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
What is a plant-based diet?

Types of plant-based diets

<table>
<thead>
<tr>
<th>Vegetarian</th>
<th>No red meat, poultry, or seafood. May include dairy and/or eggs, refined grains, added sugar, &amp; oils.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegan</td>
<td>No animal products. Only plant foods. May include refined grains, added sugar, &amp; oils.</td>
</tr>
</tbody>
</table>

Whole-foods, plant-based diet

<table>
<thead>
<tr>
<th>Food group</th>
<th>Recommended servings per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables, all types, including starch</td>
<td>4-6 servings (1 serving = 1 medium piece or 1/2 cup)</td>
</tr>
<tr>
<td>Fruit, all types</td>
<td>2-4 servings (1 serving = 1 medium piece or 1/2 cup)</td>
</tr>
<tr>
<td>Whole grains (e.g., quinoa, brown rice, oats)</td>
<td>5-11 servings (1 serving = 1/2 cup cooked or 1 slice whole grain bread)</td>
</tr>
<tr>
<td>Legumes (beans, peas, lentils, soy foods)</td>
<td>2-3 servings (1 serving = 1/2 cup cooked)</td>
</tr>
<tr>
<td>Leafy green vegetables (e.g., kale, lettuce, broccoli)</td>
<td>4-8 servings (1 serving = 1 cup raw or 1/2 cup cooked)</td>
</tr>
<tr>
<td>nuts (e.g., walnuts, almonds, pine nuts)</td>
<td>1-2 servings</td>
</tr>
<tr>
<td>Seeds (e.g., chia, hemp, and flax seeds)</td>
<td>1-3 tablespoons</td>
</tr>
<tr>
<td>Fortified plant milks (e.g., soy, almond, cashew)</td>
<td>Options; 1-2 cups</td>
</tr>
<tr>
<td>Fresh herbs and spices</td>
<td>Options; ad libitum</td>
</tr>
</tbody>
</table>
It’s not just salad all day

<table>
<thead>
<tr>
<th>Food group</th>
<th>Recommended serving per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruits</td>
<td>1 1/2 cups</td>
</tr>
<tr>
<td>Vegetables (except potatoes)</td>
<td>2 1/2 cups</td>
</tr>
<tr>
<td>Legumes (beans, peas, lentils, soy foods)</td>
<td>3 1/2 cups</td>
</tr>
<tr>
<td>Oils (avocado, nuts, seeds)</td>
<td>1 1/2 tbsp</td>
</tr>
<tr>
<td>Milk (fat-free)</td>
<td>1 cup</td>
</tr>
<tr>
<td>Refined grains (rice, pasta, bread)</td>
<td>3 1/2 cups</td>
</tr>
</tbody>
</table>

Plant-based diets in guideline recommendations

Dietary Guidelines for Americans, 2015
Healthy Vegetarian Eating Pattern; can be vegan

Academy of Nutrition and Dietetics, 2016
“Appropriately planned vegetarian, including vegan, diets are healthful, nutritionally adequate, and may provide health benefits for the prevention and treatment of certain diseases. These diets are appropriate for all stages of the life cycle, including pregnancy, lactation, infancy, childhood, adolescence, older adulthood, and for athletes.”

American Diabetes Association, 2018
“A variety of eating patterns are acceptable for the management of type 2 diabetes and prediabetes, including plant-based diets.”

American Association of Clinical Endocrinologists, 2018
“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.”
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.”


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

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 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

“Pleiotropic” benefits of a plant-based diet

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

Observational studies
- Adventist Health Studies
- Taiwanese Buddhists
- Nurses Health Study & Health Professionals Follow-Up Study

Foods and diabetes risk
- Underlying mechanisms
- Foods that increase risk
- Protective foods
- Macronutrients (carbs/protein/fat)

Odds of having type 2 diabetes, Adventist Health Study 2

![](chart.png)
Incidence of type 2 diabetes, Adventist cohorts

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample Size</th>
<th>Duration</th>
<th>Vegans:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tonstad et al</td>
<td>n=41,387</td>
<td>2 years</td>
<td>62% decreased risk of DM2 vs omnivores *Adjusted for BMI</td>
</tr>
<tr>
<td>Vang et al</td>
<td>n=8401</td>
<td>17 years</td>
<td>Omnivores eating meat ≥ once a week:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>34% increased risk of DM2 vs vegans *Adjusted for BMI</td>
</tr>
</tbody>
</table>

Incidence of type 2 diabetes, Adventist cohorts

- 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


Vang A et al. Meats, processed meats, obesity, weight gain and occurrence of diabetes among adult findings from Adventist Health Studies. Ann Nutr Metab 2008;52(2):96-104
Vegetarian diet, change in dietary patterns, and diabetes risk: a prospective study

Prospective study of 2918 Taiwanese Buddhists; 5-year follow-up

- 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.)

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

- 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

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
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
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 and increased gluconeogenesis

Adiposity, excess calories, excess dietary fat, inflammation, oxidative stress, and mitochondrial dysfunction are associated with increased risk of diabetes.

Foods & risk of diabetes (per each daily serving):

- Processed meat: 37%
- Red meat: 17%
- Sugar-added beverages: 21%

Meat Consumption as a Risk Factor for Type 2 Diabetes

Neal Barnard, Susan Levin, and Caroline Trapp

Nutrients 2014; 6, 897-910

Am J Clin Nutr 2011

Diabetologia 2009

JAMA Intern Med 2013

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

Nutrients 2010

Changes in red meat consumption and subsequent risk of type 2 diabetes mellitus: three cohorts of US men and women

NASPIT Med 2013

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

Diabetologia 2015
Why would red & processed meat increase diabetes risk?

- Kim Y et al. A review of potential metabolic etiologies of the observed association between red meat consumption and development of type 2 diabetes mellitus. Metabolism. 2015 Jul;64(7):768-79.
- 22% increased risk for highest quintile of protein intake (109g/day), adjusted for BMI & other risk factors
- Association attributed to animal protein

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

Original Contribution

Dietary Protein Intake and Risk of Type 2 Diabetes in US Men and Women

- 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
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.


Foods & risk of diabetes (per each daily serving)


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


- >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%
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

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
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---

**High-carbohydrate, high-fiber diet in insulin-treated men with diabetes mellitus**


ABSTRACT The effects of high-carbohydrate, high-fiber diets on insulin requirements and metabolic control were studied in 20 men with insulin-treated diabetes mellitus. All men received a 5-day control diet followed by a metabolic ward. All men received a 5-day control diet followed by a metabolic ward. Metabolic control was assessed by measuring plasma glucose, insulin, and lipids. The study diet was a high-carbohydrate, high-fiber diet. The results showed that the metabolic control of diabetes was improved by the high-carbohydrate, high-fiber diet.

- 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
- Fasting & post prandial glucose levels decreased significantly
- Cholesterol 206 + 10 mg/dL → 147 + 5

---

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


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 500-1000 kcal/day
### A Low-Fat Vegan Diet Improves Glycemic Control and Cardiovascular Risk Factors in a Randomized Clinical Trial in Individuals With Type 2 Diabetes


<table>
<thead>
<tr>
<th></th>
<th>Vegan</th>
<th>Conventional</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1c – overall</td>
<td>-1.0%</td>
<td>-0.6%</td>
<td>0.09</td>
</tr>
<tr>
<td>A1c – meds stable</td>
<td>-1.23%</td>
<td>-0.38%</td>
<td>0.01</td>
</tr>
<tr>
<td>Body weight</td>
<td>-0.5 kg</td>
<td>-3.1 kg</td>
<td>0.001</td>
</tr>
<tr>
<td>LDL – meds stable</td>
<td>-22.8 mg/dl</td>
<td>-10.7 mg/dl</td>
<td>0.02</td>
</tr>
<tr>
<td>Microalbuminuria</td>
<td>-18.4 mg/dl</td>
<td>-11.3 mg/dl</td>
<td>0.01*</td>
</tr>
</tbody>
</table>

*adjusted for baseline values

### A low-fat vegan diet and a conventional diabetes diet in the treatment of type 2 diabetes: a randomized, controlled, 74-wk clinical trial


<table>
<thead>
<tr>
<th></th>
<th>Vegan</th>
<th>Conventional</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1c – overall</td>
<td>-0.34%</td>
<td>-0.14%</td>
<td>0.43</td>
</tr>
<tr>
<td>A1c – meds stable</td>
<td>-0.40%</td>
<td>+0.01</td>
<td>0.03</td>
</tr>
<tr>
<td>Body weight</td>
<td>-4.4 kg</td>
<td>-3.0 kg</td>
<td>0.25</td>
</tr>
<tr>
<td>LDL – meds stable</td>
<td>-13.5 mg/dl</td>
<td>-3.4 mg/dl</td>
<td>0.03</td>
</tr>
</tbody>
</table>

*adjusted for baseline values

### Key points

- **Medication reductions common (hypoglycemia):**
  - At 22wks: 43% of vegan, 26% of conventional
  - At 74wks: 35% vs 20%

- In both groups, A1c improvements mediated primarily by weight loss

- Both groups lowered calories by ≈425 kcal/day, but via different mechanisms:
  - Vegan group: no explicit calorie restrictions. Increased fiber, lower fat, lower calorie density
  - Conventional: explicit calorie restriction

---


- 12-wk RCT; 93 pts with type 2 diabetes. Comparison groups:
  - Vegan diet (emphasizing brown not white rice, avoiding rice flour, favoring low GI foods; no portion/calorie restriction)
  - Korean Diabetes Association diet (50-60% carbs, 15-20% protein, <25% fat, <7% saturated fat, 30-35kcal/day per kg body wt)

- Results:
  - Overall, A1c reduction larger in vegan group (-0.5% vs -0.2%, p=0.017)
  - Among highly compliant patients in both groups, even larger reduction in vegan group (-0.9% vs 0.3%, p=0.01)

- Differences remained significant even after adjusting for energy intake & waist circumference

High-carbohydrate, high-fiber diets for insulin-treated men with diabetes mellitus

James W. Anderson, M.D. and Edison Wu, R.D.

ABSTRACT

The effects of high-carbohydrate, high-fiber (HCF) diets on glucose and lipid metabolism of 20 lean men receiving insulin therapy for diabetes mellitus were evaluated on a metabolic ward. All men received control diets for an average of 7 days followed by HCF diets for an average of 16 days. Diets were designed to be weight-maintaining and there were no significant alterations in body weight. The daily dose of insulin was lower for each patient on the HCF diet than on the control diet. The average insulin dose was reduced from 26 ± 3 units/day (mean ± SEM) on the control diets to 11 ± 3 (P < 0.001) on the HCF diets. On the HCF diets, insulin therapy could be discontinued in nine patients receiving 15 to 20 units/day and in two patients receiving 32 units/day. Fasting and 3-h postprandial plasma glucose values were lower in most patients on the HCF diets than on the control diets despite lower insulin doses. Serum cholesterol values dropped from 206 ± 10 mg/dl on the control diets to 147 ± 3 (P < 0.001) on the HCF diet; average fasting serum triglyceride values were not significantly altered on the HCF diets. These studies suggest that HCF diets may be the dietary therapy of choice for certain patients with the normo- or euglycemic type of diabetes. Am. J. Clin. Nutr. 30: 2312-2321, 1979.

• 9 of 20 patients stopped insulin
• Insulin reduced: 26 ± 3 units/day → 11 ± 3 units/day
• Fasting & postprandial glucose levels decreased significantly

DESPITE no changes in body weight
Yoko Yokoyama, Neal D. Barnard, Susan M. Levy, M. Hiroshige Watanabe

A Story from My Practice...

Jaime, 42 years old
Poorly controlled type 2 diabetes
BMI 23
A1c 12.7
LDL cholesterol 145

After 4 months of a whole-food plant-based diet:
A1c 12.7→6.9
LDL 145→105
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A plant-based diet reduces cardiovascular risk

<table>
<thead>
<tr>
<th>Ischemic Heart Disease (vs nonvegetarians)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key et al (Am J Clin Nutr 1999, n=76,000)</td>
</tr>
<tr>
<td>24% (mortality)</td>
</tr>
<tr>
<td>Huang et al (Ann Nutr Metab 2012, n=124,000)</td>
</tr>
<tr>
<td>29% (mortality)</td>
</tr>
<tr>
<td>Crowe et al (Am J Clin Nutr 2013, n=44,000)</td>
</tr>
<tr>
<td>32% (incident cases)</td>
</tr>
</tbody>
</table>

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

- 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
Risk of heart disease

- Decreased 25% in healthy plant-based diet
- Increased 32% in unhealthy plant-based diet


Hypertension rates, Adventist Health Study 2

<table>
<thead>
<tr>
<th></th>
<th>BMI</th>
<th>Hypertension (odds ratio)</th>
<th>Hypertension (BMI adjusted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonveg</td>
<td>28.8</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Semiveg</td>
<td>27.3</td>
<td>0.92</td>
<td>1.22</td>
</tr>
<tr>
<td>Pesco</td>
<td>26.3</td>
<td>0.92</td>
<td>1.22</td>
</tr>
<tr>
<td>Lacto-ovo</td>
<td>25.7</td>
<td>0.57</td>
<td>0.86</td>
</tr>
<tr>
<td>Vegan</td>
<td>23.6</td>
<td>0.37</td>
<td>0.53</td>
</tr>
</tbody>
</table>

Pettersen et al, Vegetarian diets and blood pressure among white subjects. Results from the Adventist Health Study-2. Public Health Nutr 2012

Hypertension rates, EPIC Oxford

<table>
<thead>
<tr>
<th>Dietary pattern</th>
<th>Prevalence of HTN*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MEN</td>
</tr>
<tr>
<td>Meat eaters</td>
<td>12.9%</td>
</tr>
<tr>
<td>Fish eaters</td>
<td>9.3%</td>
</tr>
<tr>
<td>Vegetarians</td>
<td>9.5%</td>
</tr>
<tr>
<td>Vegans</td>
<td>6.1%</td>
</tr>
</tbody>
</table>

*Adjusted for age and BMI

Long-term intake of animal flesh and risk of developing hypertension in three prospective cohort studies

Prospective, n=188,518; up to 26yrs
Risk of incident hypertension
1 serving meat/day vs <1/month
(Independent of intake of fruit/veg/whole grains)


Original Investigation
Vegetarian Diets and Blood Pressure
A Meta-analysis

Yoko Yokoyama, PhD, MPH; Kunihiko Nakamura, MD, PhD, MPH; Neel D. Ramad, MD; Mitsu Takegami, RN, PhD, MPH; Makoto Watanabe, MD, PhD; Katsutosho Sato, MD, PhD; Tomoki Shiokawa, MD, PhD; Yoshitaka Miyayama, MD, PhD

• Observational studies:
  Veg diets associated with lower BP (-6.9/-4.7 mm, p<.001)

• Interventional studies:
  Veg diets lower mean BP more than omnivorous diets
  (mean difference -4.8/-2.2 mm, p<.001)

Vegetarian & vegan diets: lipids

<table>
<thead>
<tr>
<th></th>
<th>Weighted Mean Difference vs Omnivores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vegetarian vs Omnivore</td>
</tr>
<tr>
<td></td>
<td>Vegan vs Omnivore</td>
</tr>
<tr>
<td>Total chol (mg/dL)</td>
<td>-28.16</td>
</tr>
<tr>
<td></td>
<td>(p&lt;0.0001)</td>
</tr>
<tr>
<td>LDL (mg/dL)</td>
<td>21.27</td>
</tr>
<tr>
<td></td>
<td>(-19.27 to -16.27)</td>
</tr>
<tr>
<td></td>
<td>(p&lt;0.0001)</td>
</tr>
<tr>
<td>HDL (mg/dL)</td>
<td>-2.72</td>
</tr>
<tr>
<td></td>
<td>(-3.45 to -2.04)</td>
</tr>
<tr>
<td></td>
<td>(p&lt;0.0001)</td>
</tr>
<tr>
<td>TG (mg/dL)</td>
<td>-11.39</td>
</tr>
<tr>
<td></td>
<td>(-17.42 to -5.37)</td>
</tr>
<tr>
<td></td>
<td>(p&lt;0.0001)</td>
</tr>
</tbody>
</table>

Effects of plant-based diets in hyperlipidemic individuals: RCTs

<table>
<thead>
<tr>
<th>Diet Type</th>
<th>Decrease in Total &amp; LDL Cholesterol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-veg diet, Lacto-ovo veg diet</td>
<td>10 – 15%</td>
</tr>
<tr>
<td>Vegan diet</td>
<td>15 – 20%</td>
</tr>
<tr>
<td>Veg w added fiber/soy/nuts</td>
<td>20 – 35%</td>
</tr>
</tbody>
</table>

Ornish D et al. Intensive Lifestyle Changes for Reversal of Coronary Heart Disease

• RCT, pts with CAD, 5yrs
• Plant-based lifestyle vs physician's diet advice
• CV events: RR 2.47 in control group, despite statins
• Angina: +186% in control, - 91% in intervention
• 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

How does a plant-based diet reduce cardiovascular risk?
• Lower blood pressure, lipids, insulin resistance, body weight
• Replace or “crowd out” disease-promoting foods

- 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


- 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

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
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
TMAO increases:
- all-cause mortality
- CV mortality
- major adverse CV events
- CHF severity
- CHF mortality
- 30-day adverse CV events post ACS

**HEALTHFUL PLANT-BASED DIET**
- Low energy-density
- Low saturated fat, high fiber content
- High dietary fiber
- Especially soluble fiber
- Appropriate fat composition
- Low saturated fat, high unsaturated fat
- High levels of antioxidant nutrients
- Polyunsaturated, monounsaturated, monounsaturated fats
- High levels of certain microorganisms in stool, benefits gut health
- Low levels of certain dietary factors

**CV risk**
- Help with weight loss/maintenance
- Enhance glycemic control
- Improve lipid profile
- Reduce blood pressure
- Improve vascular health
- Decrease inflammation
- Improve gut microbial profile

**Plant protein and chronic kidney disease**

*The Associations of Plant Protein Intake With All-Cause Mortality in CKD*

Xiaoxi Chen, MS,1,2 Guo Wei, MS,1, Thunder Jalali, PhD,3 Julie Metos, PhD, RD,1,7 Ayat Qam, BS,1 Monique E. Cho, MD,1,2,3 Robert Baucherc, BS,1 Tom Greene, PhD,7 and Simranjeet Brar1,2,7

- NHANES III; n=14,866
- Every 33% increase in ratio of plant protein to total protein → 23% lower mortality risk in those with GFR < 60
- Mechanisms: differences in amino acid compositions, lower oxidized LDL, TG, & uric acid; decreased acid load; decreased TMAO

*Multivariate adjusted model*
Plant protein and chronic kidney disease

Diet and Diabetic Kidney Disease: Plant Versus Animal Protein
Rajput N, Moorthi RN1,2,3,4,5. 1Department of Medicine, University of California, San Diego, CA; 2Division of Nephrology, University of California, San Diego, CA; 3Division of Endocrinology, Diabetes, and Metabolism, University of California, San Diego, CA; 4Division of Pulmonary and Critical Care Medicine, University of California, San Diego, CA; 5Division of Renal Diseases and Hypertension, University of California, San Diego, CA.

- "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

Original Article

A dietary intervention for chronic diabetic neuropathy pain: a randomized controlled pilot study
Bunner AE, Ho AM, Smeltzer CM, Hervey Y, Johnson NW, Rose BD, and Boorwash K.

- 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

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
Plant-based diets associated with healthier weight

**BMI**

- Omnivore: 28.8
- Semi-veg: 27.3
- Pesco: 26
- Lacto-ovo: 25.7
- Vegan: 23.6


Meat-based diets tied to obesity & weight gain

Prospective studies:
- EPIC-PANACEA: n=400,000; meat was #1 cause of weight gain over 8 yrs even when controlled for calories
- EPIC (5 countries): n=89,000; animal protein, especially meat & poultry, positively associated with long-term weight gain
- NHANES: Highest quintile of meat consumption → OR 1.27 for obesity
- EPIC-Oxford: Avg weight gain higher in meat eaters vs vegans


Plant-based diets for weight loss

Vegetarian Diets and Weight Reduction: a Meta-Analysis of Randomized Controlled Trials

- 12 RCTs of vegetarian vs nonvegetarian diets; 1151 subjects, median 18 wks
- Weight loss significantly greater with vegetarian diet
- Mean difference, -2.02 kg (95% CI: -2.80 to -1.23)
  - Vegan diet: -2.52 kg (95% CI: -3.02 to -1.98)
  - Lacto-ovo-vegetarian diet: -1.48 kg (95% CI: -3.43 to 0.47)
- Greater weight loss when energy restricted


Plant-based diets for weight loss

A Systematic Review and Meta-Analysis of Changes in Body Weight in Clinical Trials of Vegetarian Diets

- Intervention trials of vegetarian diets ≥4 weeks’ duration without energy intake limitations (n= 15)
- Vegetarian diets: mean weight change of
  - -3.4 kg (95% CI: -4.4 to -2.4; P<0.001) in intention-to-treat analysis
  - -4.6 kg (95% CI: -5.4 to -3.8; P<0.001) in completer analysis

A randomized controlled trial of five different diets

- Vegan diet most effective (-7.5% body wt) despite equal adherence in all groups & no calorie/portion restrictions
- Vegan diet improved macronutrient intake vs other diets (lower sat fat & cholesterol, higher fiber)
- Non-adherent vegans/vegetarians lost more weight than non-adherent omnivores (-6% vs -0.4%, p=0.04)


Plant-Based Diet for Diabetes: Mechanisms

Fiber: not just for constipation anymore!

- Improves blood glucose response to food
- Increases satiety without extra calories
- Lowers calorie intake by 10-18% for every 14g fiber added-day
- Whole grain fiber speeds metabolic rate & promotes loss of calories in stool
- Reduces heart disease, diabetes, & cancer risk
- Promotes beneficial gut bacterial patterns & production of SCFAs
Dietary fiber leads to production of short-chain fatty acids

- Ingestion of dietary fiber
- Fermentation by bacteria
- Production of short-chain fatty acids
- Decrease inflammatory cytokines
- Increase GLP-1, leptin
- Improve mitochondrial function

Short-chain fatty acids (butyrate) improve insulin resistance

- Low-fiber diet: High-calorie; Physical inactivity
- High-fiber diet: Butyrate supplementation; Physical activity

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

- Veg diet better for improvements in markers of oxidative stress
- Also better for:
  - Weight loss
  - Waist circumference
  - LDL
  - Visceral fat
  - Glucose clearance
  - Adipokines


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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

Avoids added sugar & refined grains

Short-term weight loss

Short-term glycemic improvements in persons with diabetes


Low-Carb High-Fat Diets

POSSIBLE BENEFITS

- 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 healthy foods: whole grains, beans, most fruits
- Unclear if sustainable in long-term

MAJOR CONCERNS
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✔ Mechanisms of action
  • Practical applications & resources

Practical applications

Most-heavy

Meat-heavy

100% plant-based diet

• Don’t assume your patient won’t try a fully plant-based diet
• Assess readiness to change & validate benefits of a plant-based diet
  - For those ready to try it out: consider a 21-day kickstart
  - For those not ready/willing to try 100%, encourage any movement along the spectrum towards a plant-based diet
• Planning & support are critical
• Focus on whole or minimally processed plant foods
• Supplements: B12 necessary
• Work in a team, use available resources
• Close follow up needed if on meds (insulin, sulfonylureas, HTN meds, warfarin)

5 key elements of a plant-based diet for type 2 diabetes

1. Eat from four food groups:
   • Legumes
   • Vegetables
   • Whole grains
   • Fruits
2. Emphasize whole or minimally processed foods, & low-GI
3. Obtain fats from whole plant foods (eg nuts, seeds, avocado) & limit to 1 serving/day; minimize oils
4. Avoid all animal products (red meats, poultry, fish, eggs, dairy)
5. Aim for at least 40g fiber/day
Resources for clinicians
- Position of the Academy of Nutrition and Dietetics: Vegetarian Diets. J Acad Nutr Dietetics 2016. Available at EatRightPro.org
- Vegetarian Nutrition Diabetic Practice Group, VegetarianNutrition.net
- PCRM’s Nutrition Guide for Clinicians (free online site & app; nutrionguide.pcrm.org)
- American Association of Diabetes Educators, Plant-Based Nutrition Community of Interest, myaadnetwork.org/cois
- VeganHealth.org, BecomingVegan.ca, TheVeganRD.com

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, PlantRCianProject.org/quickstartguide (free download; Eng/Sp)
- ForksOverKnives.com (recipes, testimonials, expert content)
- Chickpeaandbean.com (recipes, events; Eng/Sp)

Resources for patients – films, books, coaching, etc
- Forks Over Knives (film, 2011)
- 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)