March 15, 2021

Oregon State Legislature
House Human Services Committee
900 Court St NE
Salem, OR 97301

Committee: House Committee on Human Services

Re: HB 2348 related to plant-based meals

I am a Registered Dietitian Nutritionist (RDN) and have previously worked for more than 12 years as a long-term care (LTC) consultant RDN, assisting dietary managers with their foodservice operations, and writing menus for a LTC consulting company. For ~5 more years, I was the Nutrition and Foodservices Director, at Capital Manor Retirement Community in Salem, OR. I was also part of a team of state and national representatives that conducted a purchasing and foodservice operations review and evaluation in June, 2007 for the Oregon Department of Corrections at the request of the governor and the ODOC Director.

I currently direct and deliver the instruction, training and research in the Dietetics undergraduate and graduate programs for Dietetics and Nutrition in Foodservice Systems at Oregon State University (OSU). My course delivery includes: Science of Foods; Quantity Food Production and Purchasing; Managing Food and Nutrition Services, Management and Evaluation of Food and Nutrition Programs and Service and Organic Food and Health. OSU is the largest Oregon university with a 100+ year history of offering Food and Nutrition degree programs. My research focus includes food choice and eating behavior.

The role of a RDN is to translate nutrition science into food, recipes, and diet; my specialty is providing food to people in institutions. I am writing to express my opposition to HB 2348.

HB 2348 imposes challenges to operational efficiencies of Oregonians in LTC facilities, hospitals and prisons

- Residents or families of LTC residents are interviewed to collect dietary preferences and currently offering preferences and alternatives to a menu offering is required with the ORS for LTC residential facilities. This makes this bill unnecessary.

- The greatest challenging with LTC residents is that >50% have inadequate food and fluid intakes that leads to weakness, debilitation and more nursing care. They struggle with low appetite and unintended weight loss. The meal that is best consumed is breakfast, removing the ability to provide sausage or bacon (typically served occasionally) removes a source of enjoyment, calories and with questionable impact upon their health or longevity. More than 50% of LTC residents are 85 years of age or greater (4). Variety in menu offerings increases food acceptability and would be a concern in LTC.

- The average length of stay in hospitals is about 4.5 days. Many are on restricted diets and often are not eating for some of the stay, due to illness or procedures in process relative to their hospitalization. Room service allows for patients to choose from an individual menu and hospitals frequently offer alternatives, including plant-based choices; they keep on hand alternative foods already. Restricting the availability of all processed meats for all patients seems to be an unnecessary restriction given their length of hospital stay. Recommendations for safe processed

meats consumption is unclear and data suggesting that it “causes” cancer was not revealed in the studies (5).

- Requiring the availability of a 100% plant-based meal option to be consistent in cost disregards that plant-based alternatives have more expensive ingredients. All alternative milks are 2-2.5 times more expensive than animal dairy. In contrast to offering an individual food substitute, this implies that the site must keep on hand 100% plant-based ingredients and choices at all times. This means not just more plant foods, but the ingredients necessary to substitute for those recipes that require dairy or eggs (See substitutes on attachment, 100% Plant Based Menu Planning. Having 100% plant-based meat alternative ingredients always available means that they must be on-hand for production; contributing to the cost of the initial purchase, as well as the associated storage and waste costs.

- There are limited options of 100% plant-based entrée choices that hospitals, prisons and LTC can purchase from commercial vendors. Legumes, vegetable and soy choices are predominant, decreasing the variety of foods that can be offered. Thus, either searching and paying for more expensive pre-prepared items or requiring more from-scratch cooking would also involve added cost for the greater food preparation skills needed by chefs, cooks and managers in those sites, and in LTC sites, for the time paid to the Consultant RDN to write a 100% plant-based menu and recipes. Even when preprepared, plant-based meat alternatives are purchased, theses processed foods have significant flavor and textural differences. More sodium and sugars would inevitably be greater in those food items. Adding to that challenge for healthcare sites, when those 100% plant based offerings are required; finding those that are both suitable for patients needing modified diets (diabetic, soft texture, etc) would present an additional complexity to meal production and purchasing.

- Waste disposal is a significant cost to all food operations (and to climate change!). Alternative dairy and meat food substitutes requires many resources, including water demand, energy in processing and costs for producing and disposing of packaging. Therefore, requiring the on-hand availability creates greater cost for the budgets of hospitals, LTC and prisons as well as the environmental costs are not consistently lower than animal-based products, based on limited Life Cycle Analysis in sustainable agricultural research. There is greater trim waste in fruits and vegetables (all, but primarily when fresh) and in disposing of 100% plant-based ingredients/foods that are not used but become out of safe-use dates.

- Alternative milk processors have worked hard to create a well-accepted plant-based beverage substitute for dairy, as the taste is difficult to mimic and the nutrient profile is also much less beneficial than dairy (particularly calcium and protein). Those that are most acceptable (oat and coconut) have very high sweeteners added; distinct from lactose the sugar in cow and human milk.

HB 2348 imposes challenges to the optimal nutritional care of Oregonians in healthcare facilities

- The bill offers challenges as it appears to be related to the assumption that diets with any animal-based food or byproducts are nutritionally inferior to plant based alternatives

    - **Health Benefits of Zero Animal Food/Products is Controversial:** While popular media promotes plant-based diets for weight loss, reduction in the incidence of cardiovascular disease, hypertension, cancer and diabetes, the research is controversial for many studies. Diets that are low fat and include more fruits and vegetables, yet including eggs, yogurt, low fat dairy and small amounts of lean meats/fish and poultry have been shown to exert similar and even beneficial disease risk outcomes. Most importantly, the research evidence

cannot reveal whether positive health improvements found in some studies are due to decreasing animal food intake or increasing fruits and vegetables in the studies. (3,4)

- **Nutrient Impact of Eliminating all Animal Food: Excellent nutrient sources (> 10 to > 50% of daily requirement in one serving)**

  - Animal foods are the single whole food source of Vitamin B12.
  - Meats and fish are excellent sources of complete proteins (needed for tissue building/repair) which plants contain only when combined carefully
  - Animal meat provides B vitamins, Zinc, Iron, Iodine
  - Dairy (milk) provides Calcium, Vitamin D, Magnesium, Potassium Phosphorus, and Yogurt: similar to those from Dairy and Probiotics
  - Eggs provide the reference complete protein (meaning the quality of egg protein serves as the reference against which all other proteins are compared).
  - Eggs also provide: Vitamins A, D, E, K, and B complex, Phosphorus, Selenium, Potassium and Zinc.
  - Omega 3 Fatty acids in animal products associated with reducing chronic inflammation causing incidences of CVD, Diabetes, hypertension and cancer.
  - While plants contain excellent nutrients as well; the elimination of all animal decreases the complete profile of nutrients provided by a varied diet from all food groups.
  - Nutrients from naturally occurring sources are more readily absorbed compared to pharmaceutical supplements and from adding them as ingredients in plant-based substitutes (plant based meats, milks, and yogurts) (5).

Thank you for the opportunity to share my concerns regarding the HB 2348

Sincerely,

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References

1. Healthy Aging.org, Trusted Information. Better Care. https://www.healthinaging.org/age-friendly-healthcare-you/care-settings/nursing-homes
2. James, L. Red and Process Meat Diet Recommendation Review. Penn State Extension, October 2019. https://extension.psu.edu/red-and-processed-meat-diet-recommendation-review .
3. SUNY Downstate Medical Center, Committee on Plant Based Health and Nutrition; More Plants, Less Meat, Better Health (See Attached pdf).
4. Solan, M. Dairy: Health food or health risk? Harvard Health Publishing Harvard Medical School, 1/1/2019. https://www.health.harvard.edu/blog/dairy-health-food-or-health-risk-2019012515849
5. Feher A et al. A comprehensive review of the benefits of and the barriers to the switch to a plant-based diet. Sustainability 2020, 12, 4136. (See attached pdf).

100% Plant Based Menu Planning

Menu Item	Substitute (**BOLD** indicate those that would be purchased alternatives to have on hand in institutions)
Whole egg dishes (scrambled, etc.)	Substitute tofu or **vegan eggs** (made w/potato starch)
Egg in recipes (baked products, soufflés, custards, potato and other salads)	Substitute thickeners**: xanthan gums; various algae based and starch thickeners**
Breakfast meats (bacon, sausage, etc.)	Soy **protein substitutes, tempeh, nuts** or **tofu**
Milk beverages and in cooking	Soy or **vegetable milk substitute; soy, coconut , oat, hemp, almond, rice "milk"**
Soups	No meat broths; no cream based made with milk; **substitute soy milk**
Sandwiches	No cheese, ham, cured or smoked turkey, roast beef, meats or mayonnaise; Substitute **nut spreads** or alternates
Cheese as snack or meal	**Alternative cheeses** (soy based)
Entrée items with meat, fish, poultry, seafood	Substitute **tofu, quinoa, beans, nuts, legumes, sweet potatoes,** etc
Pasta, noodles	**Vegan pastas** (no-egg) and noodles
Dairy ingredients (yogurt, milk, cream, ice cream, half and half, evaporated milk, whipped cream, custards, puddings, or beverages)	Substitute soy or alternative -based fluid milk or creamers, or coconut-based thickeners **Vegan ice-cream or sherbet**
Baked products containing eggs or dairy (cake, angel cake, some breads, rolls with egg or egg wash, no cream-based pies or desserts)	Substitute alternatives without egg or dairy products Bagels and breads free of L-cysteine (an amino acid that softens the dough)
Oils/Sauces/Dressings/Fats	**Vegan processed oils** without mono and diglycerides (which are antioxidants in the oil) No Worcestershire; no gelatin, dairy or egg based dressings No lard or butter
Miscellaneous label ingredients to avoid for vegans	Avoid those with glycerol, glycerine, honey, casein, whey, lactose, L-cysteine

Avoid:
Fruits and vegetables that may be waxed
Pesto contains parmesan cheese
Sweets with gelatin
Refined sugars use animal products in processing
Dark chocolates
Roasted peanuts also can contain gelatin
Omega 3 supplements (often processed with animal fats)

Animal By-Product Additives (Select List: See Note below)	Found in
Gelatin	Candies, cakes, gelatin desserts, yogurts, ice cream, dips
Casein	Pasta, instant soups, creamers, toppings, ice creamers
Albumin	Clarifier in wine; binding agent; protein powder
Whey	Additive in bread, crackers, commercial pastry
Diglycerides/Monoglycerides	Bakery products, beverages, ice cream, peanut butter, gum, shortening, whipped toppings, confections, potato chips
Glycerol	Used as a sweetener
Lactic Acid	Yogurt, kefir, sourdough bread, ale (Kefir is used to control infection and promote would healing and is given as a preventive as well as treatment for patients having surgery)
Lactose	Many food applications
Lecithin (both plant and animal source)	Food additive, dietary supplements, non-stick cooking sprays
Lipase	Baking products
Oleic Acid (both plant and animal source)	Found in many cooking oils

Note: There are many more animal based by-products. It is difficult to discern which ingredients may have them; and to explore the sources of all ingredients in purchased pre-prepped food would be an on-going immense task. Food manufacturers alternate ingredient sources based on availability and market prices. It would change often.

For example, mono and diglycerides are anti-oxidants in many fats and oils. Vegetable oils, that are not sold as vegan could potentially have an animal source of glycerides.

This chart shows some of the nutrients and common food sources that require planning if you follow a vegan diet. For more information on these nutrients see Nutrients in a Vegan Diet or contact EatRight Ontario.

Nutrient	Food Sources
Vitamin B12	Meat substitutes like soy burgers or TVP (textured vegetable protein). Fortified beverages, like soy or rice drinks Nutritional yeast
Iron	Dark leafy greens Legumes, like black beans, dhal, chickpeas Dried fruit Breakfast cereals, flour Blackstrap molasses
Zinc	Whole grains, like wild rice Legumes Seeds
Calcium	Dark leafy greens Fortified beverages like soy or rice drinks Almonds Legumes
Vitamin D	Soft margarine Fortified beverages (like soy beverage or orange juice)
Omega 3 fatty acids	Canola oil Soybean oil, soybeans Ground Flax seeds, flax seed oil Walnuts Tofu Fortified soy beverages

Vegans avoid eating any animal foods, as well as any foods containing ingredients derived from animals. These include:

- **Meat and poultry:** Beef, lamb, pork, veal, horse, organ meat, wild meat, chicken, turkey, goose, duck, quail, etc.
- **Fish and seafood:** All types of fish, anchovies, shrimp, squid, scallops, calamari, mussels, crab, lobster, etc.
- **Dairy:** Milk, yogurt, cheese, butter, cream, ice cream, etc.
- **Eggs:** From chickens, quails, ostriches, fish, etc.
- **Bee products:** Honey, bee pollen, royal jelly, etc.
- **Animal-based ingredients:** Whey, casein, lactose, egg white albumen, gelatin, cochineal or carmine, isinglass, shellac, L-cysteine, animal-derived vitamin D3 and fish-derived omega-3 fatty acids.

Foods to Eat

Health-conscious vegans substitute animal products with plant-based replacements, such as:

- **Tofu, tempeh and seitan:** These provide a versatile protein-rich alternative to meat, fish, poultry and eggs in many recipes.
- **Legumes:** Foods such as beans, lentils and peas are excellent sources of many nutrients and beneficial plant compounds. Sprouting, fermenting and proper cooking can increase nutrient absorption (34).
- **Nuts and nut butters:** Especially unblanched and unroasted varieties, which are good sources of iron, fiber, magnesium, zinc, selenium and vitamin E (35).
- **Seeds:** Especially hemp, chia and flaxseeds, which contain a good amount of protein and beneficial omega-3 fatty acids (36, 37, 38).
- **Calcium-fortified plant milks and yogurts:** These help vegans achieve their recommended dietary calcium intakes. Opt for varieties also fortified with vitamins B12 and D whenever possible.
- **Algae:** Spirulina and chlorella are good sources of complete protein. Other varieties are great sources of iodine.
- **Nutritional yeast:** This is an easy way to increase the protein content of vegan dishes and add an interesting cheesy flavor. Pick vitamin B12-fortified varieties whenever possible.
- **Whole grains, cereals and pseudocereals:** These are a great source of complex carbs,

SUNY Downstate Committee On
Plant-Based Health & Nutrition
More Plants, Less Meat, Better Health

SUNY Downstate Medical Center

Evidence Summary for Plant-Based Diets
Reviews, Trials, and Landmark Observational Studies
Last update, March 2019

Definitions

- Omnivorous diet: includes animal and plant foods without any restrictions
- Plant-based diet: emphasizes eating more plant-based foods (i.e., fruits, vegetables, grains, nuts, seeds, and legumes/beans) and fewer or no animal products (i.e., red meat, poultry, fish, eggs, and dairy)
- Vegetarian diet: a plant-based diet that generally does not include meat, but may include eggs (ovo-vegetarian), dairy products (lacto-vegetarian), or both (lacto-ovo-vegetarian); some vegetarian diets also include fish (pescatarian), poultry or fowl (pollotarian)
- Semi-vegetarian diet: a vegetarian diet that excludes some types of meat (most often red meat), but may contain other types (e.g., poultry, fish)
- Flexitarian diet: a vegetarian-inclined diet that limits meat intake, but still includes meat
- Vegan diet: a more restrictive vegetarian diet that completely excludes animal products
- Whole-food, plant-based diet: a diet that emphasizes unrefined plants (such as whole grains), and avoids refined plant foods that have been processed and stripped of their nutrients (e.g., refined grains, added sugars, and extracted oils)

Note: There is increasing use of flexitarian diet and semi-vegetarian diet in the literature; the definitions here are adapted from Rosenfeld DL. The psychology of vegetarianism: recent advances and future directions. Appetite 2018; 131:125-38.

Plain Language Summary of Evidence

1. Research provides consistent evidence that plant-based diets offer significant benefits in promoting overall health and in preventing, managing, or treating many chronic diseases including excess weight, high blood pressure, coronary artery disease, high cholesterol, type 2 diabetes, and some cancers (colon, stomach, intestines).
2. The evidence is most supportive of increased consumption of whole (unrefined) plant foods as providing benefits, in contrast to reducing animal product in the diet, or removing them entirely.
3. Within the category of plant-based diet there is some evidence to suggest that vegan diets provide benefits over other vegetarian diets. While there is little evidence that a whole-food plant-based diet is better than any other type of vegan diet, there is mounting evidence that eating whole plant foods is more beneficial than eating refined plant foods.
4. Some of the observed health benefits of plant-based diets may be due, in part, to other lifestyle patterns or interventions that often accompany these diets, such as smoking cessation, limited alcohol consumption, stress reduction, and a greater emphasis on exercise and fitness.
5. Current evidence on plant-based diets is based on people whose characteristics may differ from the diverse Brooklyn population, but the higher levels of obesity, diabetes, and other chronic diseases in Brooklyn may accentuate the benefits of plant-based diets.

Executive Summary of Evidence

1. There is robust evidence on the impact of a plant-based diet on disease, mortality, and metabolic profiles based on large, population-based cohort studies that span several decades. These studies span the world and include (in order of decreasing sample size):

a. US Healthcare Worker Studies, N=200,727 enrolled in 3 studies: Nurses' Health Study 1984-2012, Nurses' Health Study 2 1991-2011, and the Health Professionals Follow-Up Study 1986-2012
b. Seventh Day Adventist Studies, N=157,728 participants enrolled in 3 studies: 1960-66, 1976, and 2002-07
c. Prospective Urban Rural Epidemiology (PURE) Study, N=135,335 enrolled from 2003-13
d. NurtiNet-Santé Study, N=93,823 web-based launched in 2009
e. European Prospective Investigation into Cancer and Nutrition (EPIC) Study, N=65,429 enrolled in the 1990s
f. Singapore Chinese Health Study, N=63,257 enrolled 1993-98
g. Prevention with Mediterranean Diet (PREDIMED) Study, N=7,216 enrolled from 2003-9
h. Rotterdam Study, N=6,798 enrolled in 3 cohorts: 1989-93, 2000-01, and 2006-08
i. The China Study, N=6,500, enrolled in 1983

2. Taken together, over 736,000 participants in large, population-based studies show lower rates of the following conditions associated with more plant foods in the diet:
   - ✓ Diseases: obesity, overweight, high body mass index (BMI), prediabetes, type 2 diabetes, high blood pressure, ischemic (coronary) heart disease, some cancers (gastrointestinal, colon), and metabolic syndrome (having at least 3 of the following 5 conditions: abdominal obesity, high blood pressure, high blood sugar, high serum triglycerides, and low HDL levels)
   - ✓ Mortality: deaths from all-causes, cardiovascular disease, ischemic heart disease, cerebrovascular disease, and some cancers (gastrointestinal, hematopoietic, lung, lymphatic, and pancreatic)
   - ✓ Metabolic profiles: lower levels of total cholesterol, LDL cholesterol, non-HDL cholesterol, apolipoprotein B, glucose levels, hemoglobin A1c, insulin resistance, and obesity inflammatory profiles (CRP, IL-6, sICAM)
   - ✓ Inadequate nutrition: not meeting nutritional recommendations (French NurtiNet-Santé Study)

3. One partial exception to the above comes from the Prospective Urban Rural Epidemiology (PURE) multination-cohort study of 135,335 individuals aged 35-70 years without cardiovascular disease from 18 low-, middle-, and high-income countries (7 geographical regions: North America/Europe, South America, Middle East, south Asia, China, southeast Asia, and Africa). In this study there was less overall mortality and cardiovascular events associated with higher fat intake (including saturate fats) and higher dairy intake (more than 2 servings daily, including butter and cheese). *Note: some have questioned the validity of the PURE study because of methodologic problems, especially confounding by different degrees of socio-economical development in different countries and questionable dietary intake data (Harvard School of Public Health, Nutrition News: https://www.hsph.harvard.edu/nutritionsource/2017/09/08/pure-study-makes-headlines-but-the-conclusions-are-misleading/)*

4. Intervention studies that randomly assign subjects with a disease or medical condition to a plant-based diet vs. a control diet (usually with meat and animal products) have found the following:
   - ✓ Obese or overweight individuals randomized to a vegan or vegetarian diet for up to 1 year lost more weight, reduced BMI, and lowered cholesterol more than those on a vegetarian or omnivorous diet
   - ✓ Obese or overweight individuals, who also had high lipids or cholesterol, randomized to a vegetarian diet (including some eggs and diary) for up to 6 months had lower BMI, triglycerides, LDL cholesterol, total cholesterol, total cholesterol to HDL ratio, and apolipoprotein B to A1 ratio than those on a meat-based diet
   - ✓ Patients with type 2 diabetes randomized to a vegan diet for up to 6 months had better glycemic control, less need for diabetes medications, and lower metabolic factors (hemoglobin A1c, total cholesterol, and LDL cholesterol) than those on a control diet (American Diabetes Association)
   - ✓ Patients with coronary artery disease randomized to a vegetarian diet (including egg whites and low-fat milk) plus lifestyle changes (stress management, moderate exercise, smoking reduction group psychosocial support) for up to 4 years had less coronary artery disease (by angiography) and fewer cardiac events than those on a meat-based diet without any lifestyle intervention

- ✓ Patients with high cholesterol randomized to a plant-based diet (low fat, added cheese and eggs) for 4 weeks had lower LDL cholesterol than those who ate a low-fate diet with animal products

5. Studies that observed a group of patients with a disease or medical condition who were placed on a plant-based diets have found the following:
   - ✓ Patients with coronary artery disease who voluntarily adopted a low-fat, plant-based diet (including skim milk, yogurt) for up to 12 years reversed, or improved, their coronary disease (angiography)
   - ✓ Patients with fibromyalgia who ate a vegan diet for 3 months had less pain, joint stiffness, and overall rheumatology symptoms than those on a regular diet; vegans also had better sleep and general health
   - ✓ Patients with rheumatoid arthritis who ate a low-fat vegan diet for 4 weeks reduced all arthritis symptoms, except morning stiffness
6. There increasing evidence that individuals who eat whole food, plant-based diets have better health outcomes than individuals who eat refined carbohydrates, some animal products, or both:
   - ✓ Individuals who eat exclusively plant-based diets in population-based and comparative studies have lower rates of obesity, hypertension, type 2 diabetes, and cardiovascular disease than those who eat plant-based diets with some animal products
   - ✓ Individuals who eat high levels of complex carbohydrates (rich in fiber and whole grains) in observational studies have a 15-30% decrease in all-cause and cardiovascular related mortality, and incidence of coronary heart disease, stroke incidence and mortality, type 2 diabetes, and colorectal cancer, compared with individuals who eat high levels of refined carbohydrates
   - ✓ Individuals who eat high levels of fiber and/or whole grains in clinical trials have lower body weight, systolic blood pressure, and total cholesterol, compared to individuals who eat low levels of fiber and/or whole grains

Study Types

The purpose of this document is to summarize the best published evidence regarding the impact of plant-based diets on wellness and physical health. This is not an exhaustive list, but instead focuses on English-language articles in human subjects that fall into 4 main categories:

1. Systematic Reviews and High-quality Reviews: Systematic reviews, including meta-analyses, use explicit criteria to reduce bias in locating, appraising, and synthesizing information from multiple research studies to reach valid conclusions. High-quality reviews identify articles with a well-defined literature search and with explicit criteria for including or excluding studies, but may lack the rigorous protocol of a formal systematic review. Reviews are extremely useful in drawing conclusions from a large body of related research, but they are limited by the quality and consistency of the included studies.
2. Randomized Controlled Trials (RCTs): RCTs are experimental studies that provide the highest level of clinical evidence regarding a specific research question. Study participants typically have a baseline condition or disorder (e.g., obesity, diabetes, high cholesterol) and are randomly assigned by the investigators to a plant-based diet or something different (e.g., omnivorous [all foods, including meat] diet, their normal baseline diet, or some other dietary restriction) and then assessed at some future time point for changes from baseline or other measures of health and disease status. RCTs provide the most reliable results because they reduce bias in how people are allocated to different treatment (diet) groups, but the results may not apply outside the study because of intensive intervention in a restricted and narrow subject group that could be difficult to replicate in more pragmatic, real-world settings.
3. Large Cohort Studies: These are performed in large populations of people (healthy and sick) who are surveyed regarding dietary and food habits, and then assessed at the same time, in the future, or both, for various health outcomes. The investigators then look for associations (correlations) between diet and baseline health of future disease states. By using large populations the results can often be broadly applied (generalized), but cohort studies can only discover associations (e.g., relationships) and cannot prove cause and effect.

4. Intervention Studies: Intervention studies begin with one or more groups of people with a specific disease, condition, or disorder and then ask them to follow a specific diet, with or without other lifestyle changes. The study may have one intervention or many, but unlike the RCT there is no random allocation to different groups. Intervention studies are great for showing changes over time (e.g., improvement from baseline), but they are limited by loss of subjects (attrition), limited ability to monitor compliance with the intervention, and by bias in how subjects are selected (often volunteers) or assigned to different interventions (if more than one).

Systematic and High-Quality Review Articles

1. Benatar JR, Stewart RAH. Cardiometabolic risk factors in vegans: a meta-analysis of observational studies. PLoS One 2018; 13(12):e0209086. doi: 10.1371/journal.pone.0209086. *Systematic review of 40 observational studies, with 12,619 vegans and 179,630 omnivores, that reported 1 or more cardio-metabolic risk factors. Based on food frequency questionnaires in 28 studies, vegans had lower BMI (-1.72 kg/m2, 95% CI -2.30 to -1.16), waist circumference (-2.35 cm, 95% CI -3.93 to -0.76), LDL cholesterol (-0.49 mmol/L, 95% CI, -0.62 to -0.36), triglycerides (-0.14 mmol/L, 95% CI -0.24 to -0.05), fasting blood glucose (-0.23 mmol/L, -0.35 to -0.10), and systolic (-2.56 mm Hg, 95% CI, -4.66 to -0.45) and diastolic pressure (-1.33 mm HG, 95% CI, -2.67 to -0.02). Exception was a subgroup of studies from Taiwan where vegan diets were not associated with more favorable outcomes.*

2. Dinu M, Abbate R, Gensini GF, Casina A, Sofi F. Vegetarian, vegan diets and multiple health outcomes: a systematic review with meta-analysis of observational studies. Crit Rev Food Sci Nutr 2017; 22:3640-9. *Systematic review of 86 cross-sectional and 10 cohort studies. Cross-sectional studies showed significantly reduced levels of BMI, total cholesterol, LDL cholesterol and glucose levels in vegans & vegetarians vs. omnivores; cohort studies showed less ischemic heart disease (*RR *0.75, 95% CI 0.68 to 0.82) and less total cancer (*RR *0.92, 95% CI, 0.87 to 0.98), but no differences in total cardiovascular disease, cerebrovascular disease, or mortality (all-cause or cancer-related). Vegans had reduced risk of cancer (*RR *0.85, 95% CI 0.75 to 0.95).*

3. Eichelmann F, Schwingshackl L, Fedirko V, Aleksandrova K. Effect of plant-based diets on obesity-related inflammatory profiles: a systematic review and meta-analysis of intervention trials. Obes Rev 2016; 17:1067-79. *Systematic review of 29 intervention trials showed that plant-based diets had mean reductions of CRP by -0.55 mg/l (95% CI -0.78 to -0.32), IL-6 by -0.25ng/l (05% CI, -0.56 to 0.06), and sICAM -25.07 (95% CI -52.32 to 2.17). Pooled analyses had high heterogeneity but suggest that improved inflammatory profiles could help treat and prevent chronic disease risk.*

4. Guo J, Astrup A, Lovegrove JA, et al. Milk and dairy consumption and risk of cardiovascular diseases and all-cause mortality: dose-response meta-analysis of prospective cohort studies. Eur J Epidemiol 2017; 32:269-87. *Systematic review of 29 cohort studies (938,465 participant) with 93,158 mortalities, 28,419 coronary heart disease (CHD) cases, and 25,416 cardiovascular disease (CVD) cases. No associations were found for total (high-fat/low-fat) dairy and milk for any health outcomes.*

5. Huang RY, Huang CC, Hu FB, Chavarro JE. Vegetarian diets and weight reduction: a meta-analysis of randomized controlled trials. J Gen Intern Med 2016; 31:109-16. *Systematic review of 12 randomized trials of 1,151 adults (mostly overweight or with type 2 diabetes) comparing vegan or lacto-ovo-vegetarian diets to non-vegetarian diets over a median duration of 4.5 months. The vegetarian group had 2.02 kg greater weight loss (95% CI, 1.23 to 2.80), with greater weight loss for the vegan diet (2.52 kg) than the lacto-ovo-vegetarian diet (1.48 kg), and greater weight loss for subjects followed less than 1 year (2.05 kg) than those followed 1 year or longer (1.13 kg).*

6. Iguacel I, Miguel-Berges ML, Gómez-Bruton A, Moreno LA, Julián C. Veganism, vegetarianism, bone mineral density, and fracture risk: a systematic review and meta-analysis. Nutr Rev. 2019; 77:1-18. *Systematic review of 20 studies (37,134 participants) assessing bone mineral density (BMD) and fracture risk with a vegan, vegetarian, or omnivorous diet. Vegans and vegetarians had lower BMD at the femoral neck and lumbar spine, and vegans also had higher fracture rates (relative risk 1.44, 95% CI, 1.05 to 1.98). Nearly all studies had exclusively women participants, so results cannot be applied to men. Potential variables that were not controlled for in the analyses, but are also associated with BMT and fracture risk, include daily hours of physical activity, duration of vegan/vegetarian diet, BMT,*

use of hormone replacement therapy, consumption of alcohol, and smoking behavior. Bottom line is that although not definitive, results women who are vegans should be aware of bone health and avoid dietary deficiencies.

7. Lee J, Fu Z, Chung M, Jang DJ, Lee HJ. Role of milk and dairy intake in cognitive function in older adults: a systematic review and meta-analysis. Nutr J 2018; 27: 17(1):82. doi: 10.1186/s12937-018-0387-1. *Systematic review of 1 small randomized trial and 7 cohort studies concluding that the existing evidence is too poor (high risk of bias, methodological problems) to draw a firm conclusion about the effect of milk or dairy intake on the risk of cognitive decline or disorders in adults.*

8. Lu W, Chen H, Nu Y, et al. Dairy products intake and cancer mortality risk: a meta-analysis of 11 population-based cohort studies. Nutr J 2016; 15:91. DOI 10.1186/s12937-016-0210-9. *Systematic review of 11 cohort studies (778, 929 participants) showing that total dairy products intake is not associated with all-cancer mortality risk (relative risk 0.99, 95% CI, 0.92 to 1.07), with a similar lack of association noted for subgroups (milk, yogurt, cheese, and butter in males and females). The only significant relationship was an increased risk of prostate cancer mortality (relative risk 1.50, 95% CI 1.03 to 2.17) in men for whole milk, with dose-response analysis showing a linear relationship and increased risk with a single additional serving per day (relative risk 1.43, 95% CI, 1.13 to 1.81)*

9. Rinaldi S, Campbell EE, Fournier J, O'Connor C, Madill J. A comprehensive review of the literature supporting recommendations from the Canadian Diabetes Association for the use of plant-based diet for management of type 2 diabetes. Can Diabetes 2016; 40:471-7. *Systematic review of 13 intervention and large observations studies of plant-based diets as medical nutrition therapy. Studies reported that plant-based diets improved A1C levels, BMI, body weight, waist circumference, quality of life scores, and fasting blood glucose; decreases total cholesterol, LDL cholesterol, non-HDL cholesterol, and depressions; and resulted in oral hypoglycemic medication discontinuation.*

10. Kwok CS, Umar Saadia, Myint PK, Mamas, MA, Loke YK. Vegetarian diet, Seventh Day Adventists and risk of cardiovascular mortality: a systematic review and meta-analysis. Int J Cardiol 2014; 176:680-6. *Meta-analysis of 8 observational studies (183,321 participants) comparing a vegetarian/non-meat group with a control group (either general population or meat-eaters) that aimed to evaluate cardiovascular mortality. Risk of bias was moderate for 5 studies and low for 2, with all studies assessing dietary intake with questionnaires. For all outcomes, studies in Seventh Day Adventists (SDA) cohorts had greater effect sizes compared with non-SDA cohorts for reduced overall mortality (SDA -32%, 95% CI, -55 to 2% vs. non-SDA +4%, 95% CI, -2 to 10%), mortality from ischemic heart disease or a cardiac event (SDA -40%, 95% CI -57 to -17% vs. non-SDA -16%, 95% CI -26 to -4%), and cerebrovascular disease mortality (SDA -29%, 95% CI -59 to 20% vs. non-SDA +5%, 95% CI -11 to 24%). All analyses had high heterogeneity. Conclude that vegetarian diet has modest cardiovascular benefit, but no clear reduction in overall mortality; evidence in driven mainly by SDA results and effect of vegetarian diet in other cohorts is unproven.*

11. Le LT, Sabate J. Beyond meatless, the health effects of vegan diets: findings from the Adventists Cohorts. Nutrients 2014; 6:2131-47. *Systematic review of 13 articles based on 3 prospective cohorts – Adventist Mortality Study, Adventist Health Study, and Adventist Health Study-2 – reporting clearly defined dietary patterns as exposures and comparing vegetarians (about 50% [8% vegans]) to non-vegetarians (50%) for cardiometabolic factors, cancer-related sites, and/or mortality. Compared to omnivorous diets, vegetarians (including vegans) had reduced odds of hypertension (55%), diabetes (49%), metabolic syndrome* (56%), colon cancer (45-51%), GI cancer (23%), all-cause mortality (12-20%), and cardiovascular mortality for men only (29%); overall cancer rates reduced by 7-8% but not statistically significant (95% CI, -3 to 19%). A subgroup analysis comparing lacto-ovo-vegetarians to vegans showed that vegan diets offer additional protection for obesity, hypertension, type-2 diabetes, and cardiovascular mortality; in one study, vegans had 73% higher odds of urinary tract cancer. [*metabolic syndrome defined as having at least 3 of the following 5 conditions: abdominal obesity, high blood pressure, high blood sugar, high serum triglycerides, and low HDL levels]*

12. Namazi N, Saneei P, Larijani B, Esmaillzadeh A. Soy product consumption and the risk of all-cause cause, cardiovascular, and cancer mortality: a systematic review and meta-analysis of cohort studies. Food Funct 2018; 23:2576-88. *Systematic review of 7 studies with 627,209 participants and 39,250 deaths in 7 to 18 years of follow-up. No significant associations were found between a high intake of soy products and all-cause, cardiovascular, and cancer mortality.*

13. Reynolds A, Mann J, Cummings J, et al. Carbohydrate quality and human health: a series of systematic reviews and meta-analyses. Lancet 2019; 393:434-45. *Systematic review of 185 prospective studies (135 million person-years of data) and 58 clinical trials (4,635 adult participants) comparing the highest vs. lowest consumption of whole grains and carbohydrates rich in fiber. Observational studies showed a 15-30% decrease for the highest consumers in all-cause and cardiovascular related mortality, and incidence of coronary heart disease, stroke incidence and mortality, type 2 diabetes, and colorectal cancer. Clinical trials showed that the highest consumers had significantly lower body weight , systolic blood pressure, and total cholesterol. Consuming 25-29 grams of fiber daily conferred greatest risk reduction and dose-response curves showed that higher consumption could protect against cardiovascular disease, type 2 diabetes, colorectal and breast cancer. Certainty of evidence was moderate for fiber outcomes and low to moderate for whole grains.*

14. Schwingshackl L, Schwedhelm C, Hoffmann G, et al. Food groups and risk of all-cause mortality: a systematic review and meta-analysis of prospective studies. Am J Clin Nutr 2017; 105:1462-73. *Systematic review of 102 studies of association between 12 nutrient groups and all-cause mortality (studies: whole grains 19, refined grains 4, vegetables 37, fruits 34, nuts 16, legumes 17, egg consumption 8, dairy products 25, fish 37, red meat 10, processed meat 7, and sugar-sweetened beverages (SSB) 5). The risk of all-cause mortality decreased with increasing intake (for each daily serving of whole grains (*RR *0.92), vegetables (*RR *0.96), fruits (*RR *0.94), nuts (*RR *0.76), and fish (*RR *0.93). Conversely, mortality increased with higher intake of red meat (*RR *1.10) and processed meat (*RR *1.23). Dairy products increased mortality in a non-linear fashion, with no detrimental effects for intake up to 750 g/d but a 15% increased risk of mortality above this level. Refined grains and SSBs did not show significant relations.*

15. Segovia-Siapco G, Sabaté J. Health and sustainability outcomes of vegetarian dietary patterns: a revisit of the EPIC-Oxford and the Adventist Health Study-2 cohorts. Eur J Clin Nutr. 2018 Oct 2. doi: 10.1038/s41430-018-0310-z. *Narrative review comparing 2 ongoing, longitudinal studies with large proportions of vegetarians (essentially no meat intake, but some fish), with new emphasis on sustainability. Risk for all cancers was 16% lower in AHS-2 study for vegans and 11-19% lower in EPIC-Oxford for vegetarians and fish-eaters; morbidity and chronic diseases were overall lower in vegetarians. Greenhouse gas emissions of equicaloric diets were 29% less in vegetarian diet in AHS-2 and 47-60% less for vegetarian/vegan diets in EPIC-Oxford than non-vegetarian/meat-eating diets. Conclude that the beneficial health outcomes and reduced carbon footprints make the case for adoptiing vegetarian diets to address global food supply and environmental sustainability.*

16. Soedamah-Muthu SS, de Goede J. Dairy consumption and cardiometabolic diseases: systematic review and updated meta-analyses of prospective cohort studies. Current Nutrition Reports 2018; 7:171-82. *Update of a 2011 meta-analysis (17 studies) with 9 newer studies. Total dairy and low-fat dairy reduced the risk of diabetes by 3 to 4%, with a larger impact for yogurt (relative risk 0.86, 95% CI 0.83 to 0.90). Total dairy and milk were not associated with coronary heart disease.*

17. Toumpanakis A, Turnbull T, Alba-Barba I. Effectiveness of plant-based diets in promoting well-being in the management of type 2 diabetes: a systematic review. BMJ Open Diabetes Res Care. 2018 Oct 30;6(1):e000534. doi: 10.1136/bmjdrc-2018-000534. *Systematic review of 9 unique controlled (7 randomized) trials (433 participants, mean age 55 years) of plant-based diet interventions for adults with type 2 diabetes. Plant-based diets were associated with significant improvement in emotional well-being, physical well-being, depression, quality of life, general health, HbA1c levels, weight, total cholesterol and low-density lipoprotein cholesterol, compared with several diabetic associations' official guidelines and other comparator diets. No forest plots or data pooling.*

18. Yokoyama Y, Levin SM, Barnard ND. Association between plant-based diets and plasma lipids: a systematic review and meta-analysis. Nutr Rev 2017; 75:683-98. *Systematic review of 30 observational studies and 19 clinical trials assessing association of plant-based diets (for at least 4 weeks) and plasma lipids. Compared to omnivorous diets, participants on vegetarian diets showed greater reductions from baseline in cholesterol (-29.2 vs. -12.5 mg/dL, P<.001) and LDL cholesterol (-22.9 vs. -12.2, P<.001), but no differences in triglycerides.*

19. Yokoyama Y1, Nishimura K2, Barnard ND3, et al. Vegetarian diets and blood pressure: a meta-analysis. JAMA Intern Med. 2014; 174:577-87. *Systematic review of 7 clinical trials (311 adults) and 32 observational studies (21,604 adults) assessing the change in blood pressure (BP) after vegetarian diet as an exposure or intervention. In the clinical trials, vegetarian diets reduced mean systolic BP by 4.8 mm Hg (95% CI, 3.1 to 6.6) and diastolic BP by 2.2 mm*

Hg (95% CI, 1.0 to 3.5). In the observational studies, the mean systolic BP reduction was 6.9 mm Hg (95% CI, 4.7 to 9.1) and the diastolic reduction was 4.7 mm Hg (95% CI, 3.1 to 6.3).

20. Wang F, Zheng J, Yang B, et al. Effects of vegetarian diets on blood lipids: a systematic review and meta-analysis of randomized controlled trials. J Am Heart Assoc 2015; 4: 10):e002408. doi: 10.1161/JAHA.115.002408. *Systematic review of 11 clinical trials with 832 participants that randomized participants to a vegetarian vs. omnivore diet and assessed blood lipids. Vegetarian diets lowered blood concentrations of total cholesterol by 0.36 mmol/L (95% CI, 0.17 to 0.55), LDL cholesterol by 0.34 mmol/L (95% CI, 0.11 to 0.57), and HDL cholesterol by 0.30 (95% CI, 0.10 to 0.50). There was no impact of diet on blood triglyceride levels.*

21. Wu J, Zeng R, Huang J, et al. Dietary protein sources and incidence of breast cancer: a dose-response meta-analysis of prospective studies. Nutrients 2016; 8,730; doi:10.3390/nu8110730. *Systematic review of 46 prospective studies. High soy consumption reduced the risk of breast cancer by 8% relative to low soy consumption in 10 studies with 452,916 participants (relative risk 0.92, 95% CI 0.84 to 1.00). A linear association was observed between soy food intake and decreased breast cancer risk. In contrast, total red meat intake increased breast cancer risk by 7% in 8 studies with 691,383 participants (relative risk 1.07, 95% CI 1.01 to 1.07). No associations were found for poultry, fish, egg, nuts, total milk, and whole milk intake.*

Randomized Controlled Trials of Plant-based Diets vs. Alternatives

Overweight or obese samples

1. Barnard ND, Scialli AR, Turner-McGrievy G, et al. The effects of a low-fat, plant-based dietary intervention on body weight, metabolism, and insulin sensitivity. Am J Med 2005; 118:991-7. *64* ***overweight****, post-menopausal women randomized to low-fat vegan diet vs. control diet (Nat'l Cholesterol Education Program) without limits on portion size or energy intakeD for 14 weeks. Vegan group had higher weight loss (P=.012) and increased insulin sensitivity (P=.017) vs. control group.*

2. Kahleova H, Dort S, Holubkov R, Barnard ND. A plant-based high-carbohydrate, low-fat diet in overweight individuals in a 16-week randomized controlled trial: the role of carbohydrates. *75* ***overweight*** *adults without diabetes randomized to a plant-based high-carbohydrate, low-fat (vegan) diet vs. their current diet. Vegan diet had 6.5 kg more weight loss (95% CI, 4.1 to 8.9), 4.3 kg more fat reduction (95% CI, 3.2 to 5.4), and significantly reduced insulin resistance. Increased carbohydrate intake (as a percentage of energy) correlated significantly (P<.001) with reduced body mass index (r 0.53), fat mass (r 0.55), visceral fat (0.35), and insulin resistance (0.27). Similar associations were observed for increased consumption of total and insoluble fiber. A sub-analysis in a spin-off study (Nutr Diabetes. 2018 Nov 2;8(1):58. doi: 10.1038/s41387-018-0067-4) found that the decrease in fat mass was associated with an increased intake of plant protein (r -0.30, P-0.011) and decreased intake of animal protein (r +0.39, P=.001).*

3. Sofi F, Dinu M, Paglai G, et al. Low-calorie vegetarian versus Mediterranean diets for reducing body weight and improving cardiovascular risk profile: CARDIVEG stud (Cardiovascular Prevention with Vegetarian Diet). Circulation 2018; 137:1103-1113. *118 overweight omnivores, with a low-to-moderate cardiovascular risk profile randomized to a lacto-ovo-vegetarian diet vs. a low-calorie Mediterranean diet for 3 months with a cross-over design. Both diets had similar reductions in body weight (1.8-1.9 kg), body mass index, and fat mass. The vegetarian diet was more effective in lowering LDL cholesterol but the Mediterranean diet was better for triglycerides.*

4. Turner-McGrievy GM, Barnard ND, Scialli AR. A two-year randomized weight loss trial comparing a vegan diet to a more moderate low-fat diet. Obesity 2007; 15:2276-81. *64* ***overweight*** *postmenopausal women randomized to vegan or National Cholesterol Education Program (NCEP) diet for 14 weeks. Vegan diet had significantly greater weight loss at 1 year (11 vs. 4 lbs) and 2 years (7 vs. 2 lbs), with additional benefits when combined with group support meetings.*

5. Turner-McGrievy GM, Wirth MD, Shivappa N, et al. Randomization to plant-based dietary approaches leads to larger short-term improvements in dietary inflammatory index scores and macronutrient intake

compared with diets that contain meat. Nutr Res 2015; 35:97-106. *64* ***overweight and obese*** *adults (BMI 25-50) randomized to dietary instruction on vegan (n=12), vegetarian (13), pescovegetarian (13), semivegetarian (13), or omnivorous (12) diet for 6 months. Vegan diet compared to others showed greater improvements in fiber, carbohydrate, fat, saturated fat, cholesterol, and the Dietary Inflammatory Index scores at 2 and 6 months.*

6. Turner-McGrievy GM, Davidson CR, Wingard EE, Wilcox S, Frongillo EA. Comparative effectiveness of plant-based diets for weight loss: a randomized controlled trial of five different diets. Nutrition 2015; 31:350-8. *Reports a different endpoint (weight loss) on the same patients studied in the 2015 article by the first author in Nutrition Research (64 adults with* ***BMI 25-50****, 12 randomized to vegan diet, 12 omnivorous, and remainders different vegetarian). Vegan diet had greater weight loss than other groups at 6 months (-7.5% vs. -3.2%, P=.03) and had greater decreases in fat and saturated fat (P<.05).*

7. Wright N, Wilson L, Smith M, Duncan B, McHugh P. The BROAD study: a randomized controlled trial using a whole food plant-based diet in the community for obesity, ischaemic heart disease or diabetes. Nutrition & Diabetes 2017; 7: e256; doi:10/1038/nutd.2017.3. *65 adults age 35-70 years who were* ***obese/overweight*** *and had 1 or more chronic disease (type 2 diabetes, ischemic heart disease, hypertension, or hypercholesterolemia) randomized to whole-food plant-based diet (7-15% fat with no energy restrictions) vs. control group with normal care for 12 months. Plant-based group lost about 25 lbs more than control group after 1 year and showed greater improvements in BMI, and cholesterol.*

High cholesterol sample

8. Gardner CD, Coulston A, Chatterjee L, et al. The effect of a plant-based diet on plasma lipids in hypercholesterolemic adults: a randomized trial. Ann Intern Med 2005; 142:725-33. *120 adults (age 30-65y) with* ***LDL cholesterol of 130-190 mg/dl****, and a BMI <31 with otherwise good health, randomized to a plant-based diet (low fat plus some added cheese and eggs) vs. low-fat diet with animal products (both diets had identical total fat, saturated fat, protein, carbohydrate, and cholesterol content) for 4 weeks; plant-based diet had greater effect in lowering total and LDL cholesterol (P=0.02) but not on HDL or triglycerides.*

Overweight (or obese) and high lipids/cholesterol

9. Jenkins DJ, Wong JM, Kendall CW, et al. The effect of a plant-based low-carbohydrate ("Eco-Atkins") diet on body weight and blood lipid concentrations in hyperlipidemic subjects. Arch Intern Med 2009; 169; 1046-54. *47* ***overweight hyperlipidemic*** *adults randomized to a plant-based diet (carbohydrates 26%, vegetable protein 31%, vegetable oil 43%) vs. a lacto-ovo vegetarian diet (carbohydrates 58%, protein 16%, fat 25%) for 4 weeks. Plant-based group had greater reductions in LDL-C (-8.1%, P=.002), total cholesterol to HDL-C ratio (-8.7%, P=.004), and apolipoprotein B/A1 ratios (-9.6%, P=.001). Similar weight loss (about 8.8 lbs) in both groups.*

10. Jenkins DJ, Wong JM, Kendal CW, et al. Effect of a 6-month vegan low-carbohydrate ("Eco-Atkins") diet on cardiovascular risk factors and body weight in hyperlipidemic adults: a randomized controlled trial. BMJ Open 2014; 4:e0003505. doi: 10/1136/bmjopen-2013-003505. *39* ***overweight hyperlipidemic*** *men and postmenopausal women randomized to a plant-based diet (carbohydrates 26%, vegetable protein 31%, vegetable oil 43%) vs. a lacto-ovo vegetarian diet (carbohydrates 58%, protein 16%, fat 25%) for 6 months. 23 completed the study (50% plant-based, 68% control) with similar weight loss (about 22 lbs), but plant-based group had greater reductions in LDL-C (P<.001), triglycerides (P=.005), total cholesterol to HDL-C ratio (P<.001), and apolipoprotein B:A1 ratios (P<.001).*

11. Macknin M, Kong T, Weier A, et al. Plant-based no added fat or American Heart Association Diets' impact on cardiovascular risk in obese hypercholesterolemic children and their parents. J Pediatr 2015; 166:953-9. *30 children-parent pairs with* ***child BMI>95th percentile and child cholesterol >169 mg/dL*** *randomized to a plant-based vs. American Heart Association diet for 4 weeks with weekly 2 hour nutrition education classes. Plant-based group had lower BMI scores, total cholesterol, LDL, and HgB A1C; plant-based group also had higher hsCRP levels.*

Diabetic samples

12. Barnard ND, Jenkins CJ, Turner-McGrievy G, et al. A low-fat vegan diet improves glycemic control and cardiovascular risk factors in a randomized clinical trial in individuals with type 2 diabetes. Diabetes Care 2006; 29:1777-83. *99* ***type 2 diabetics*** *randomized to low-fat vegan diet vs. control diet (American Diabetes Association) for 22 weeks. Both diets improved glycemic control and lipid control, with greater benefits for vegan diet; 43% of vegan group reduced diabetes medications.*

13. Barnard ND, Jenkins CJ, Turner-McGrievy G, et al. A low-fat vegan diet and a conventional diabetes diet in the treatment of type 2 diabetes: a randomized, controlled, 74-wk clinical trial. Am J Clin Nutr 2009; 89:1588S-96S. *99* ***type 2 diabetics*** *randomized to a low-fat vegan diet vs. control diet (American Diabetes Association) for 74 weeks. Both diets had sustained reductions in weight an plasma lipids. When controlling for medication changes, the low-fat vegan diet was better than the control diet in lowering Hb A(1c) (-.40 vs. .01, P=.03), total cholesterol (-20.4 vs. -6.8 mg/dL, P=.01), and LDL cholesterol (-13.5 vs. -3.4 mg/dL, P=.03).*

14. De Natale C, Annuzzi G, Bozzetto L, et al. Effects of a plant-based high-carbohydrate/high-fiber diet versus high-monunsaturated fat/low-carbohydrate diet on postprandial lipids in type 2 diabetic patients. Diabetes Care 2009; 32:2168-73. *Randomized, crossover study of 18* ***type 2 diabetic*** *patients (mean age 59, mean BMI 27) who followed either a plant-based high-carbohydrate & high fiber diet vs. a low-carbohydrate diet high in monounsaturated fats (e.g., red meat, whole milk, nuts, avocados) for 4 weeks, followed by crossover; plant-based diet significantly decreased postprandial plasma glucose, insulin responses, and glycemic variability, with additional positive effects on triglyceride-rich lipoproteins.*

Coronary artery disease samples

15. Ornish D, Brown SE, Scherwitz LW, et al. Can lifestyle changes reverse coronary heart disease? The Lifestyle Heart Trial. Lancet 1990; 336:129-33. *28 adults with* ***coronary artery disease*** *(documented by angiography) randomized to low-fat (10%) vegetarian diet (egg whites and 1 cup of milk/yogurt per day allowed) with lifestyle interventions (stress management training, moderate exercise, smoking reduction, and group psychosocial support) vs. control group with no lifestyle changes for 1 year. Coronary angiography showed reduced stenosis diameter of 5.5% for intervention group vs. 7.4% increase for control group; overall, 82% of intervention group showed regression of coronary artery disease. Intervention group has greater decreases in total cholesterol (P=.019), LDL cholesterol (P=.007), and apolipoprotein B (P=.010) than control group.*

16. Ornish D, Scherwitz LW, Billings, et al. Intensive lifestyle changes for reversal of coronary heart disease. JAMA 1998; 280:2001-7. *4-year extension of 1990 randomized trial in Lancet, now with 48 adults with moderate-severe* ***coronary artery disease*** *(documented by angiography). Primary outcome was stenosis seen on coronary angiography. Compared to the control group, the intervention group had greater reduction in stenosis at 1 year (4.5% improvement vs. 5.4% worsening, statistical significance not stated) and after 5 years (7.9% improvement vs. 27.7% worsening, P<.001). Risk ratio for cardiac events was higher for controls: RR=2.47 (95% I, 1.48 – 4.20).*

17. Shah B, Newman JD, Woolf K, et al. Anti-inflammatory effects of a vegan diet vs. the American Heart Association-recommended diet in coronary artery disease (EVADE CAD) trial. J Am Heart Assoc. 2018 Dec 4;7(23):e011367. doi: 10.1161/JAHA.118.011367. *Randomized, open-label trial with blinded study endpoint of 100 adults (mean age 61 years, 85% male) with angiographically defined* ***CAD*** *(≥50% lestion in an artery with ≥2 mm caliber), without prior myocardial infarction or bypass surgery in prior 3 months, randomized to vegan vs. AHA-recommended diet for 8 weeks. Vegan group had 32% lower (95% CI, 6 to 51%) high-sensitivity C-reactive protein, an inflammatory marker of risk for major adverse cardiovascular outcomes in CAD, and also had 13% reduction in LDL cholesterol (95% CI, 3 to 22%).*

Cancer sample

18. Dewell A, Weidner G, Sumner MD, Chi CS, Ornish D. A very low-fat vegan diet increases intake of protective dietary factors and decreases intake of pathogenic dietary factors. J Am Diet Assoc 2008; 108:347-56. *93 patients with* ***early-stage prostate cancer*** *randomized to very low-fat (10%) vegan diet supplemented with soy protein and lifestyle changes vs. control group of usual care for 1 year. Vegan diet increased protective nutrients and phytochemicals (e.g., fiber from 31 to 59 grams/day) and decreased intake of dietary factors implicated in chronic diseases.*

Multiple sclerosis sample

19. Yadav V, Marracci G, Kim E, et al. Low-fat plant-based diet in multiple sclerosis: a randomized controlled trial. Mult Scler Relat Disord 2016; 9:80-90. *61 patients with multiple sclerosis (mean age 42 years) randomized to a very low-fat plant-based diet or a wait-listed (control) group for 1 year. No difference seen in brain MRI outcomes, number of MS relapses, or disability at 12 months, but the plant-based diet group at 6 months showed reduced LDL cholesterol, total cholesterol, and fatigue scores.*

Multi-morbidity samples

20. Klementova M, Thieme L, Haluzik M, et al. A plant-based gastrointestinal hormones and satiety more than an energy- and macronutrient processed-meat meal in T2D, obese, and healthy men: A three-group randomized crossover study. Nutrients 2019; 11(1). pii: E157. doi: 10.3390/nu11010157. *Sixty men, aged 30-65 years, in 3 groups of 20 each (healthy, obese, and type 2 diabetes) were randomized to one of two meals matched for energy and micronutrients, either a processed-meat and cheese burger (M-meal) or a vegan meal with tofu (V-meal). GI hormones and satiety were assessed at 30, 60, 120, and 180 minutes after eating, and on the next day given the other meal with similar measurements. Repeated measures ANOVA showed increased satiety after the V-meal for all 3 groups: a 9% increase (95% CI, 4.4-13.6%) for diabetics, an 18.7% increase (95% CI, 12.8-24.6%) in obese men, and a 24.6% increase (95% CI, 18.2-31.7%) in healthy men. Gut hormones were also significantly higher after the V-meal in all groups.*

21. Mishra S, Xu J, Agarwal U, Gonzales J, Levin S, Barnard ND. A multicenter randomized controlled trial of plant-based nutrition program to reduce body weight and cardiovascular risk in the corporate setting: the GEICO study. Eur J Clin Nutrition 2013; 67:718-24. *291 GEICO employees with* ***BMI ≥ 25, type 2 diabetes, or both*** *randomized to low-fat vegan diet vs. no dietary changes for 18 weeks. Compared to the control group, vegans had greater decrease in weight (6.5 vs. 1.0 lbs, P<.001), total cholesterol (8.0 vs. 0.01 mg/dL, P<.01), LDL cholesterol (8.1 vs. 0.9 mg/dL, P<.01), and HbA1c (0.6 vs. 0.08%, P<.01). Benefits of vegan diet were more pronounced in participants who completed the trial (66% of vegans, 78% of control group).*

22. Wright N, Wilson L, Smith M, Duncan B, McHugh P. The BROAD study: a randomized controlled trial using a whole food plant-based diet in the community for obesity, ischemic heart disease, or diabetes. Nutr Diabetes 2017; 7(3):e256. doi: 10.1038/nutd.2017.3. *65 subjects aged 35-70 years who were overweight or obese and had at least 1 other chronic condition (type 2 diabetes, ischemic heart disease, hypertensions, or high cholesterol) randomized to a whole-food plant-based diet (not energy restricted) plus twice-weekly facilitated meetings vs. no dietary change for 6 months (75% completed the study). The plant-based group had 3.9 kg more reduction in body mass index (95% CI, 3.7 to 4.0) after 6 months, with little change at 12 months. The plant-based diet did not have a significant impact on total cholesterol levels.*

Rheumatoid arthritis sample

23. Peltonen R, Nenonen M, Helve T, et al. Faecal microbial flora and disease activity in rheumatoid arthritis during a vegan diet. Br J Rheumatol 1997; 36:64-8. 43 patients with rheumatoid arthritis randomized to raw vegan diet rich in lactobacilli vs. control group (ordinary omnivorous diet) for 1 month. Vegan group showed greater rates of improvement (high- and low-improvement) and a significant diet-induced change in fecal flora.

Large Cohort Studies

The China Study

1. Campbell TC, Parpia B, Chen J. Diet, lifestyle, and the etiology of coronary artery disease: the Cornell China Study. Am J Cardiol 1998; 82:181-211. *Studied of mortality data for >50 diseases (including 7 cancers, up to 400-fold variations in geographic incidence) from 6,500 adults in 65 counties and 130 villages in rural mainland China (about 27-year time span), conducted by Cornell University, Oxford University, and Chinese Academy of Preventive Medicine, and funded by NIH and ACS. Chinese diet is typically only 10% animal products and has 3 times higher fiber than Western diet. Coronary artery disease mortality rates were inversely associated with frequency of green vegetables (r=-0.43, P<.01) and monounsaturated fatty acids (r=-0.64, P<.001) but positively associated with salt intake/urinary sodium (r=0.42, P<.01) and plasma apolipoprotein B (r=-0.37, P<.05). These apolipoproteins in turn were positively associated with meat intake (r=0.32, P<.01) and negatively associated with plant protein (r=-0.26, P<.05) and legume (r=-0.26, P<.05) intake. There was no evidence of a threshold beyond which further benefits did not accrue with increasing proportions of plant-based foods in the diet.*

2. Campbell TC, Chen J. Diet and health in rural china: lessons learned and unlearned. Nutrition Today 1999; 34:116-23. *Summary of the significant findings and rationale for the ecological, cross-sectional study (China Study) undertaken in 1983 in 65 Chinese countries to investigate association between dietary/lifestyle factors and widely varying (-10- to 400-fold) localized cancer mortality rates. Chinese diet differed from Western diet in fat (15% vs. 30-45% total energy), dietary fiber (33 vs. 10-11 g/day), and total protein (10% vs. 15-20% of total calories) intakes. Recorded 367 characteristics of diet, medical conditions, lifestyle, and disease mortality. Found that cancers, cardiovascular disease, and diabetes clustered geographically (suggesting common causes), with the strongest correlation being total cholesterol. In turn, chief determinants of increased cholesterol were intakes of fat, animal protein, and meat. Intakes of legume protein and dietary fiber were associated with lowered cholesterol. Single-factor analyses showed positive associations of lipids/fats/cholesterol with liver, colorectal, breast cancer (men and women) and all cancers (men only); and animal foods with colon cancer in men. Green vegetable intake had an inverse correlation with stomach and colon cancer. References are given to several spin-off publications with more detailed analyses.*

EPIC (European Prospective Investigation into Cancer and Nutrition) Study

1. Davey GK, Spencer EA, Appleby PN, et al. EPIC – Oxford: lifestyle characteristics and nutrient intakes in a cohort of 33,883 meat-eaters and 31,546 non meat-eaters in the UK. Public Health Nutrition 2002; 6:259-68. *Describes the EPIC-Oxford cohort as part of the European Prospective Investigation into Cancer, a cohort of over 500,000 adults recruited from 10 European countries in the 1990s. The EPIC-Oxford cohort focuses on dietary and lifestyle characteristics of 4 diet groups (N=65,429): meat-eaters (n=33,883), fish-eaters (n=10,110), lacto-ovo vegetarians (n=18,840), and vegans (n=2,596). Participants were categorized into a diet group based on responses to the following items in the questionnaire: (1) "Do you eat any meat (including bacon, ham, poultry, game, meat pies, sausages)?"; (2) "Do you eat any fish?"; (3) "Do you eat any dairy products (including milk, cheese, butter, yogurt)?"; and, (4) "Do you eat any eggs (including eggs in cakes and other baked foods)?" This study describes the cohort; subsequent publications give specific results.*

2. Appleby PN, Davey GK, Key TJ. Hypertension and blood pressure among meat eaters, fish eaters, vegetarians, and vegans in EPIC-Oxford. Public Health Nutrition 2002; 5:645-54. *Self-reported hypertension found in 15% of male meat eaters, 12% of female meat eaters, 6% of male vegans, and 8% of female vegans. Blood pressure measurements in 11,000 subjects who did not report hypertension showed that vegans had lower systolic (4.2 and 2.6 mmHg) and diastolic (2.8 and 1.7 mmHg) results compared to male and female meat-eaters, respectively.*

3. Appleby PN, Crowe FL, Bradbury KE, Travis RC, Key TJ. Mortality in vegetarians and comparable nonvegetarians in the United Kingdom. Am J Clin Nutr 2016; 103:218-30. *Analysis of 60,310 adults (34% vegetarian, 4% vegan) from the EPIC-Oxford study and Oxford Vegetarian Study (n=10,359) with 5,924 deaths in more than 1 million total years of follow-up. No difference in overall (all-cause mortality between vegetarians, vegans, regular meat eaters, low meat eaters, and fish eaters. Compared with regular meat eaters, vegetarians (including vegans) had 50% lower mortality from pancreatic cancer and cancers of the lymphatic/hematopoietic tissue. When participants were*

excluded if they had changed diet group at least once during follow-up in the early mortality analysis (because a change in diet could have been prompted by onset of illness), vegetarians/vegans 10% lower all-cause mortality, 20% lower mortality from malignant cancer, and 50-60% lower mortality from cancers of the lymphatic/hematopoietic tissue. No differences found between vegetarians and vegans.

4. Bradbury KE, Crowe FL, Appleby PN, et al. Serum concentrations of cholesterol, apolipoprotein A-I, and apolipoprotein B in a total of 1,694 meat-eaters, fish-eaters, vegetarians, and vegans. Eur J Clin Nutr 2014; 68:178-83. *Cross-sectional analysis of 1,694 participants in the European Prospective Investigation into Cancer and Nutrition (EPIC)-Oxford cohort, including 422 vegans (matched on age and sex); vegans had lowest levels of total cholesterol and apolipoprotein B than all other dietary groups, with only a small amount of the differences explained by a lower BMI among vegans.*

5. Spencer EA, Appleby PN, Davey GK, Key TJ. Diet and body mass index in 38,000 EPIC-Oxford meat-eaters, fish-eaters, vegetarians, and vegans. Int J Obes Relat Metab Disord 2003; 27:728-34. *Age-adjusted mean BMI was highest for meat-eaters (24.4 men, 23.5 women) and lowest in vegans (22.5 men, 22.0 women. Half the observed difference was explained by differences in macronutrient intake (e.g., high BMI correlated with increased protein and decreased fiber), but less than 5% of differences were related to lifestyle factors (e.g., smoking, physical activity, education level).*

Lifetime Risk Pooling Project

1. Wilkins JT, Karmali KN, Huffman MD, et al. Data resource profile: the cardiovascular disease lifetime risk pooling project. Int J Epidemiol 2015; 1557-64. *Although not undertaken with a primary intent of dietary analysis, baseline data is available on many of the included cohorts and has been used to analyze risk of incident cardiovascular disease (CVD) and all-cause mortality (see below). This dataset includes over 225,000 unique individuals from 20 prospective, community-based cohort studies (including Framingham) with long-term follow-up data collected between 1948-2010. Information about risk status, demographics, medications, health behaviors, smoking status assessed at baseline and in many studies with repeated measures and outcomes were ascertained using national databases, Medicare claims, and direct review of medical records.*

2. Zhong VW, Van Horn L, Cornelis MC, et al. Associations of dietary cholesterol or egg consumption with incident cardiovascular disease (CVD) and mortality. JAMA 2019; 321:1081-95. *Analysis of 29,615 participants from 6 cohorts (median 17.5y follow-up) with dietary information and no baseline CVD from the Lifetime Risk Pooling Project. Each additional 300 mg of dietary cholesterol/day was associated with an adjusted increase of 17% in CVD (95% CI, 2-26%) and 18% in all-cause mortality (95% CI, 10-26%). Each additional half an egg/day was associated with an adjusted increase of 6% in CVD (95% CI, 3-10%) and 8% in all-cause mortality (95% CI, 4-11%), but were no longer significant after adjusting for dietary cholesterol consumption. Recommend that dietary guidelines and updates consider the dose-response relationship of dietary cholesterol and eggs on CVD and all-cause mortality.*

NurtiNet-Santé Study

3. Alles B, Baudry J, Mejean C, et al. Comparison of sociodemographic and nutritional characteristics between self-reported vegetarians, vegans, and meta-eaters from the NurtiNet-Santé Study. Nutrients 2017; 9:1023; doi:10/3390/nu9091023. *Study of 93,823 French adults (96.6% meat-eaters, 2.5% vegetarians, 0.8% vegans), from a web-based cohort study launched in 2009. Participants completed 3 web-based 24-hour dietary records. Compared with meat-eaters, vegetarians had a higher educational level and were more likely to be female, younger, and self-employed. Vegetarians had the most balanced diets and better adherence to French dietary guidelines, whereas vegans had highest fiber intake (53% above 30g/day vs. 11% of meat-eaters and 28% of vegetarians), but also a higher prevalence of vitamin B12 inadequacy. Conclude that only self-reported vegetarians and vegans may meet nutritional recommendations.*

4. Kane-Diallo A, Srour B, Sellem L, et al. Association between a pro plant-based dietary score and cancer risk in the prospective NutriNet-santé cohort. Int J Cancer 2018; 143(9):2168-2176. doi:

10.1002/ijc.31593. Epub 2018 Aug 7. *Prosopective cohort of 42,544 adults aged 45y or older who complete at least 3 24-hour dietary records during the 1st year of follow-up, with 1,591 new cancer cases (including 487 breast, 243 prostate, 198 digestive, 68 lung) diagnosed during follow-up (2009-2016). A higher pro plant-based dietary score was associated with decreased overall cancer risk (hazard ratio 0.85, 95% CI 0.76 to 0.97), decreased digestive cancer risk (hazard ratio 0.68, 95% CI, 0.47 to 0.99), and decreased lung cancer risk (hazard ratio 0.47, 95% CI 0.25 to 0.90). There were no associations between dietary score and breast or prostate cancers.*

PREDIMED Study: Prevención con Dieta Mediterránea

1. Martinez-González MA, Sánchez-Tainta A, Corella D, et al. A provegetarian food pattern and reduction in total mortality in the Prevención con Dieta Mediterránea (PREDIMED) study. Am J Clin Nutr 2014; 100(Suppl 1): 320S-8S. *Prospective cohort of 7,216 participants (mean age 67 years), enrolled from 2003-2009, at high cardiovascular risk received a validated 137-item food-frequency questionnaire at baseline then yearly for a median of 4.8 years (323 deaths: 76 cardiovascular, 130 cancer, 117 other). Fruit, vegetables, nuts, cereals, legumes, olive oil, and potatoes were positively weighted for the provegetarian food pattern (PFP, range 12-60 points); added animal fats, eggs, fish, dairy products, and meats or meat products were negatively weighted. A PFP ≥ 40 points reduced mortality when compared to a PFP < 30 points (adjusted hazard ratio 0.59, 95% CI 0.40 to 0.88); similar results were found when using updated information on diet (relative risk 0.59, 95% CI, 0.39 to 0.89).*

PURE (Prospective Urban Rural Epidemiology) Study

1. Dehghan M, Mente A, Zhang X, et al. Associations of fats and carbohydrate intake with cardiovascular disease and mortality in 18 countries from five contents (PURE): a prospective study. Lancet 2017; 390:2050-62. *Multi-national cohort study of 135,335 individuals aged 35-70 years without cardiovascular disease enrolled from 2003-13 from 18 low-, middle-, and high-income countries (7 geographical regions: North America/Europe, South America, Middle East, south Asia, China, southeast Asia, and Africa) with 5,796 total deaths (1,649 cardiovascular deaths) and 4,784 major cardiovascular events between 2003 and 2018 (median 7.4 years follow-up). Higher carbohydrate intake (5th quintile vs. 1st quintile) increased total mortality (hazard ratio 1.28, 95% CI 1.12 to 1.46), but no distinction was made between whole grains and refined carbohydrates (which predominate in low- and middle-income countries). Higher fat intake (5th quintile vs. 1st quintile) reduced total mortality (HR 0.77, 95% CI, 0.67 to 0.87) with similar findings for fat types (saturated, monounsaturated, and polyunsaturated). Total fat, saturated fat, and unsaturated fats were not associated with myocardial infarctions or cardiovascular mortality.*
2. Dehghan M, Merite A, Rangarajan S, et al. Association of dairy intake with cardiovascular disease and mortality in 21 countries from five continents (PURE): a prospective cohort study. Lancet 2018; 392:2288-97. *Multi-national cohort study of 136,384 individuals aged 35-70 years without cardiovascular disease from 21 low-, middle-, and high-income countries (originally 18, but 3 joined later), with 10,567 major cardiovascular events or mortalities between 2003 and 2018. Higher dairy intake >2 servings per day compared to no intake was associated with lower risk of composite mortality/events (hazard ratio 0.84, 95% CI 0.75 to 0.94 for all dairy; HR 0.71, 95% CI 0.60 to 0.83 if only whole fat dairy), total mortality (HR 0.83, 95% CI, 0.72 to 0.96), non-cardiovascular mortality (HR 0.86, 95% CI 0.72 to 1.02), and stroke (HR 0.66, 95% CI 0.53 to 0.82). Higher milk intake >1 serving per day vs. no intake was associated with lower composite mortality/events (HR 0.90, 95% CI, 0.82 to 0.99) and yogurt intake >1 serving per day also had lower composite mortality/events (HR 0.86, 95% CI 0.75 to 0.99). No significant associations found between outcomes and higher intakes of butter or cheese.*
3. Miller M, Mente A, Dehghan M, et al. Fruit, vegetable, and legume intake, and cardiovascular disease and deaths in 18 countries (PURE): a prospective cohort study. *Lancet 2017; 390:2037-49. Multi-national cohort study of 135,335 individuals aged 35-70 years without cardiovascular disease from 18 low-, middle-, and high-income countries (7 geographical regions: North America/Europe, South America, Middle East, south Asia, China, southeast Asia, and Africa) with 5,796 total deaths (1,649 cardiovascular deaths) and 4,784 major cardiovascular events between 2003 and 2018 (median 7.4 years follow-up). Higher total fruit, vegetable, and legume intake was associated with lower total mortality (hazard ratio 0.81, 95% CI 0.68 to 0.96) and lower non-cardiovascular mortality (HR 0.84, 95% CI*

0.68 to 1.04, P=.004). Optimal benefit for total mortality seen with 3-4 servings per day (HR 0.78, 95% 0.69 to 0.88), with no change for higher consumption. Similar results for individual analyses of fruits, vegetables, and legumes, but raw vegetables had more benefits than cooked vegetables.

Rotterdam Study

1. Chen Z, Zuurmond MG, van der Schaft N, et al. Plant versus animal-based diets and insulin resistance, prediabetes, and type 2 diabetes: the Rotterdam Study. Eur J Epidemiol 2018; 33:883-93. *Long-term follow-up study of 6,798 adults (mean age 63 years) in a prospective, population-based cohort study with dietary intake data collected at baseline and 3 sub-cohorts (1989-93, 2000-01, and 2006-08). A continuous plant-based dietary index (PBDI), range 0-92, was used to assess adherence to a plant-based vs. animal-based diet. After adjusting for lifestyle and sociodemographic factors, a higher PBDI was associated with lower insulin resistance, lower prediabetes risk (hazard ratio 0.89, 95% CI 0.81 to 0.98), and lower type 2 diabetes risk (hazard ratio 0.82, 95% CI 0.73 to 0.92). After additional adjustment for body mass index, the association with insulin resistance remained significant but not for prediabetes risk.*

2. Chen Z, Schoufour JD, Rivadeneira F, et al. Plant-based diet and adiposity over time in a middle-aged and elderly population: the Rotterdam Study. Epidemiology. 2018 Nov 30. doi: 10.1097/EDE.0000000000000961. *Follow-up of 9,633 adults, with data collection (anthropometrics and body composition) every 3 to 5 years from 1989 to 2016 (median 7.1 years), showed that participants with a 10 point higher score on the plant-based dietary index score (range 0 to 92) a lower BMI by 0.70 kg/m over the study period (95% CI 0.59 to 0.81), lower waist circumference by 2.0 cm (95% CI, 1.7 to 2.3), lower fat mass index by 0.66 kg/m (95% CI, 0.52 to 0.80), and lower body fat percentage by 1.1 points (95% CI 0.84 to 1.10).*

Seventh-Day Adventist Cohort Studies

3. [Adventist Mortality Study]. Kahan HA, Phillips RL, Snowdon DA, Choi W. Association between reported diet and all-cause mortality. Twenty-one year follow-up on 27,530 adult Seventh-day Adventists. Am J Epidemiol 1984; 119:775-87. *Long-term follow-up on original study conducted between 1960 and 1966, by matching food consumption at beginning of study with death certificates for 1960 to 1980. All-cause mortality was significantly reduced with green salad consumption and increased for eggs and meat, when adjusted for age, sex, smoking history, history of major chronic disease, and age at initial exposure to the Adventist Church. This is one of many studies that have been published based on this cohort.*

4. [Adventist Health Study 1]. Beeson WL, Mills PK, Phillips RL, Andress M, Fraser GE. Chronic disease among Seventh-day Adventists, a low-risk group: rationale, methodology and description of the population. Cancer 1989; 64:570-81. *Describes cohort of 34,198 Adventists (55% lacto-ovovegetarian) age 30y or older, enrolled in 1976 and followed for 6 years, with reports on all-cause mortality for 8 years (1975-82) and incident cancers and ischemic heart disease (1977-82). Subsequent analyses give specific findings based on dietary patters (e.g., vegan vs. vegetarian vs. ominivorous).*

5. [Adventist Health Study 2]. Butler TL, Fraser GE, Beeson WL, et al. Cohort profile: the Adventist Health Study-2 (AHS-2). Int J Epidemiol 2008; 37:260-5. *Large cohort study designed to investigate role of foods, nutrients, lifestyle factors, and metabolic risk indicators in cancer causation, especially breast, colon, and prostate. Recruited 96,000 Seventh-day Adventists age 30y or older from 2002 through 2007. Dietary pattern definitions were based on measured foot intake rather than self-identification of dietary patterns. Multiple subsequent publications report findings.*

6. Orlich MJ, Singh PN, Sabate J, et al. Vegetarian dietary patterns and mortality in Adventist Health Study 2. JAMA Intern Med 2013; 173:1230-8. *Analysis of 2,570 deaths from a subset of 73,308 participants from the AHS-2 study (mean follow-up 5.8 years) should 12% decrease in adjusted all-cause mortality (95% CI, 3-20%) for all vegetarians vs. nonvegetarians. Greater decrease for men (18%, 95% CI, 6-28%) than for women (7%, -5 to 18%). Vegetarian diets also had lower cardiovascular mortality, noncardiovascular noncancer mortality, renal mortality, and endocrine mortality. The lack of similar results with the EPIC-Oxforsd cohort could be because AHS-2 participants consumed less saturate fat, twice as much fiber, and were generally nonsmokers and nondrinkers.*

Singapore Chinese Health Study

1. Hankin JH, Stram DO, Arakawa K, et al. Singapore Chinese Health Study: development, validation, and calibration of the quantitative food frequency questionnaire. Nutr Cancer. 2001; 39:187–195. *Describes the cohort of 63,257 Chinese persons aged 45–74 years (citizens or permanent residents) enrolled between 1993 and 1998, with in-person interviews at recruitment to collect information on habitual diet (165-item food frequency questionnaire), demographic factors, height, weight, tobacco use, physical activity, female menstrual and reproductive, history, and medical history. The first and second follow-up interviews were conducted by telephone calls made during 1999–2004 and 2006–2010, respectively, with a participation rate of 89.9% for the first follow-up and 81.9% for the second follow-up.*

2. Chen GC, Koh WP, Neelakantan N, et al. Diet quality indices and risk of type 2 diabetes mellitus: the Singapore Chinese Health Study. Am J Epidemiol 2018; 187; 12: DOI: 10.1093/aje/kwy183. *Subset of 45,411 adults (aged 45-74 years) from the Singapore Chinese Health Study – who were free of diabetes, cancer, and cardiovascular disease at baseline (1993-1998) – followed through 2010 (median 11.1 years) for type 2 diabetes diagnosis. Dietary pattern scores for the highest vs. lowest quintile showed reduced incidence of diabetes for the alternate Mediterranean diet (aMED) of 16% (95% CI, 8-23%) for the Alternate Healthy Eating Index 2010 of 21% (95% CI, 13-27%), for the Dietary Approaches to Stop Hypertension (DASH) diet of 29% (95% CI, 21-35%), an overall plant-based index of 6% (95% CI, 3-8%), and for a healthful plant-based index of 7% (95% CI, 5-10%).*

Tzu Chi Health Study, Taiwan

1. Chang CM, Chiu THT, Chang CC, Ming-Nan L, Lin CL. Plant-based diet, cholesterol, and risk of gallstone disease: a prospective study. Nutrients 2019, 11, 335; doi:10.3390/nu11020335. *Analysis of 4,839 participants with 29,295 person-years of follow-up from the Tzu Chi Health Study, which included 6,002 participants (ages 18-87 years) recruited from 2007-2009, primarily (77%) from a Buddhist Hospital. A Food Frequency Questionnaire and dietary questionnaire were used to assess intake and participants were encouraged, but not required, to become vegetarians. Vegetarian diet reduced risk of symptomatic gallstone disease by 48% in women (HR 0.52, 95% CI, 0.28-0.96), but not in men, compared with non-vegetarian diet, adjust for age, education, smoking, alcohol, physical activities, diabetes, kidney diseases, BMI, lipid-lowering medication, and hypercholesterolemia. Women non-vegetarians with high cholesterol had 3.8 times risk of gallstone disease (HR 3.81, 95% CI 1.61-9.01) compared with vegetarians with normal cholesterol.*

US Healthcare Worker Studies (Nurses and Health Professionals)

1. Song M, Fung TT, Hu FB, et al. Association of plant protein intake with all-cause and cause-specific mortality. JAMA Int Med 2016; 176:1453-63. *Analysis of 131,342 participants (65% women, mean age 49 years) from the Nurses' Health Study (121,700 US female nurses from 1980 to 2012) and the Health Professionals Follow-up Study (51,529 US male health professional from 1986-2012). Participants rated by survey every 2 years how often, on average, they consumed standard portions of different foods in the prior year, from which the investigators calculated protein (animal vs. plant) as percent of total energy consumption. For participants with at least 1 unhealthy lifestyle factor (e.g., smoking heavy alcohol, overweight/obesity, physical inactivity) a higher plant protein intake significantly reduced all-cause mortality and cardiovascular mortality (adjusted for lifestyle and dietary risk) and a higher animal protein intake significantly increased cardiovascular mortality (but not all-cause mortality). When 3% of animal protein was replaced with plant protein, all-cause mortality fell by 34% if processed red meat was replaced, 19% when eggs were replaced, and 12% when unprocessed red meat was replaced.*

2. Satija A, Bhupathiraju SN, Spiegelman D, et al. Healthful and unhealthful plant-based diets and the risk of coronary artery heart disease in US adults. J Am Coll Cardiol 2017; 70:411-422. *Pooled analysis of 73,710 women from the Nurses' Health Study (1984-2012), 92,329 women from the Nurses' Health Study 2 (1986-2012), and 43,259 men in the Health Professionals follow-up study (1986-2012) who were free of chronic disease at baseline. A plant-based diet index (PDI) score was created, with higher scores for healthy plant foods (e.g., whole grains, fruits, vegetables, nuts, legumes, oils) and lower scores for less healthy foods (juices, sweetened beverages, refined grains, potatoes, fried food, sweets) and for animal foods. There were 8,631 coronary heart disease (CHD) incidents over 4.8 million person-*

years of follow-up. A high PDI reduced risk of CHD by 25% (hazard ratio 0.75, 95% CI 0.68 to 0.83, p trend <.001) and a low (unhealthy) PDI increased risk by 32% (HR 1.32, 95% CI 1.20 to 1.46, p trend <.001). Conclude that higher plant-based intake substantially lowers CHD risk.

3. Satija A, Bhupathiraju SN, Rimm EB, 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; 14:13(6):e1002039. *Pooled analysis of 69,949 women from the Nurses' Health Study (1984-2012), 90,239 women from the Nurses' Health Study 2 (1991-2011), and 40,539 men from the Health Professionals Follow-Up Study (1986-2010) who were free of chronic disease from baseline. A plant-based diet index (PDI) score was created, with higher scores for healthy plant foods (e.g., whole grains, fruits, vegetables, nuts, legumes, oils) and lower scores for less healthy foods (juices, sweetened beverages, refined grains, potatoes, fried foods, sweets) and for animal foods. There were 16,162 new cases of type 2 diabetes during 4.1 million person-years of follow-up. Looking at extreme deciles, a high PDI reduced incidence of type 2 diabetes by 49% (hazard ratio 0.51, 95% CI, 0.47 to 0.55, p trend <.001) and a low (unhealthy) PDI increased risk by 16% (HR 1.16, 95% CI 1.08 to 1.25, p trend <.001). The impact of a high PDI on diabetes decreased from 49% to 20% after adjusting for body-mass index; the impact of an unhealthy PDI was unchanged. Conclude that higher plant-based intake substantially lower risk of developing type 2 diabetes.*

Intervention Studies Without a Comparison or Control Group

Coronary Artery Disease

1. Esselstyn CB Jr, Ellis SG, Medendorp SV, Crowe TD. A strategy to arrest and reverse coronary artery disease: a 5-year longitudinal study of a single physician's practice. J Fam Pract 1995; 41:560-8. *Cohort of 22 patients with angiographically documented, severe coronary artery disease who took cholesterol-lowering drugs and followed a plant-based diet with <10% fat. 5 patients dropped out within 2 years, 17 maintained the diet (mean 5.5 years follow-up). Cholesterol reduced from mean 246 mg/dl to 150 mg/dl. Of 25 cardiac lesions, 11 regressed and 14 remained stable. For the 11 subjects remaining after 10 years all had arrest of disease and none had new infracts.*

2. Esselstyn CB Jr. Updating a 12-year experience with arrest and reversal therapy for coronary hear disease. Am J Cardiol 1999; 84:339-41. *Cohort of 24 adults (23 men, 1 woman) with severe, angiographically demonstrated coronary artery disease (but all non-smoking, non-hypertensive, non-diabetic) who agreed to follow a plant-based diets with <10% of calories from fat (no oil, but did allow skim milk and no-fat yogurt); 18 patients adhered to the diet and 6 were dropped from the study after 12-18 months. After 5 years, 11/18 in the adherent group had angiography, showing disease arrest in 100% and regression in 8 (73%). Adherent patients after 12 years had no extension of clinical disease, no coronary events, and no interventions, despite having 49 coronary events in the 8 years before the study. Mean total cholesterol was 145 mg/dl.*

3. Esselstyn CB Jr, Gendy G, Doyle J, Golubic M, Roizen MF. A way to reverse coronary artery disease? J Fam Pract 2014; 63:-63. *Cohort study of 198 consecutive, self-selected nonsmoking adults (91% male) with multiple comordibities (hyperlipdemia 161, hypertension 60, diabetes 23) who voluntarily asked for counseling in plant-based nutrition (whole-food, plant-based diet with no added oil, salt, sugar or processed foods) for disease treatment and were followed for a mean of 44 months (patients were encouraged to exercise and were later asked to avoid caffeine and fructose). Patients who adhered (e.g., avoided all meat, fish, dairy, and added oils) to the diet (89%) did better than those who did not (11%) in terms of symptom reduction (94% vs. 0%), disease reversal (22% vs. 0%), and adverse events (0.6% vs. 62%) (e.g., sudden cardiac death, heart transplant, ischemic stroke, coronary artery bypass surgery). Although the results are impressive, generalizability is limited by self-selection, reliance on patient history for baseline conditions (e.g., no angiogram as in prior study), and telephone follow-up to assess outcomes and results.*

Fibromyalgia

4. Kaartinen K, Lammi K, Hypen M, et al. Vegan diet alleviates fibromyalgia symptoms. Scand J Rheumatol 2000; 29:308-13. Comparative (non-randomized) study of 33 patients with fibromyalgia on an uncooked vegan diet vs. omnivorous diet for 3 months. Vegan group had significant reductions in pain, joint

stiffness, BMI, and serum cholesterol; and significant improvements in quality of sleep, general health, and overall rheumatology symptoms.

Rheumatoid arthritis

5. McDougall J, Bruce B, Spiller G, Westerdahl J, McDougall M. Effects of a very low-fat, vegan diet in subjects with rheumatoid arthritis. J Altern Complement Med 2002; 8:71-5. *24 patients (mean age 56 years) with moderate-to-severe rheumatoid arthritis (RA) placed on a low-fat (10%) vegan diet for 4 weeks. All measures of RA symptomatology decreased significantly, except for morning stiffness. CRP and RA factor decreased; ESR was unchanged.*

Influential Books

1. Campbell TC, Campbell TM II. The China Study: The Most Comprehensive Study of Nutrition Ever Conducted and the Startling Implications for Diet, Weight Loss and Long-Term Health. Dallas: Benbella Books; 2006.
2. Esselstyn CB Jr. Prevent and Reverse Heart Disease: The Revolutionary, Scientifically Proven, Nutrition-Based Cure. New York: Penguin Group; 2007.
3. Greger M, Stone G. How Not to Die: Discover the Foods Scientifically Proven to Prevent and Reverse Disease. New York: Flatiron Books
4. Stone G. Forks Over Knives: The Plant-Based Way to Health. New York: The Experiment, LLC; 2011.

Prevalence data: Radnitz C, Beezhold B, DiMatteo J. Investigation of lifestyle choices of individuals following a vegan diet for health and ethical reasons. Appetite 2015; 90:31-6.

- ✓ US population 1997: 300-500,000 vegans; about 0.11 to 0.19% population
- ✓ US population 2012: 2.5-6.0 million vegans; about 1-2% population (about 10-fold increase in 15 years)
- ✓ Other countries: Israel 5% vegans, UK 2%, Australia 1%, Germany 1%
- ✓ India: 31% vegetarians, but relatively few vegans

Google trends: Use of "vegan" as search term has increased 6-fold from 2004 to 2017, and 2-fold from just 2015 to 2017. Top search locations are Australia, Canada, New Zealand, US, and UK.

Quotations of Note

From TC Campbell: Nutritional renaissance and public health policy. J Nutr Biol 2017; 3:124-38.

"The health benefits associated with whole plant-based foods are not sufficiently proven for many people. Thus I suggest that the evidence supporting the health value of a whole food diet be considered a hypothesis, not proven fact. For me, this evidence is more than convincing enough to make major decisions, public and private. Whether this evidence rises to the level of a traditionally defined 'fact' is not necessarily the right question. Very little traditionally produced biomedical research ever becomes unequivocal fact because what is true for one set of experimental conditions may be different for other conditions…The narrower the scope of diets being investigated, the more compromised becomes the evidence supporting food guidelines for the larger population."

"Among diet and health studies on large cohorts of people, virtually none of these cohorts, to date, have included individuals accustomed to using the whole food plant-based dietary lifestyle. Vegans and vegetarians approach the nutrition of this dietary lifestyle and, in doing so, are known to have lower mortality rates for non-communicable chronic diseases [Sobiecki JG, Nutr Res 2016; 36:464-77][Huang T, Ann Nutr Metab 2012; 60:233-40], but this cannot be the full expression of health effects because, according to the most robust dietary studies on vegans and vegetarians, the mean contents of total fat and sugar for vegans, vegetarians and meat eaters were the same, 30-31% fat and 22-23% sugar" [Sobiecki JG, Nutr Res 2016; 36:464-77]."

"There is still an abundance of evidence which supports, as a goal, the use of a diet wholly composed of whole food plant-based foods, without added oil or refined carbohydrates. Two kinds of evidence convincingly expose the need for dietary change and offer

a solution to support this change. These are 1) breadth of effect [Campbell TMI, Primary Care Reports 2012; 18:25-35], and 2) reversal of disease [Esselstyn CB Jr, J Fam Pract 1995; 41:560-8 and Am J Cardiol 1999; 84:339-41][Ornish D, Lancet 1990; 336:129-33]. Breadth of effect evidence challenges the contemporary and popular concept of 'targeted drug therapy,' which encourages research and development of specific drugs for controlling specific diseases…Reversal of disease means using the same nutritional protocol to prevent and to treat disease, which challenges the use of pills and procedures to control disease. Both of these kinds of evidence are best appreciated when considering and appreciating the infinitely complex, dynamic and unknowable details of nutritional function."

sustainability

MDPI

Review

A Comprehensive Review of the Benefits of and the Barriers to the Switch to a Plant-Based Diet

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Abstract: In recent decades, the food industry has been faced with new challenges, and it has had to develop new types of diets and produce new types of foods that can slow down the spread of chronic diseases. The aim of our research was to identify the characteristics of plant-based nutrition, based on international and Hungarian literature. The comprehensive analysis was performed based on the theoretical model called Theory of Planned Behavior, in the course of which the perceived and objective benefits of and barriers to the conversion to a plant-based diet were examined. According to our results, the main benefits of plant-based nutrition are its many factors associated with a reduction in risk of developing numerous chronic diseases. This is followed by benefits of well-being and satisfaction, followed by ethical and environmental benefits. The most commonly reported inhibitory factor of a vegetarian diet is the enjoyment of eating meat and the difficulty in giving up meat consumption. This is followed by health considerations, e.g., lack of various ingredients in foods. Convenience and taste factors are also important disincentives, as well as the irrelevant nature of some plant-based nutrition information sources. Besides, social barriers, negative discrimination, and negative effect on mental health associated with them can also be a hindrance, as can financial barriers. The classification developed during our analysis can serve as a relevant guideline for decision-makers, and also as a basis for further primary qualitative and quantitative research.

Keywords: plant-based diet; benefits and barriers; vegan; vegetarian; consumer attitudes; theory of planned behavior; perceived; objective; comprehensive review; international and Hungarian

1. Introduction

The past decades have seen a dramatic worldwide increase in chronic diseases. Obesity, diabetes, cardiovascular diseases, respiratory disorders, and malignant tumors account for 63% of total mortality at a global level annually. Furthermore, chronic diseases represent almost 45.9% of all diseases worldwide [1]. People's health has deteriorated over the past decades, a phenomenon which can be associated with an unhealthy way of life, unbalanced nutrition, and the excessive consumption of discretionary foods and drinks [2]. According to Tóth [3], throughout their lives, people consume more than one and a half tons of food per capita, the composition of which is of particular importance, since 40–60% of illnesses depend on diet to a great extent. Hungarians spend 23.1% of their income on food, alcoholic beverages, and tobacco, and this percentage can be regarded as a significant proportion [4]. Thus, the composition of our daily diet does indeed make a difference.

Parallel to the rapid spread of chronic diseases, the population of developed countries is ageing at an increasing rate; consequently, the numbers of inactive people and those requiring medical treatment

is growing. Moreover, average life expectancy at birth is also increasing, and, together with ageing, this will impose an ever-increasing burden on healthcare systems in the future. As a general rule, the longer people live, the more expensive their medical treatment is, which, among other things, can be attributed to higher levels of inactivity, as well as stressful lifestyles [1,5]. Among the numerous components of sustainability (social, ecological, and economic), the dimension of health also has a major role [6]. Tilman and Clark [7] claim that the proper selection of our diet and the sustainability of the environment and human health are closely related factors. Managing them presents a global challenge and is of high priority in terms of the environment and public health. The factors outlined above have obviously posed new challenges to the food industry. It has become necessary to develop nutritional habits and produce foods which, because of their positive impacts on health, are able to slow down the spread of the chronic diseases afflicting humankind and lay the foundations for a longer healthy life expectancy for the ageing population [1]. Therefore, health is of outstanding value for the majority of the society. To specify the barriers to the conversion to a health-conscious lifestyle, we need to define health behavior and examine the factors influencing it.

Consumers, in most cases, draw a parallel between a switch to a healthy lifestyle and a change in their dietary habits. According to Fürediné Kovács [8], there are three potential ways which lead to a conversion to a healthy diet. On the one hand, a healthy diet can be regarded as a way to cure illnesses, while on the other hand, a new type of health consciousness can be observed which offers the chance to achieve well-being and highlights the health-promoting functions of nutrition.

Between the abovementioned two approaches, a third way can also be observed, which focuses on consumer behavior aimed at reducing and avoiding risks. When adopting this approach, the consumer consciously chooses foods with which certain negative effects on health can be prevented.

A change has taken place in nutrition research that can be characterized by diseases relating to malnutrition (bulimia and anorexia), by sociocultural embeddedness and by an intra-active vision of human beings (nutrition as part of a way of life). Consequently, nutrition as a preventive and therapeutic method at the same time can be considered an integral part of the practical toolkit of health psychology. Vegetarianism (a plant-based diet) can be linked to the intra-active vision of human beings, emphasizing a conscious way of life, and health-consciousness in the life of consumers [9,10].

McManus [11], a contributor to the Harvard Medical School claims the following: "Plant-based or plant-forward eating patterns focus on foods primarily from plants. This includes not only fruits and vegetables, but also nuts, seeds, oils, whole grains, legumes, and beans. It does not mean that you are a vegetarian or a vegan and never eat meat or dairy. Rather, you are proportionately choosing more of your foods from plant sources". It should also be added to the definition above that the plant-based diet can be used at every stage of an individual's life cycle [12]. People using vegetarian (plant based) diets can be classified into different subgroups. Vegans do not consume any products of animal origin; therefore, they avoid such types of products in their everyday lives, and this attitude is not restricted to their meals. Lacto-vegetarians consume milk and dairy products, as well. Semi-vegetarians predominantly use a plant-based diet, which, however, may be moderately supplemented with the consumption of poultry and fish. Flexitarians are similar to the previously mentioned subgroup; they mostly eat vegetables and fruit, but they do not have to give up on meat and fish. Pesco-vegetarians are considered to be one of the most permissive users of a plant-based diet, apart from ingredients of plant origin, milk, dairy products, eggs, and fish also feature in their diet [2,13,14].

The history of plant-based diets goes back hundreds of years. Several historical figures, including Pythagoras, Plato, George Bernard Shaw, Mahatma Gandhi, Albert Einstein, Leonardo da Vinci, and Leo Tolstoy followed such a diet [15]. However, these diets have become widespread nowadays, a phenomenon which can be attributed to health-consciousness becoming increasingly popular among the general population. These dietary habits, however, cannot be considered fashion diets, because the majority of them have been designed on the basis of scientific facts. Thus, the plant-based diet is a nutritional trend where foodstuffs of animal origin, such as eggs, meat, meat products, milk and dairy products, and highly processed foods, such as oil, sugar, and flour, are limited to the background.

Most of these diets comprise mainly raw, unprocessed or minimally processed foods of plant origin, such as cereals, tubers, legumes, vegetables, and fruit. It is important to point out that this type of diet cannot be regarded as uniform or standardized, since the particular dietary trend is usually chosen by the individual, possibly after having consulted a specialist (usually a dietician). People may convert to a plant-based diet for different reasons, including animal protection, or political, economic, ethical, ecological, and spiritual motives, or because a traditional diet has a negative effect on health. Plant-based diets have been of increasing significance to nutritional science, and to wider medical science, as it deals with nutrition [15–20]. Among the attitudes (motivations) of vegetarians, priority is attributed to perceived health benefits. People using a plant-based diet do not consider meat a necessary and integral part of their daily nutritional needs. Some individuals may choose simply to limit the amount of animal product consumed rather than removing it completely from the diet [9,21,22].

The precise proportion of consumers following a vegetarian diet is particularly difficult to assess, since several types of plant-based diets are differentiated a priori by the profession and they may vary even across countries. In addition, there are no standardized surveying methods valid across countries that would make it possible to differentiate among those following a vegetarian diet in the whole population. It must definitely be taken into account that the number and proportion of individuals adopting a plant-based diet may be higher as compared to the actual situation, due to the different methodology research reports used. Below, some major tendencies are highlighted which are based on data and information provided by vegetarian organizations in different countries. The highest proportion of vegetarians can be found in India, where 30–40% of the population follows such a diet [23,24]. In Europe, the proportion of vegetarians is the highest in Italy, the UK, and Germany (9%), while in the Netherlands it is 4% [15]. It is also worth highlighting Austria and Switzerland, where the proportion of vegetarians is 3–3% [15,25]. Cramer et al. [26] carried out a nationally representative questionnaire in the USA entitled the "National Health Interview Survey". Only 4% of the participants reported using a vegetarian diet and 2% a vegan diet for health reasons within the past 12 months.

These people were typically aged from 30 to 65 years, were female, college educated, chronically ill, and physically active. They were less likely to be in a relationship. Only 6% of them consulted a specialist concerning their health problems (being overweight or obese were the problems most often mentioned). Twenty-six percent of them started to follow the special diet because of a specific health problem [26]. The number of Hungarian vegetarians is estimated by experts to be approximately 150,000, which represents 1.5% of the population (to the best of our knowledge, no representative survey has been carried out in this area) [14]. According to the Ahimsza Hungarian Vegetarian Association, 43% of Hungarian vegetarians are ovo-lacto vegetarians, 46% are lacto vegetarians, and 11% are vegans [14].

The key objective of our research was to identify the characteristics of plant-based diets within different special dietary trends, with the help of relevant Hungarian and international literature sources and to specify the benefits of and barriers to converting to and sustaining a new vegetarian diet. Our research was conducted to identify the benefits and barriers concerning plant-based diets, which were already dealt with in several previous research studies [21,22,27–32].

In addition to presenting international literature on the topic, we also considered it important to introduce the situation in Hungary, from the perspective of consumer behavior. It has been determined to what extent Hungarian consumers follow global cultural and consumer trends as concerns plant-based diets.

The logical structure of the literature research was based on international sources examining the benefits of and barriers to a plant-based diet. The uniqueness of our analysis lies in the Theory of Planned Behavior Model, in which we have integrated the perceived and objective benefits and barriers. We believe that the theoretical model has not been used in the literature reviews published to date, and this model can provide a framework for future research.

2. Material and Methods

We conducted a comprehensive literature review during the analysis. In the first step, relevant articles connected to the plant-based-diet topic were collected. Our aim was to collect not just international sources but Hungarian sources too. As a second step, we categorized the relevant literature in two steps: First, we examined the potential perceived and objective benefits, and then the potential perceived and objective barriers to the switch to a plant-based diet.

The behavior of an individual is influenced both by the perceived benefits and barriers of a particular action. Perceived benefits refer to the individual's assessment of the value and effectiveness of a particular behavior, in order to reduce the risks of action. If the individuals believe that, by taking an action, they are able to reduce the potential risks, they will be likely to engage in that behavior. Perceived barriers are factors identified during the change of behavior of an individual, which may prevent behavioral change that appears to be fundamentally optimal by the perceived benefits. For behavior change to actually happen, the perceived benefits must outweigh the perceived barriers [33–35].

In order to give a systematic description of the benefits and barriers related to plant-based diets, we used the Theory of Planned Behavior (TPB) model (Figure 1) [36–40]. The TPB model is a theoretical approach which examines, among others, the belief in the manageability of health. Perceived behavioral control depends on personal and external factors that directly influence behavior, and also, together with subjective norms and attitudes toward action, have an effect on behavioral intention.

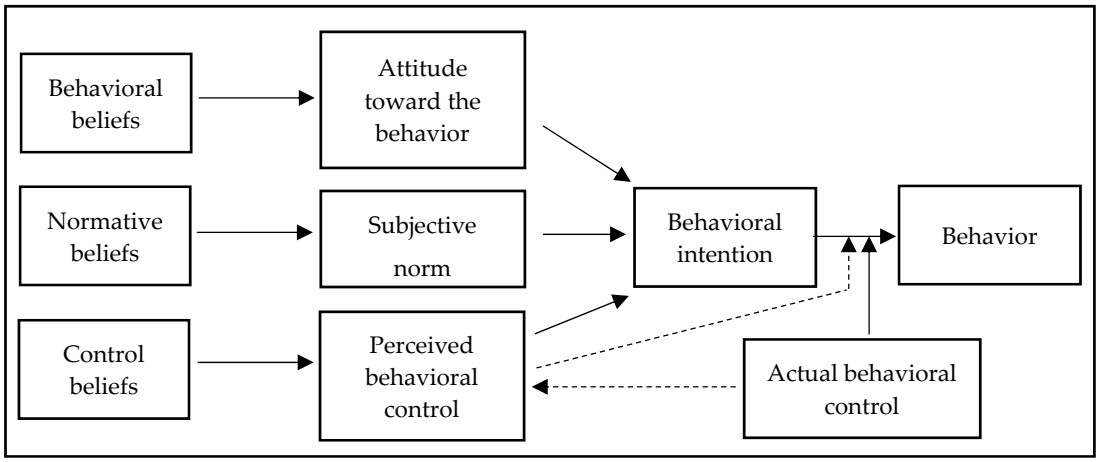

Figure 1. Theoretical research model based on the Theory of Planned Behavior. Source: Authors' own editing, based on Ajzen [36], Ajzen [37], Ajzen-Fishbein [38], Cheung et al. [39], and Fishbein [40].

Certain elements of the process are based on different beliefs (such as behavioral, normative, and control beliefs). These are followed by attitudes toward a particular action (behavior), subjective norms, and perceived behavioral control. The elements of the TPB model described above affect the behavioral intention and through this, affect behavior. The perceived benefits and barriers are part of the beliefs in the TPB. They represent antecedents of the attitude, subjective norm, and perceived behavioral control and indirectly the behavioral intention and behavior. The objective benefits and barriers appear in the "actual behavioral control" component. When individuals feel, to a certain extent, able to control their behavior, (they are at the level of controllability of the behavior—threshold of stimulation), they are expected to act if the favorable opportunity arises. Consequently, the actual behavioral control refers to the level, which, considering the abilities, tools, and resources, is sufficient for the individual to feel able to implement that particular behavior (they are already aware that they are responsible for their own health). Thus, the successful implementation of the behavior depends not only on positive intent, but also on a sufficient level of behavioral control. If the perceived behavioral control is of adequate level, that is the individual feels maximally able to implement the behavior, then, optimally, the level of actual and perceived behavioral control is the same (which results in

action) [37,38,40]. This theoretical structure provided the framework for research, making it possible for us to systematically represent the factors identified during the analysis.

We made a comprehensive overview of the benefits of the plant-based diet and differentiated our findings in three categories: (1) factors beneficial to health; (2) benefits linked to well-being and contentment; and (3) ethical and environmental benefits. On the other hand, we highlighted our results about the barriers to switch to a plant-based diet and determined seven categories: (1) the enjoyment of eating meat; (2) essential nutrient deficiency risks; (3) convenience and taste factors; (4) difficulty in obtaining information; (5) social constraints and negative discrimination; (6) negative effect for mental health; and (7) financial constraints.

Various relevant search expressions' combinations were used in our analysis: "plant-based"; "vegetarian"; "vegan"; "diet"; and "consumer attitudes". We used international databases (EBSCO, Emerald Insight, ScienceDirect, and Web of Science) for data and information gathering, without limiting the publication date of articles. The oldest article included is from 1974, and the most recent one is from 2019. During the search, only the sources relevant to our research aim were retained.

Altogether, 101 literature sources (14 Hungarian and 87 international references) were collected. We collected literature both with primary and secondary data; in some cases we analyzed other review articles too. We studied 81 academic articles, 16 books, and 4 other sources from the internet.

Based on our results, the information about the plant-based diet has risen over recent years. For the 1970s and 1980s, we found just five publications, and for the 1990s, there were just nine publications. The number of publications on the subject has increased dramatically in the 2000s (39 publications) and 2010s (48 publications).

3. Results

3.1. Plant-Based Diets and Influencing Factors

In nutritional science, there are two ways to differentiate the so-called special diets. One approach includes special diets that are adopted because of a particular illness, such as a food intolerance or a food allergy. These diets are beyond the scope of the present study and are not discussed here in detail. The other differentiation is based on special diets adopted by individuals on their own initiative (a plant-based vegetarian diet and its specific forms).

A plant-based diet has already been defined above; however, it is worth adding that it can be considered a collective term, including diets ranging from a strict plant based one to semi-vegetarian or pesco-vegetarian. Plant-based diets consist of vegetables, fruit, legumes, oilseeds, and whole grain cereals. These components may be supplemented with milk, dairy products, and eggs in some alternative vegetarian diets or in rare cases by poultry and fish. It is also important to stress that those following a vegetarian diet mostly prefer their meals with ingredients which have been changed as little as possible and which have undergone only minimal industrial preprocessing as compared to their original form. In this way, phytonutrients (compounds in plants having a positive effect on health) can be more efficiently preserved [20]. The general recommendations for a plant-based diet regarding the food categories above are shown in Table 1.

Table 1. General recommendations for a plant-based diet.

Groups of Ingredients	Recommended Daily Allowances
Vegetables (with the exception of starchy vegetables)	"Ad libitum", aiming at diversity
Fruit	2–4 portions (1 portion = 1 medium-sized piece or 1/2 cup)
Whole grain cereals (e.g., oat, brown rice, quinoa)	6–11 portions (1 portion = 1/2 cup of cooked cereals or one slice of whole wheat bread)
Legumes (lentils, peas, beans, soybean)	2–3 portions (1 portion = 1/2 cup of cooked legumes)
Leaf vegetables (e.g., broccoli, lettuce, kale)	At least 2–3 portions (1 portion = 1 cup raw or 1/2 cup of cooked leaf vegetables)

Table 1. *Cont.*

Groups of Ingredients	Recommended Daily Allowances
Oilseeds (e.g., pistachio, almond, walnut)	30–55 g
Seeds (e.g., chia, linseed, hempseed)	1–3 tablespoons
Vegetable milk (e.g., cashew, soy, almond)	2–3 cups
Fresh herbs	"Ad libitum"

Source: Authors' own editing, based on Hever [41] and Szabó et al. [20].

The ability to sustain plant-based dietary habits is influenced by several factors. Personal factors (habits and physical feedback) and the characteristics of the social network (vegetarian relatives or acquaintances, organized groups of animal rights supporters, those active in environmental protection, and those interested in healthcare) play a crucial role in this respect. The availability of the ingredients of a plant-based diet is also considered essential (in shops and in restaurants) [9,42].

Overall, it can be concluded that a vegetarian way of life is appropriate for all kinds of activities (intellectual and physical work, and sport) and suitable for all ages, as long as it is well planned in advance and properly sustained later on [14,43].

3.2. The Emergence and History of the Plant-Based Diet

Research by Kökény [14] shows that plant-based diets are long-established dietary practices, as vegetarianism in the East has existed since the beginning of history. In India, cows and other animals are considered sacred, and their protection has always been taken for granted (Ahimszá); thus, India has always represented the strongest base of vegetarian diets. The Egyptians had a predominantly plant-based diet and consumed mainly grain crops [44]. In ancient Persia, priests used a vegetarian diet [45]. The plant-based diet of the Western world can be traced back to the Ancient Greek culture (Socrates and Hippocrates). Given the above factors, several religious trends (e.g., Judaism, Brahmanism, Adventism, and Hinduism) prefer meat-free or mostly meat-free diets [20].

The first official organization was the Vegetarian Society, which was established in Great Britain in 1847, and the word "vegetarian" originates from the name of this society [46,47]. Scientific research into vegetarianism started in the 1950s and was mainly aimed at examining the adverse effects of this type of diet. Due to the positive findings, in the 1960s and 1970s, research focused more on the health benefits. It was around the turn of the millennium that the first studies on the preventive and therapeutic objectives of plant-based diets appeared, and these were concerned with the different physiological and pathological conditions of individuals [14,20,48,49].

The history of vegetarianism in Hungary dates back to 1883, when the Vegetarian Society of Hungary was established (later renamed the Hungarian Vegetarian Association). The society was formed with the aim of developing action plans and contributing to maintaining and improving people's health, with a healthy way of life. The first vegetarian restaurant was opened in 1991, in Budapest [14,50]. The 1980s saw a new boost in the emergence of plant-based diets in Hungary and it was then that new trends toward a natural lifestyle and 'reformed' diets started to develop. The "esoteric boom" in the 1990s prompted the government of the time to issue legal regulations. As a result, vegetarianism, naturopathic medicine, esotericism, and the 'reformed' lifestyle evolved into an increasingly profitable business and an important element in the economy [43]. The next most important change was the separation of naturopathic medicine and vegetarianism. Naturopathic medicine was able to gather more support from the very beginning, and it had political influence as well, while the followers of vegetarianism formed separate associations and societies [14].

3.3. Benefits of the Plant-Based Diet

Research shows that the most important benefits of vegetarian diets can be associated with positive health factors [21,22,29,51,52]. The findings of a representative survey carried out in the USA suggest that the prevalence, patterns, and other related factors of vegetarian and vegan diets, are

more significant among Americans when they make these dietary changes to protect their health [26]. Dyett et al. [53] questioned 100 people in the USA about how their health beliefs motivate them toward a switch in their lifestyle behavior and in changing their dietary patterns. Nutrient intake was assessed based on "Dietary Reference Intakes". Health (47%) proved to be the main reason for making a dietary change. The second most significant reason for a switch to a plant-based diet can be linked to well-being and satisfaction. Compared to these, connections to animal welfare and environmental sustainability were factors less-frequently preferred and reported [28–30]. Jabs and Devine [54] looked at the preferences of vegetarians related to health and animal welfare. They conducted personal interviews with 19 vegetarians. They subdivided vegetarians into two categories. The main motivation for health-oriented vegetarians is associated with the health benefits of the diet and, through these, the avoidance of health risks. The key considerations of ethical vegetarians are moral ones and connected to maintaining animal welfare. Hoek et al. [55] carried out a nationally representative survey and interviewed Dutch consumers over the age of 18 in their research entitled the "National Food Consumption Survey". It was revealed that, besides health-related and social factors vegetarian consumers had a positive attitude toward the importance of product information, specialty shops, novelties, and ecological products. A detailed analysis of factors mostly supporting plant-based diets are presented below. The analysis is based on the classification given by Corrin and Papadopoulos [27], Rosenfeld [56], and Ruby [57]. Factors supporting the plant-based diet are shown in Table 2.

Table 2. A comprehensive overview of perceived and objective benefits of plant-based diets.

Benefits	Types of Benefits [1,2]	Author(s), Year of Publication
Factors Beneficial to Health		
May reduce body fat and thus the degree of obesity	Objective	Berkow and Barnard, 2006; CJDPR, 2003; Cummings et al., 2002; Friedewald et al., 2011; Szabó et al., 2016
Decreased intake of saturated fat	Perceived	Lea and Worsley, 2003a; Lea et al., 2006a
	Objective	Kökény, 2009
Having levels of serum albumin with a more favorable effect on balanced nutritional status	Objective	Benzie and Wachtel-Galor, 2009
The essential nutritional ingredients can be found in a greater amount	Objective	Antal, 2005; CJDPR, 2003; Dwyer, 1988; Pomerleau et al., 2002
Reduces the risk factors for developing chronic diseases	Perceived	Graça et al., 2015; Knutsen, 1994; Melina et al., 2016; Lea and Worsley, 2002; Lea and Worsley, 2003a; Lea et al., 2006a; Weinrich, 2019
	Objective	Berkow and Barnard, 2005; Barnard et al., 2009; Dwyer, 1988; Leroy and Cofnas, 2019; Micha et al., 2010; O'Connor et al., 2017
Reduces the likelihood of developing cancer	Objective	IARC, 2015; Nechuta et al., 2012; Pérez-Cueto and Verbeke, 2012; Richman et al., 2010; Szabó et al., 2016
Benefits Linked to Well-Being and Contentment		
Has a positive effect on the development of well-being and on achieving peace and contentment	Perceived	Kökény, 2005; Lea and Worsley, 2002; Lea et al., 2006b
May contribute to a decrease in social dysfunction	Perceived	Judge and Wilson, 2015
Improves the quality of life	Objective	Kökény, 2009; Meyer et al., 2006

Table 2. *Cont.*

Benefits	Types of Benefits [1,2]	Author(s), Year of Publication
Ethical and Environmental Benefits		
May result in more effective exploitation of economic resources	Perceived	Weinrich, 2019
	Objective	Candy et al., 2019; Oláh et al., 1985; Sabaté, 2001
Reduces the effect of global warming and environmental pollution	Perceived	Mylan, 2018; Schenk et al., 2018
	Objective	Candy et al., 2019; Kökény, 2009; Leitzmann, 2003
More favorable results concerning indicators measuring environmental impacts	Perceived	Mullee et al., 2017; Vanhonacker et al., 2013
	Objective	Castané and Anton 2017; Goldstein et al., 2016; Könczey and Nagy, 1997;
Prioritizing the protection of animals as individuals and as species	Perceived	Janssen et al., 2016; Kenyon and Barker, 1998; PADADC, 2003; Schenk, 2018; Weinrich, 2019
Increased willingness to contribute to animal welfare organizations	Perceived	Backer and Hudders, 2015

[1] The perceived or objective assessment of the benefits shown in the table may be subjective, depending on the individual. [2] Perceived benefits were based on consumer surveys, and objective benefits were based on objective measurements (e.g., laboratory and clinical studies). Source: Author's own development, 2020.

3.3.1. Factors Beneficial to Health

A plant-based diet may reduce body fat and thus the degree of obesity [43,58]. It must be added, however, that if total body mass is lower as well, one might have lower total fat mass, but the degree of adiposity is not necessarily lower. This has been stated by a research study conducted by Berkow and Barnard [59], who assessed the body weight of vegetarians and that of non-vegetarians. Evidence suggests that vegetarian men weighed 4.6–12.6 kg less and vegetarian women weighed 2.9–10.6 kg less than their non-vegetarian peers. By using a well-constructed diet, cardiovascular diseases, which mainly develop as a result of obesity or risk factors leading to obesity, could be prevented [20,60]. Decreased intake of saturated fat is also considered an important health benefit of vegetarian diets [14,21,29]. By conducting human trials, researchers demonstrated that individuals using a plant-based diet had levels of serum albumin with a more favorable effect on their balanced nutritional status than those using a mixed diet [61]. The quantity of important nutritional components such as magnesium, potassium, folic acid, fibers, antioxidants including vitamins C and E, and phytochemicals is higher in people with a plant-based diet [43,62,63]. The absorption of iron of plant origin can be facilitated with a proper amount of vitamins [64]. Plant-based diets are able to reduce risk factors leading to the development of diseases, which is an outstanding health benefit [65]. Fewer people have been found to die of heart diseases, and the occurrence of type 2 diabetes, dementia, gallstones, kidney diseases, rheumatoid arthritis, and different types of allergies has decreased [12,21,62]. In addition to the above, it should be emphasized that a number of nutrition guidelines stress the risk factors of consuming red and processed meat in the development of primarily cardiovascular diseases. However, it has been suggested by an increasing number of research studies, that it is only excessive meat consumption that can be considered a real risk factor [66–68]. Even so, the overall negative view in relation to meat consumption supports the opinion of those who have chosen plant-based nutrition, which is considered healthier [66–68]. The cholesterol level and blood pressure in most vegetarians are found at the lower end of the normal range [21,28,29,51,62,69–71]. Reducing meat consumption and the preference for plant-based diets can be effective methods for reducing the likelihood of developing some (not all) types of cancer. According to the International Agency for Research on Cancer (IARC), red meat is "probably carcinogenic to humans", while processed meat products are "carcinogenic to humans" [20,72–75].

3.3.2. Benefits Linked to Well-Being and Contentment

It has previously been elaborated that the improvement in the health condition of the individual is the main driving force in the changes in dietary patterns and in the shift to a plant-based diet. Thus, the individual seeks to reduce health risks and seeks well-being, which makes the feeling of maximum contentment attainable. Well-being and contentment, in turn, are associated with the increased amount of time devoted to physical activity and recreation. Consequently, a plant-based diet has a positive effect on well-being, enabling the achievement of peace and contentment [9,28,30]. Judge and Wilson [76] carried out a questionnaire-based survey with a sample of 506 New Zealand university students. They presented a vision which symbolized a society in 2050, where consumers predominantly followed plant-based, i.e., vegetarian or vegan diets. The findings suggested that vegetarianism could promote a decrease in social dysfunction. Individuals adopting a plant-based diet usually spend less money on health and health care, and at the same time, the quality of their lives improves [14,77].

3.3.3. Ethical and Environmental Benefits

Evidence suggests that a plant-based diet may result in more effective exploitation of economic resources, which may reduce environmental impacts [50,65,78,79]. Concerning environmental protection, the ameliorating effects on global warming and environmental pollution are mostly reported by researchers [14,15,32,78,80]. It has been confirmed by a growing number of studies that excessive meat production and meat consumption and factory farm conditions impose an unreasonable burden on the natural environment [52,81,82]. Indicators measuring environmental impacts were found to show more favorable results concerning all the factors in the case of plant-based products than in the case of Mediterranean diets (meat-based products and fish) [83]. In Denmark, so-called life-cycle assessments (LCA) were used to compare traditional diets with vegetarian and vegan diets, based on factors related to environmental impact. The two plant-based diets (vegetarian and vegan) turned out to produce significantly better results than the mixed diet. However, there were no notable differences between the two plant-based diets [84]. The protection of life is of particular importance; this is understood as prioritizing the protection of animals as individuals and as species [32,65]. With the aim of protecting animals, for moral reasons, individuals are reluctant to contribute to the existence of factory farm conditions that torture animals and then kill them (the ahimsa principle) [85,86]. Backer and Hudders [87] examined the relationships between animal and human well-being attitudes and the willingness to donate, and the connections between moral issues and the choice of diets among meat consumers, flexitarians, and vegetarians. Donating behavior was assessed by examining the respondents' willingness to contribute to charitable organizations working for the protection of animals and humans. Their studies revealed that vegetarians showed more willingness to donate to animal protection organizations than those using a mixed diet. In their research, Janssen et al. [88] identified a vegetarian consumer group, which may also be open to the processing of products of animal origin, where the aspects of the well-being of animals are taken into consideration.

3.4. Barriers to Consuming Plant-Based Diets

The enjoyment of eating meat and the immense difficulty in giving it up are suggested by surveys to be the biggest barriers to the switch to a plant-based diet [21,30,51,89]. Compared to the popularity of eating meat, factors associated with health and convenience have been found to be less important [22,29–31,51,89]. Similar to the previous section, the following analysis was based on the classification made by Corrin and Papadopoulos [27], Rosenfeld [56], and Ruby [57]. The barriers to consuming plant-based diets are summarized in Table 3.

Table 3. A comprehensive overview of perceived and objective barriers to plant-based diets.

Barriers	Types of Barriers [1,2]	Author(s), Year of Publication
The Enjoyment of Eating Meat		
Excessive commitment to eating meat and the difficulty in abandoning it	Perceived	Graça et al., 2015; Kenyon and Barker, 1998; Lea and Worsley, 2003a; Lea and Worsley, 2003b; Pohjolainen et al., 2015
Essential-Nutrient-Deficiency Risks		
Risk of low protein intake	Perceived	Lea and Worsley, 2001; Lea et al., 2006b
	Objective	Dwyer, 1988; Kökény, 2009; Szabó et al., 2016
Low intake of micronutrients for example, vitamin B12 and vitamin D, as well as that of riboflavin, iron, calcium and zinc	Objective	Balk et al., 2005; Candy et al., 2019; Dwyer, 1988; Kökény, 2009; Watanabe, 2007
Convenience and Taste Factors		
The preparation of meals is too complicated	Perceived	Lea et al., 2006b; Pohjolainen et al., 2015
The availability of meals to choose from is limited in restaurants	Perceived	Lea and Worsley, 2001; Lea et al., 2006a; Lea et al., 2006b; Vanhonacker et al., 2013
It easily becomes boring and tasteless	Perceived	Lea and Worsley, 2001; Povey et al., 2001
Difficulty in Obtaining Information		
The range of relevant and available information is very limited	Perceived	Lea and Worsley, 2001; Lea and Worsley, 2003a; Lea et al., 2006a
Social Constraints, Negative Discrimination		
It may lead to eating disorders	Perceived	Povey et al., 2001
	Objective	Dwyer, 1988; Glasauer and Leitzmann, 2005
Negative associations, stereotypes	Objective	Szabó et al., 2016
The preservative effect of family habits	Perceived	Kenyon and Barker, 1998; Lea and Worsley, 2003a; Lea et al., 2006b; Taren and Wiseman, 2003
	Objective	Kökény, 2005;
Motivation based on imitation	Perceived	Hodson and Earle, 2018
	Objective	Kökény, 2005
Negative Effects on Mental Health		
Vegetarians are more neurotic and depressed than omnivores, causing them poorer mental health	Perceived	Baines et al., 2007; Forestell and Nezlek, 2018
Financial Constraints		
Daily meals and raw materials are too costly to obtain	Perceived	Kenyon and Barker, 1998; Lea et al., 2006b; Povey et al., 2001; Taren and Wiseman, 2003

[1] The perceived or objective assessment of the barriers shown in the Table may be subjective, depending on the individual. [2] Perceived barriers were based on consumer surveys, and objective barriers were based on objective measurements (e.g., laboratory and clinical studies). Source: Author's own development, 2020.

3.4.1. Enjoyment of Eating Meat

Graça et al. [51] examined the decline in meat-based diets and the growth in the proportion of plant-based diets, which, in their view, represent a positive step forward in increasing sustainability, in developing public health, and in minimizing the suffering of animals. They conducted a questionnaire-based research study among a sample of 410 meat consumers, with the aim of assessing the potential conversion to a plant-based diet. During the analysis, the sample was broken up into three

clusters, and one major cluster included those supporting meat consumption. It has been confirmed by numerous studies that excessive commitment to eating meat and the difficulty in giving it up are of prime importance among the potential barriers to changing dietary patterns [21,22,31,86].

3.4.2. Essential Nutrient Deficiency Risks

Opponents of plant-based diets often argue that these diets run the risk of low protein intake. It must be noted that experts are divided on the protein content of plant-based diets. Researchers claim in several studies that no significant difference can be found between plant-based diets and diets of animal origin in terms of protein supply [12,90]. However, nowadays there is a wide range of new alternatives available to address this problem. There is a considerable selection of plant-based protein-rich foods such as soy products, tofu, seitan, and tempeh [14,20,30,62,89]. The low intake of micronutrients, for example, vitamin B12 and vitamin D, as well as that of riboflavin, iron, calcium, and zinc, may easily lead to nutrient deficiency in vegetarians [78]. Vitamin B12 is of particular importance since it can be introduced to the body with water-soluble foods of mostly animal origin (e.g., liver, meat, milk and dairy products, and eggs) [14,62,91]. However, according to the findings of a research study in 2014, nori sheets made of dried algae, which are very popular in Japan, may function as a source of vitamin B12, to a considerable degree. Other functional foods of a similar type or dietary supplements can also contribute to vitamin B12 intake [20,92].

3.4.3. Convenience and Taste Factors

A potential barrier to vegetarian diets may be associated with the fact that they are too complicated to prepare [30,31]. Restaurants do not provide good opportunities for vegetarian diets, because the availability of meals to choose from on the menu is limited and the preparation of meals is not appropriate [29,30,82,89]. A vegetarian diet may easily become boring and tasteless [89,93]. Mullee et al. [52] conducted an online questionnaire-based survey among Belgian consumers (N = 2436), with the aim of exploring attitudes and beliefs associated with vegetarianism and meat consumption. The sample included only 38 vegetarians, 288 semi-vegetarians, and 2031 omnivores. The most important reasons for rejecting a vegetarian diet were the following: lack of interest and willingness, bad taste, and a lack of cooking skills.

3.4.4. Difficulty in Obtaining Information

There is little relevant and available information about what dishes are worth preparing and about how to prepare them in a vegetarian diet, and about which types of food are mostly suitable for replacing meat [21,29,89].

3.4.5. Social Constraints, Negative Discrimination

Individuals try to keep their body mass balanced by using a plant-based diet; however, this carries the risk of developing eating disorders and may lead to various illnesses [62,93]. For this reason, vegetarians may suffer from certain deficiency diseases [94]. The negative associations, stereotypes (malnourishment, vitamin or mineral deficiency, poor nutrition, and protein deficiency) previously established in relation to vegetarian diets are still persistent among the public nowadays [20]. Another barrier is that the family of the individual adopting a plant-based diet is reluctant to follow this type of diet [30]. Owing to the already established dietary habits and attitudes, the preservative effect of family habits can be a barrier, mainly for women and the elderly, during conversion to a plant-based diet [86,95]. Dietary attitudes are largely determined by different personal habits and by habits arising from close social relationships and family ties. These relationships become more pronounced with age [9,21]. Motivation based on imitation is strongly evident in connection with plant-based diets. If a popular actor or media personality adopts a vegetarian diet, his or her fans are likely to find it an example to be followed. In this way, the health and ethical considerations of the change in the dietary pattern are overshadowed by an external control [9]. The consumer habits of

former and current vegans were examined in a largely representative US community sample involving 1313 people in a questionnaire-based survey. A conservative attitude was considered an important issue. Findings revealed that the adoption of a vegan diet was less incited by justice concerns (animal rights, environment issues, and the starvation of the poor) [96].

3.4.6. Negative Effect on Mental Health

Baines et al. [97] compared the health status of vegetarian and omnivorous young Australian women. Their findings indicate that vegetarians experienced poorer mental health at their own discretion. Forestell and Nezlek [98] also reached a similar conclusion; according to their results, people following a plant-based diet are more open to novelties; however, they are also more prone to depression. It should be emphasized, however, that scientific views on the impact of plant-based nutrition on mental health are divided. In addition to the negative effects presented above, several researchers believe that, in a number of cases, plant-based nutrition can also have a positive effect on the individual's mood [99–101].

3.4.7. Financial Constraints

A further perceived barrier to a plant-based diet may be the fact that the daily meals of vegetarians are too expensive and, in addition to this, the accessibility to food ingredients of plant origin is difficult [30,93]. Similar research also examined the perceived barriers to the conversion to a plant-based diet, and beside the change in taste and convenience, price was also found to be a potential barrier [86,95]. We believe that meat prices have a clear impact on the willingness to convert to a plant-based diet.

4. Conclusions

The main objectives of the present study were to identify the most important characteristic features of a plant-based diet and to define the perceived and objective benefits of and barriers to converting to and sustaining a vegetarian diet, based on Hungarian and international literature sources.

The past decades have seen a dramatic increase in the spread of chronic diseases worldwide. Consumers' health has deteriorated over the past decades, something which can be associated with an unhealthy way of life, involving the excessive consumption of discretionary foods and drinks, with unbalanced nutrition. The development of diseases is largely dependent on the quality of nutrition. Consequently, the food industry is facing new challenges, and it has become necessary to produce foods which, because of their positive impact on health, are able to slow down the spread of the chronic diseases afflicting humankind [1]. Healthy eating can be considered a way to "heal" diseases and a tool to achieve well-being, as well as a preventive method to combat health problems [8]. Following the paradigm shift in nutritional science, nutrition can be considered an integral part of the health industry, both as a preventive and a therapeutic method.

The plant-based (vegetarian) diet—which cannot be regarded as being uniform—is an effort to change nutrition habits, during the course of which foods of animal origin and highly processed foods are avoided and replaced with raw, unprocessed, or minimally processed foods of plant origin. The reasons for an individual to convert to a vegetarian diet can be health concerns, animal rights, or economic, political, ethical, and spiritual concerns. Research into plant-based diets is becoming increasingly important from a nutritional, as well as a medical, point of view [20]. Vegetarian diets can be divided into several subcategories (vegan, lacto-vegetarian, ovo-lacto-vegetarian, semi-vegetarian, and pesco-vegetarian). A vegetarian diet can be important at any stage of life, as long as it is sufficiently well planned and maintained [14].

The health benefits of a plant-based diet (decreased rate of body fat and obesity, increased presence of essential nutritional ingredients, and reduced risk factors leading to diseases) have been found to be the primary reasons for converting to and sustaining a vegetarian diet.

Health benefits are followed by benefits related to well-being and contentment (improved quality of life and positive effects on the individual and social environment, as well as on the development of well-being). Finally, there are ethical and environmental benefits (a more efficient exploitation of economic resources, which promotes the protection of life on Earth) [27,56,57].

The biggest barrier to a vegetarian diet is the enjoyment of eating meat and the difficulty in abandoning it. Health concerns come second, among which the most frequently mentioned reason is the lack of certain ingredients (nutrients), for example, a lack of important vitamins. As regards convenience and time, evidence suggests that the preparation of meals is too time-consuming, and a plant-based diet may become tasteless and dull. In restaurants, the choice of vegetarian food tends to be rather poor. Moreover, it may become inconvenient if the individual's family does not follow the rules of a vegetarian diet. There seems to be relatively little reliable information available about this type of diet, and this may also hinder the conversion to a plant-based diet. The vegetarian way of life may generate social constraints and negative discrimination (i.e., that it may lead to the development eating disorders and it has negative associations) and the occurrence of motivation based on imitation. Financial constraints may also arise, since the purchase of certain raw materials of a plant-based diet may be too expensive [27,56,57].

In terms of plant-based nutrition, Hungarian consumers have also been found to follow the trends typical of countries with more developed consumer cultures. Demand for plant-based nutrition is on the increase in Hungary, as well, and this trend will continue in the near future [14]. We assume that these trends do not qualify as a purely Hungarian feature; they are also more or less prevalent in the other countries of the Central and Eastern European region. However, this claim still needs to be confirmed by further research.

A certain degree of uncertainty can clearly be noticed concerning the perceived and objective benefits of and barriers to plant-based nutrition, both in the international and the Hungarian literature. The objective benefits of the plant-based nutrition have been confirmed by numerous laboratory and clinical studies [59,62,66–70,73,75,77,83,84]. Nevertheless, the communication of results has not been so successful. Because of the often-contradictory findings, consumers find it difficult to interpret these pieces of information, so they rather tend to rely on their preconceived beliefs concerning plant-based nutrition [21,29,89]. The classification (perceived and objective categories) established in our analysis may serve as a relevant guideline for decision-makers. Decision-makers may include governmental, industrial, and other organizations connected to health and food economy. Market operators, by emphasizing the benefits and by breaking down the barriers can do a lot to shift consumers to a healthier diet, especially if opinion leaders are also identified.

We are, of course, aware of the limitations of the research, which at the same time determine future research directions. While conducting the present literature review, we did not used special tool-supported methods (such as PRISMA), which would have enabled us to provide a systematic analysis of the topic. For the systematization of information, a Theory of Planned Behavior model (TPB) was used that was developed by [36–40]. We believe that, with this method, we were able to give a relevant picture of the benefits of and the barriers to plant-based nutrition. We are fully aware that the literature on plant-based nutrition is extensive, and in the present research, we were unable to map the entire literature. The differentiation of the perceived and objective benefits and barriers in the present paper has exclusively been based on literature used for and cited in the manuscript. Nevertheless, we are aware that the perceived or objective assessment of the benefits and barriers provided in the study may be subjective, depending on the individual.

It can be stated that the results of the research may be expanded in the future. In our study, we did not aim to examine consumer behavior by using primary qualitative and quantitative market research procedures. Consequently, the testing of the theoretical model (TPB), which was the basis for our analysis, by using primary research methods, can be considered a potential direction for future research. The structure of the analysis and classification developed in the paper creates an opportunity for us to identify the peculiarities of the Hungarian consumer market in terms plant-based nutrition by

a national representative questionnaire-based survey to be conducted in the near future. The practical applicability of the theoretical model (TPB) can be confirmed by that survey. A research study like that would, at the same time, fill a gap, since we believe no such surveys on a representative sample of the population have been conducted to date in Hungary.

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