am J Clin Nutr. 2013;97(3):597-603

NYU Langone

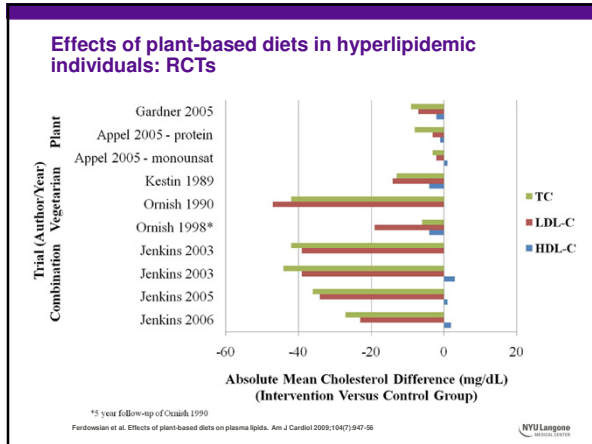
Healthful and Unhealthful Plant-Based Diets and the Risk of Coronary Heart Disease in U.S. Adults

Ambika Satija, ScD,¹ Shilpa N. Bhupathiraju, PhD,^{1,2} Donna Spiegelman, ScD,^{3,4,5,6,7} Stephanie E. Chiuve, ScD,⁸ JoAnn E. Manson, MD, DrPH,^{9,10} Walter Willett, MD, DrPH,^{1,2,3,4,5,6,7} Kathryn M. Rexrode, MD, MPH,¹¹ Eric B. Rimm, ScD,^{1,2,3,4,5,6,7} Frank B. Hu, MD, PhD^{1,2,3,4,5,6,7}

- Nurses' Health Study 1 & 2, Health Professionals Follow-Up Study; 4.8 million person-years of follow-up
- Plant-based diet index (PDI): high in all plant foods, low in animal foods
 - **Healthy PDI:** high in whole grains, fruits, vegetables, nuts, legumes, vegetable oils, tea & coffee
 - **Unhealthy PDI:** high in fruit juice, refined grains, fried potatoes/chips, sugar-sweetened beverages, sweets/desserts

Satija et al. Healthful and unhealthful plant-based diets and the risk of coronary heart disease in US adults. J Am Coll Cardiol 2017;70(4):411-422.

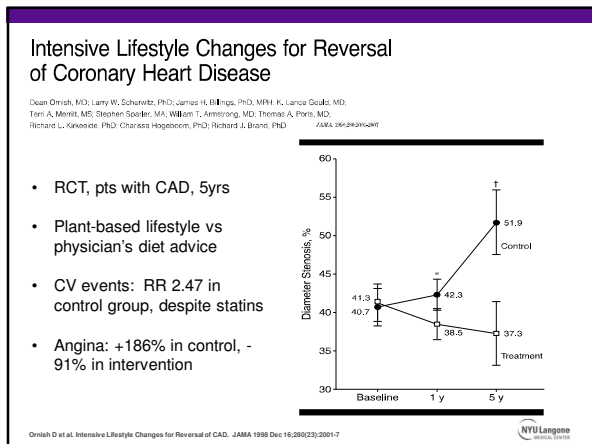
NYU Langone



Effects of plant-based diets in hyperlipidemic individuals: RCTs

	DECREASE IN TOTAL & LDL CHOLESTEROL
Semi-veg diet, Lacto-ovo veg diet	10 – 15%
Vegan diet	15 – 20%
Veg w added fiber/soy/nuts	20 – 35%

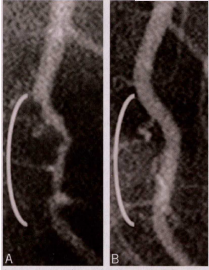
Ferdowsian et al. Effects of plant-based diets on plasma lipids. Am J Cardiol 2009;104(7):947-56



Caldwell B. Esselstyn Jr, MD; Gina Gendy, MD; Jonathan Doyle, MCS; Miladen Golubic, MD, PhD; Michael F. Roizen, MD

ORIGINAL RESEARCH


A way to reverse CAD?



- 198 patients with established coronary artery disease
- Whole foods, plant-based diet
- 177 pts adherent (89%)
- 3.7 yrs of follow-up
- CV event rate:
 - 0.6% among adherent pts
 - 62% among nonadherent

Coronary angiography reveals a diseased distal left anterior descending artery (A). Following 32 months of a plant-based nutritional intervention without cholesterol-lowering medication, the artery regained its normal configuration (B).

Esselstyn CB et al. A Way to Reverse CAD? J Fam Pract 2014 Jul;63(7):398-399



How does a plant-based diet reduce cardiovascular risk?

- Lower blood pressure, lipids, insulin resistance, body weight



65



How does a plant-based diet reduce cardiovascular risk?

- Lower blood pressure, lipids, insulin resistance, body weight
- Replace or "crowd out" disease-promoting foods



66




JAMA Internal Medicine | Original Investigation

Association of Animal and Plant Protein Intake With All-Cause and Cause-Specific Mortality

Mingyang Song, MD, ScD; Teessa T. Fung, ScD; Frank B. Hu, MD, PhD; Walter C. Willett, MD, DrPH; Walter D. Longo, PhD; Andrew L. Chan, MD, MPH; Edward L. Giovannucci, MD, ScD

- Higher ANIMAL protein intake associated with higher CV mortality
- Higher PLANT protein intake associated with lower CV and all-cause mortality
- Among those with ≥1 risk factor, replacing animal protein with plant protein (just 3% of calories) lowered mortality by
 - 34% for processed red meat
 - 19% for eggs (including 17% decrease in cancer death)
 - 12% for unprocessed red meat
 - 8% for dairy
 - 6% for poultry & fish

Song M et al. Association of Animal and Plant Protein Intake With All-Cause and Cause-Specific Mortality. JAMA Intern Med. 2016 Oct 1;136(10):1423-1433.




Intake of individual saturated fatty acids and risk of coronary heart disease in US men and women: two prospective longitudinal cohort studies

Geng Zong,¹ Yanping Li,¹ Anne J Wanders,² Marjan Alsema,² Peter L Zock,² Walter C Willett,³ Frank B Hu,¹ Qi Sun⁴

- Individual & combined saturated fats associated with higher risk of CHD (HR 1.18 for highest vs lowest intake, multivariate model)
- Lower risk of CHD when saturated fats replaced with
 - Polyunsaturated fats
 - Whole grains
 - Plant protein

Zong G et al. Intake of individual saturated fatty acids and risk of coronary heart disease in US men and women: two prospective longitudinal cohort studies. BMJ. 2016 Nov 23;353:g7195.



How does a plant-based diet reduce cardiovascular risk?

- Lower blood pressure, lipids, insulin resistance, body weight
- Replace or “crowd out” disease-promoting foods
- Reduce LDL oxidation via polyphenols/antioxidants




69



How does a plant-based diet reduce cardiovascular risk?


- Lower blood pressure, lipids, insulin resistance, body weight
- Replace or “crowd out” disease-promoting foods
- Reduce LDL oxidation via polyphenols/antioxidants
- Improve endothelial function




70 

How does a plant-based diet reduce cardiovascular risk?

- Lower blood pressure, lipids, insulin resistance, body weight
- Replace or “crowd out” disease-promoting foods
- Reduce LDL oxidation via polyphenols/antioxidants
- Improve endothelial function
- Decrease inflammation



71 

How does a plant-based diet reduce cardiovascular risk?

- Lower blood pressure, lipids, insulin resistance, body weight
- Replace or “crowd out” disease-promoting foods
- Reduce LDL oxidation via polyphenols/antioxidants
- Improve endothelial function
- Decrease inflammation
- Beneficially alter gut microbiota & their metabolites



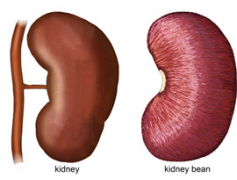
72 

Plant protein and chronic kidney disease

Diet and Diabetic Kidney Disease: Plant Versus Animal Protein

Ranjani N. Moorthi¹ · Colby J. Vorland² · Kathleen M. Hill Gallant²

- "Dietary patterns that focus on plant-based foods...may be useful in prevention of diabetic kidney disease progression."
- In RCTs, soy protein decreases urinary albumin compared with animal protein
- TMAO is hypoexcreted in CKD & may directly affect progression of renal disease



Moorthi RN et al. Diet and Diabetic Kidney Disease: Plant Versus Animal Protein. Curr Diab Rep. 2017 Mar;17(3):15.
Tang WH et al. Trimethylamine N-Oxide as a Novel Therapeutic Target in CKD. J Am Soc Nephrol. 2016 Jan;27(1):8-16.

NYU Langone

ORIGINAL ARTICLE

A dietary intervention for chronic diabetic neuropathy pain: a randomized controlled pilot study

AE Bunner¹, CL Wells¹, J Gonzales¹, U Agarwal², E Bayat³ and ND Barnard^{1,4}

- Pilot RCT, 20 weeks
- Low-fat plant-based diet + B12, vs usual diet + B12
- Plant-based diet demonstrated significant improvements vs usual diet:
 - Electrochemical skin conductance in feet
 - Pain scores (McGill Pain Questionnaire)
 - Neuropathy scores (Michigan Neuropathy Screening Instrument)
- Plant-based group lost 7.0 kg & reduced A1c by 0.8% even with lower medication doses

Bunney AE et al. A dietary intervention for chronic diabetic neuropathy pain: a randomized controlled pilot study. Nutr Diabetes. 2015 May 20;5:e105.

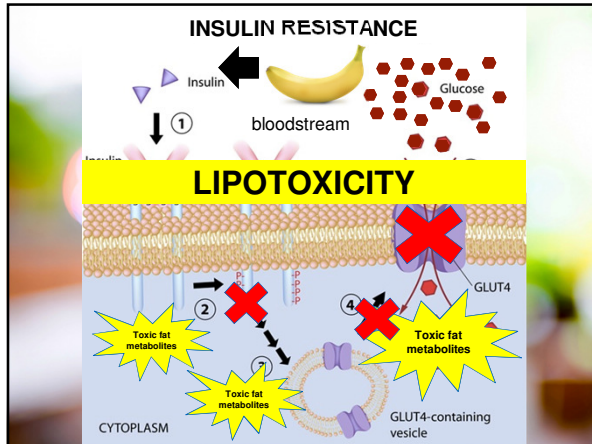
NYU Langone

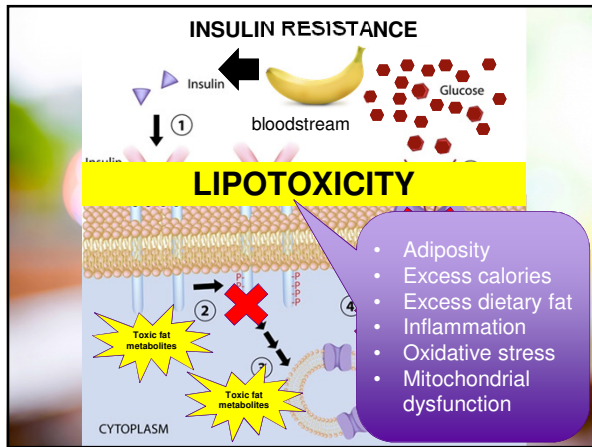
What I'll cover...

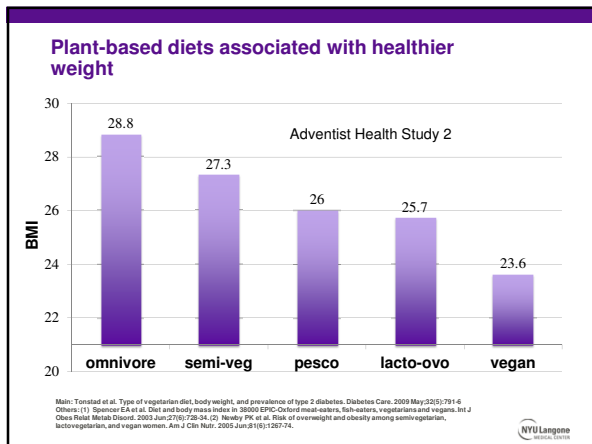
- ✓ • What is a plant-based diet?
- ✓ • Guidelines & nutrient considerations
- ✓ • Prevention of type 2 diabetes
- ✓ • Treatment of type 2 diabetes
- ✓ • Reduction of diabetes-related complications
 - Mechanisms of action ←
 - Practical applications & resources

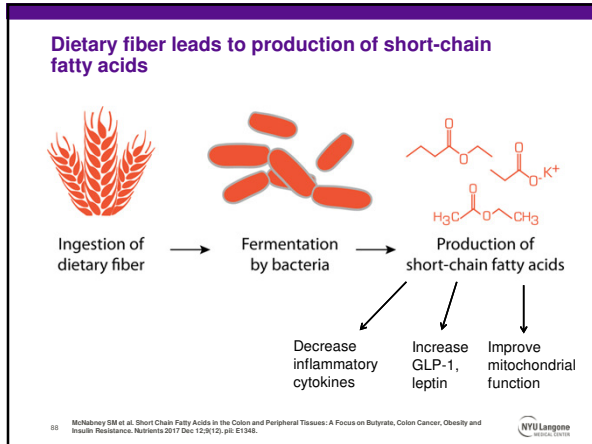
78

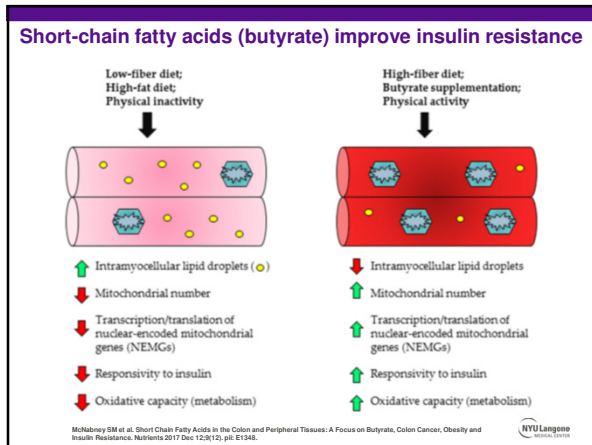
NYU Langone

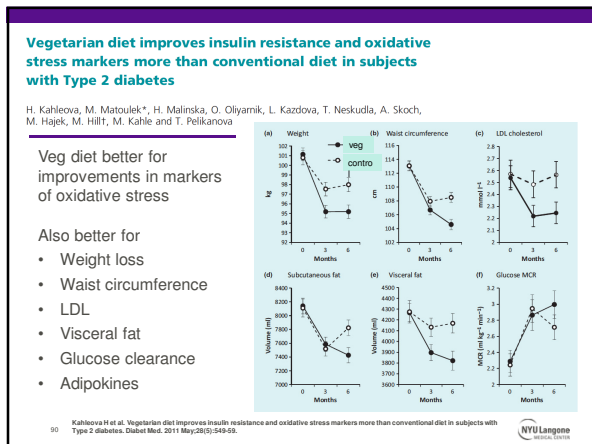












Vegetarian diet improves insulin resistance and oxidative stress markers more than conventional diet in subjects with Type 2 diabetes

H. Kahleova, M. Matsuoka*, H. Malinska, O. Oliyarnik, L. Kazdova, T. Neskedlova, A. Skoch, M. Prochazka, M. Hill, A. Kahleova and T. Poth-Ussakova

Our data suggest that a vegetarian diet leads to a complex improvement of enzymatic and non-enzymatic oxidative stress markers. Both enzymatic and non-enzymatic antioxidant defence mechanisms work in synergy against different types of free radicals [25], which play a major role in the development and progression of diabetes and its complications [26].

- Visceral fat
- Glucose clearance
- Adipokines

Kahleova H et al. Vegetarian diet improves insulin resistance and oxidative stress markers more than conventional diet in subjects with Type 2 diabetes. *Diabet Med.* 2011 May;28(5):549-59.

Article

A Plant-Based Dietary Intervention Improves Beta-Cell Function and Insulin Resistance in Overweight Adults: A 16-Week Randomized Clinical Trial

Hana Kahleova ^{1,*}, Andrea Tura ², Martin Hill ³, Richard Holubkov ⁴ and Neal D. Barnard ^{1,5}

- RCT: low-fat plant-based diet vs control (no diet changes) in overweight adults (n=75)
- Plant-based group vs control:
 - Decrease in basal insulin secretion
 - Marked increase in meal-stimulated insulin secretion (p<0.001)
 - Increase in beta-cell glucose sensitivity
 - Decrease in fasting insulin resistance (HOMA-IR) (p<0.001) & postprandial glucose

Kahleova H et al. A Plant-Based Dietary Intervention Improves Beta-Cell Function and Insulin Resistance in Overweight Adults: A 16-Week Randomized Clinical Trial. *Nutrients.* 2018 Feb 8;10(2).

Low-Carb High-Fat Diets

POSSIBLE BENEFITS	MAJOR CONCERNS
<ul style="list-style-type: none"> • Avoids added sugar & refined grains • Short-term weight loss • Short-term glycemic improvements in persons with diabetes 	<ul style="list-style-type: none"> • Limited evidence; most studies short-term, w intermediate markers • Worsened oral glucose tolerance in short-term studies • High saturated fat; LDL can increase or at best stay stable • May increase risk of CV disease, cancer, premature death like other low-carb diets • Can be low in fiber & restricts very healthful foods: whole grains, beans, most fruits • Unclear if sustainable in long-term

Numao S, et al. *Eur J Clin Nutr.* 2012;66:926-931.
Lagiou P, et al. *BMJ.* 2012;344:e4026.
Norris H, et al. *PLoS One.* 2013;8:e59030

Resources for clinicians

- Trapp C et al. Preparing to prescribe plant-based diets for diabetes prevention and treatment. *Diabetes Spectrum* 2012;25:38-44.
- Hever J. Plant-based diets: a physician's guide. *Perm J.* 2016;20:93-101.
- Position of the Academy of Nutrition and Dietetics: Vegetarian Diets. *J Acad Nutr Dietetics* 2016. Available at EatRightPro.org
- Vegetarian Nutrition Dietetic Practice Group, VegetarianNutrition.net
- PCRM's Nutrition Guide for Clinicians (free online site & app; nutritionguide.pcrm.org)
- American Association of Diabetes Educators, Plant-Based Nutrition Community of Interest, myadenetwork.org/cois
- VeganHealth.org, BecomingVegan.ca, TheVeganRD.com

97



Resources for patients – free of charge

- The Power Plate: ThePowerPlate.org
- Physicians Committee for Responsible Medicine (PCRM) diabetes resources, pcrm.org/health/diabetes-resources (free)
- 21DayKickstart.org (Eng/Sp/Chinese/Indian/Japanese)
- Tackling diabetes with a bold new dietary approach: Neal Barnard at TEDxFremont (video at TED.com)
- The Plant-Based Diet Booklet (Kaiser Permanente; free online)
- Quick Start Guide to Plant-Based Nutrition, PlanticianProject.org/quickstartguide (free download; Eng/Sp)
- ForksOverKnives.com (recipes, testimonials, expert content)
- Chickpeaandbean.com (recipes, events; Eng/Sp)

98



Resources for patients – films, books, coaching, etc

- *Dr. Neal Barnard's Program for Reversing Diabetes*, Revised Edition, 2018 (book)
- *Forks Over Knives* (film, 2011)
- *The Forks Over Knives Plan: A 4-Week Meal-by-Meal Makeover*, Alona Pulde MD & Matthew Lederman MD (book, 2017)
- Food for Life cooking classes: FFLclasses.org
- *Prevent & Reverse Heart Disease*, Caldwell Esselstyn MD (book, 2007)
- *The End of Diabetes: The Eat to Live Plan to Prevent and Reverse Diabetes*, Joel Fuhrman MD (book, 2014)
- *Becoming Vegan*, Brenda Davis RD & Vesanto Melina MS RD (book, 2014)
- MasteringDiabetes.org (online coaching, group support, recipes)

99



THANK YOU