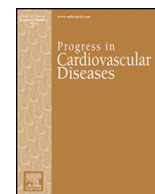




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Debunking the vegan myth: The case for a plant-forward omnivorous whole-foods diet

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ABSTRACT

Vegan diets are widely promoted as protective against cardiovascular disease (CVD); however, removing all animal foods from a human's diet usually causes unfavorable health consequences. Our hominin ancestors began consuming meat, fish, seafood, and eggs >2 million years ago. Consequently, humans are genetically adapted to procure nutrients from both plant and animal sources. In contrast, veganism is without evolutionary precedent in *Homo sapiens* species. Strict adherence to a vegan diet causes predictable deficiencies in nutrients including vitamins B₁₂, B₂, D, niacin, iron, iodine, zinc, high-quality proteins, omega-3, and calcium. Prolonged strict veganism increases risk for bone fractures, sarcopenia, anemia, and depression. A more logical diet is a plant-forward omnivorous eating pattern that emphasizes generous consumption of natural, unprocessed foods predominantly from plants. To balance this diet, modest amounts of wholesome animal foods, such wild-caught fish/seafood, pasture-raised meat and eggs, and fermented unsweetened dairy should be consumed regularly.

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Contents

Introduction	0
Diet for which humans are evolutionarily adapted	0
Pros and cons of veganism/vegetarianism	0
Problems arising when animal foods are avoided.	0
Vitamin B ₁₂ deficiency	0
Omega-3 deficiency	0
Mineral deficiencies	0
Inadequate protein.	0
Mental health	0
Nose-to-tail eating	0
Plant-forward omnivorous diet.	0
Conclusion	0
References	0

Abbreviations: ALA, Alpha Linolenic Acid; CHD, Coronary Heart Disease; CVD, Cardiovascular Disease; DHA, Docosahexaenoic Acid; EPA, Eicosapentaenoic Acid; GI, Gastrointestinal; T2D, Type 2 Diabetes; TMAO, Trimethylamine N-oxide; US, United States.

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Introduction

Vegan diets have been widely promoted in the field of cardiovascular diseases (CVD) for decades, despite an absence of randomized controlled trial data demonstrating long-term safety or effectiveness of these restrictive eating patterns. A vegan diet, when it is followed

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strictly, has many potential drawbacks related to predictable nutritional deficiencies. Plant-based diets that shun all animal-based foods predispose to specific health problems because veganism is an unnatural pattern of consumption with no evolutionary precedent in the *Homo sapiens* species.^{1,2}

Vegans refrain from consuming any animal-sourced foods and/or their by-products. Lacto-ovo-vegetarians consume no meat but do eat eggs and dairy products. Approximately 2.2% of adults in the United States (US) consider themselves to be vegetarian, and 0.5% self-identify a vegan.^{3,4} Two out of 3 vegetarians are female, so about 2.9% of females and 1.5% of males are vegetarian. Vegetarians are more likely college-educated and younger than non-vegetarians.^{3,4} Most people who try vegetarianism or veganism return to an omnivorous diet; surveys find there are 5-times more former vegetarians/vegans than current ones.^{3,4}

The primary aim of this review is to summarize to the current literature related to vegan/vegetarian diets with respect to the potential benefits and dangers of eliminating or restricting the intake of animal-based foods in one's diet.

Diet for which humans are evolutionarily adapted

Using an evolutionary template to guide our food and beverage choices is a simple and logical approach for altering the modern human diet in ways that can improve health and longevity. Archeological evidence such as stone tools and fossilized bones bearing butchery marks indicate that our ancient ancestors began consuming meat and fish at least 2.6 million years ago,⁵ which was approximately the same time as the first evidence for the origins of our *Homo* genus.⁶ Thus, investigators speculate that our ability to successfully fish and hunt large game provided the calories and nutrients that enabled the rapid evolutionary expansion/development of the *Homo sapiens* brain.

The enzymes and anatomy of our gastrointestinal (GI) tract attest to our omnivorous nature.⁷ Like carnivores, we have assorted proteases in our gut designed specifically to digest animal protein. On the other hand, like herbivores, we have sucrases in our gut enabling us to digest fruit. Indigestible fiber, found in plants but not animals, is fundamental for the health of our digestive tract. Yet, vitamin B₁₂, which is obtained mostly from animal food sources, is essential for normal function of our brain and nerves.

The great apes have a dominant colon that is adapted to ferment and digest bulky plant material. In contrast, the human gut is morphologically intermediate between carnivores and herbivores; it is characterized by a dominant small intestine that is effective for digesting both

animal and plant foods.⁷⁻⁹ Humans also have shoulder, arm, and trunk adaptations that enable us to accurately throw projectiles like rocks and spears at high velocity. These unique anatomical endowments were almost certainly selected for their ability to augment hominin hunting prowess.⁸

Clearly, humans are evolutionarily adapted to procure calories and nutrients from both plant and animal sources, thus we are classified as opportunistic omnivores.^{10,11} In fact, all pre-agricultural hunter-forager societies were omnivores, and derived anywhere from 14% to 65% of calories consumed from animal-based foods, such as seafood, wild fish, wild birds, game meats, and eggs.^{10,11}

Pros and cons of veganism/vegetarianism

The American College of Cardiology/American Heart Association 2019 Guideline on the Primary Prevention of Cardiovascular Disease endorse a "plant-based" diet.¹² The Academy of Nutrition and Dietetics stated that an appropriately planned vegan diet is "healthful, nutritionally adequate, and may provide health benefits in the prevention and treatment of chronic diseases" and is "appropriate for all stages of the life cycle".¹³ Unfortunately, high-level evidence in support of these statements is lacking.

Admittedly, vegan diets are associated with some health advantages compared to the standard American diet, including lower rates of obesity, type 2 diabetes (T2D), non-alcoholic fatty liver disease, CVD, and some GI cancers (colon and pancreatic cancers), with reduced levels of blood pressure and low-density lipoprotein cholesterol.^{14,15} However, epidemiology studies report that vegan or vegetarian diets are not associated with reduction in all-cause mortality rates (Fig. 1).^{1,2,16,17}

The standard American diet with its abundance of processed, high-calorie, low-fiber, high-sugar, nutrient-depleted foods and beverages is so detrimental that almost any diet that restricts food choices will at least temporarily improve health. Moreover, vegetarians and vegans, compared to non-vegetarians, are generally more health-conscious, more physically active, have higher socioeconomic status, with lower rates of tobacco, alcohol, and drug use.^{18,19} So, some of the vegan/vegetarian health advantages may be due to a healthy user bias: individuals who decide to follow a vegan/vegetarian diet tend to be more conscientious and proactive about their health than the general population. This bias would overestimate any health benefits of vegetarianism reported in observational studies. On the other hand, the adverse health effects of vegan diets are rarely discussed. Eliminating all animal foods from a human's diet nearly always results in some unfavorable health consequences.^{14,17,20,21}

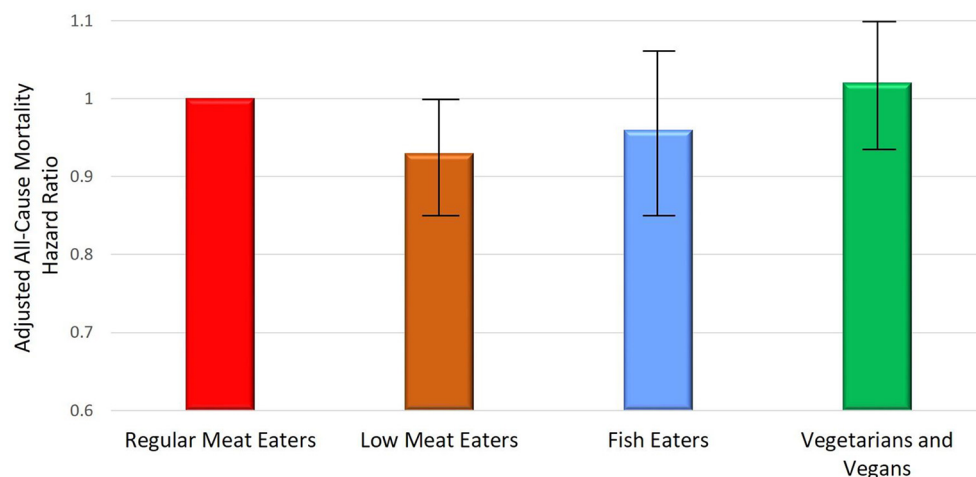


Fig. 1. Hazard ratios for all-cause mortality as calculated by Cox proportional hazards multi-variable regression analysis¹⁶. $P = 0.082$.

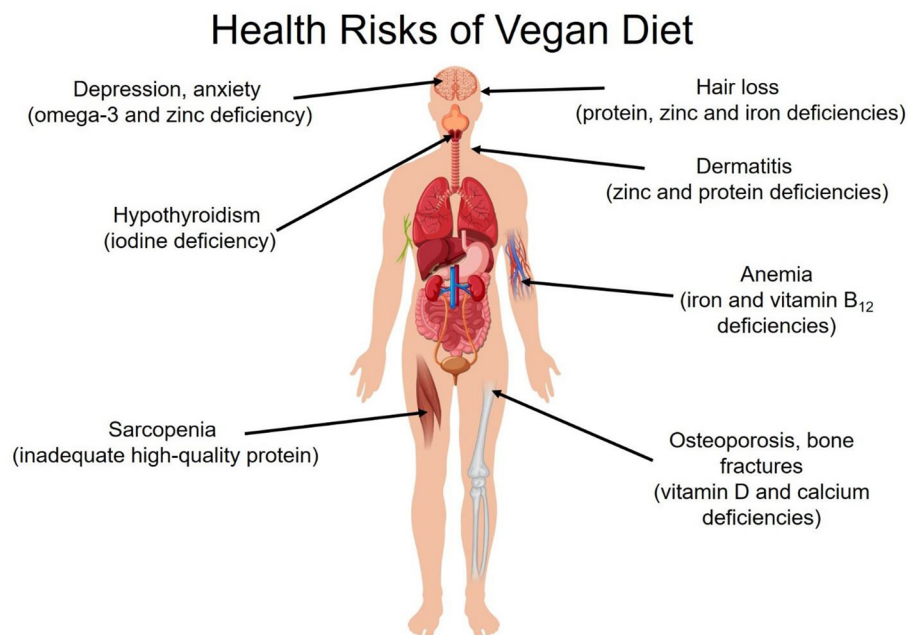


Fig. 2. Potential health problems caused by a strict vegan diet.

Plant-based diets centered around refined grains, sweetened beverages, candy, desserts, baked goods, fries, chips, etc. are particularly detrimental, and correlate with worse CVD outcomes compared to vegetarian diets emphasizing fresh produce, nuts, legumes, whole grains, tea, and coffee.²² The toxic features of the standard American that cause obesity, T2D, CVD and shortened life expectancy would not be averted by simply excluding all animal-based foods, but rather by reducing intake of the highly processed foods, refined carbohydrates, deep-fried foods, processed meats and sweetened beverages that are ubiquitous in our culture.¹⁴

Veganism has been linked with dysfunction of the neurological, psychological, musculoskeletal, hematological, and immunological systems.²¹ Dietary sources of vitamins B₁₂, B₂, niacin and D are almost exclusively animal-based foods. For vegans not on dietary supplementation, inadequate levels of these essential nutrients can result in neurocognitive impairment, anemia, and immune compromise.²⁰ Veganism increases the risk for bone fractures, sarcopenia and, depression/anxiety (Fig. 2).^{14,21,23}

A deficiency of terrestrial animal food might have contributed to Japan's historically high cerebrovascular mortality. In the Japanese

population between 1960 and 2013, both the all-cause mortality and death rate from stroke declined precipitously in an inverse relationship to its annual meat consumption, which rose during that same time frame from <5 kg/person to 52 kg/person (still only 45% of the current US level) (Fig. 3).²⁴ Some of these benefits might have been from contemporaneous reductions in salt and smoking. Even so, the nutrients provided by red meat and dairy when consumed in excess contribute to atherosclerosis, but in moderation may balance the diet and improve overall health and longevity.²⁴

Infants fed a vegan diet suffer from growth retardation/failure to thrive, and are at increased risk for psychomotor regression, bone fractures, severe vitamin B₁₂ deficiency, marked hypocalcemia with seizures, anemia, respiratory distress with metabolic alkalosis, and death.²⁵

Problems arising when animal foods are avoided

Vitamin B₁₂ deficiency

Low vitamin B₁₂ intake is a significant problem in vegan diets due to avoidance of vitamin B₁₂-rich foods, such as meat, poultry, and eggs.^{17,20} A lack of vitamin B₁₂ has been linked to neurological and hematologic problems.²⁶ Moreover, Vitamin B₁₂ may possess anticancer properties; conversely, inadequate B₁₂ consumption may contribute to carcinogenesis.²⁷ Consequently, if B₁₂ is not adequately replaced, a vegan diet may inadvertently increase risk of some types of malignancy, including cancers of the breast, cervix, GI tract, and liver.^{27,28}

Omega-3 deficiency

Epidemiological studies report the vegans who do not supplement with omega-3 fatty acids will be at high risk for deficiency of both eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are found predominantly in fish, seafood, game meats and pasture-raised eggs.²⁹ Recent studies report that low omega-3 levels in the cell membranes and blood are associated with reduced life expectancy, and higher risk of major adverse CVD events (myocardial infarction, stroke, and CVD death).³⁰ Furthermore, omega-3 deficiency is

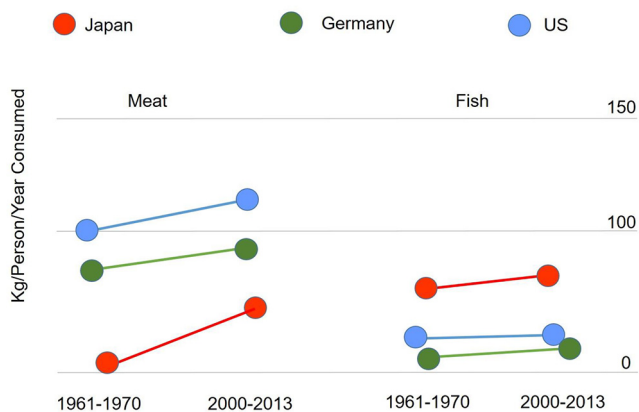


Fig. 3. Change in mean amounts of animal foods consumed (Kg per person, per year) during a half-century in 3 nations²⁴.

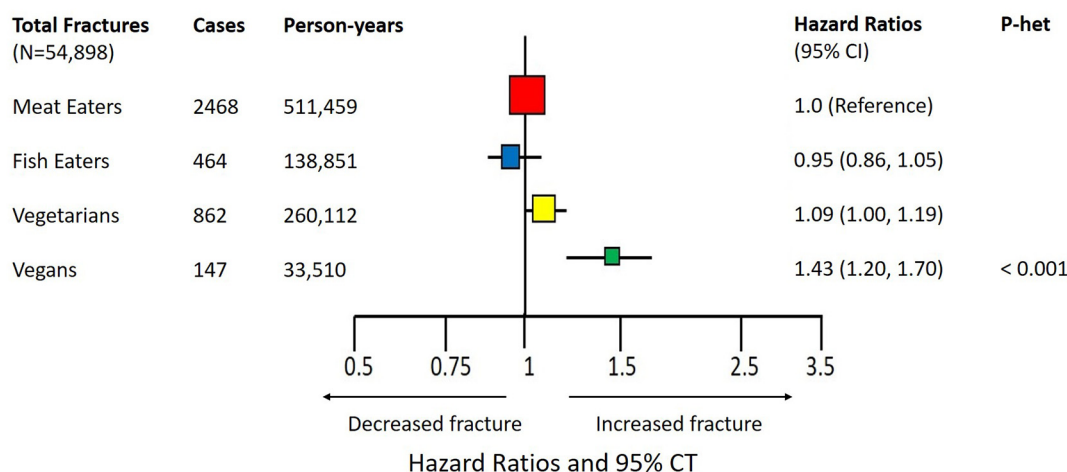


Fig. 4. Risk of bone fracture among various dietary groups.³⁸

associated with depression, anxiety, systemic inflammation, autoimmune disorders, autism, macular degeneration, asthma, and periodontal disease.³¹ Alpha linolenic acid (ALA) is a plant-based omega-3 that can be hepatically converted to the beneficial long-chain fatty acids, but the liver converts <5% of ALA to EPA, and virtually none (<1%) to DHA.³²

Mineral deficiencies

Vegan and vegetarian diets frequently result in mineral deficiencies. Phytates are anti-nutrients found in grains and legumes. These compounds interfere with the absorption of essential minerals including calcium, zinc, iron, iodine, and magnesium.³³ Because vegan and vegetarian diets generally include copious amounts of grains and legumes, they are unavoidably high in phytates, which reduce the absorption of non-sodium minerals.

Vegans and vegetarians are at increased risk for iron-deficiency²⁰ despite the presence of substantial amounts of iron in many plant-based foods. Plants contain the non-heme form iron, which is and less bio-available than heme-iron from animal sources.³⁴ Accordingly, levels of ferritin and hemoglobin are significantly lower in vegans/vegetarians. Iron deficiency increases a pregnant woman's risk of having preterm delivery, low-birth-weight infant, and impaired brain development in their infant.²⁰

Vegans also are at increased risk for zinc deficiency.²⁰ While meat, fish, shellfish, dairy, and eggs are rich sources of bioavailable zinc, some zinc-rich plant foods (nuts, seeds, and whole grains) have poor bioavailability, again owing to the presence of phytates, which inhibit zinc absorption in the gut.³³ Inadequate zinc consumption is associated with depression, dermatitis, diarrhea, and alopecia, all of which are more common among vegans.³⁵

Observational studies routinely find that vegan and vegetarian diets increase the risk for iodine deficiency and hypothyroidism.³⁴ A European study reported that 80% of vegans and 25% of lacto-vegetarians had iodine deficiency.³⁶ Plant-based foods, except for seaweed, are inadequate dietary sources of iodine compared to animal products, such as fish, meat, and eggs. Iodine is a particularly vital nutrient for pregnant women and young children. Iodine deficiency during pregnancy increases risk of impaired mental development during childhood.³⁷

Vegans customarily consume insufficient calcium and vitamin D, owing to the avoidance of dairy products, and calcium bioavailability problems in plant-based diets.¹⁷ Vitamin D insufficiency impairs calcium absorption and hinders bone formation, thereby compromising skeletal health in vegans and vegetarians. Multiple studies reported

increased multivariable-adjusted risk of bone fractures among vegetarians and vegans (Fig. 4).^{38,39} Vegans have reduced bone mineral density at the femoral neck and lumbar vertebrae, and higher fracture rates, as reported in meta-analysis comprising 20 studies and 37,134 individuals.²¹

Inadequate protein

A meta-analysis concluded that vegans consume significantly less protein and fewer essential amino acids compared to other diet groups.^{20,40} Moreover, plant protein is less digestible than animal proteins.^{20,41} Adequate protein intake is essential for growth and development in children, for maintaining muscle and bone strength in adults, as well as for avoiding frailty among older individuals.⁴¹

Taurine is an amino acid that helps to support endogenous antioxidant levels, and may be important for optimal function of the brain, heart, eyes, and immune system.⁴² Because plants contain little to no taurine, many vegans and vegetarians are deficient in this important amino acid, which can predispose them to a myriad of health issues.⁴² Animal foods such as seafood, fish, poultry, and beef are rich in taurine.

The gut microbiota-dependent metabolite, trimethylamine N-oxide (TMAO) is formed from ingested red meat, eggs, and fish. Increased blood levels of TMAO are associated with an increased risk of adverse CV events. However, a recent Mendelian randomization study found that T2D and chronic kidney disease increase TMAO levels, suggesting that the observational evidence implicating TMAO in heart disease may be due to confounding from reverse causation—risk factors that cause CV disease also increase TMAO.⁴³

Mental health

A comprehensive systematic review comprised of 18 studies and 160,257 individuals, including 149,559 meat-eaters and 8584 meat-abstainers (aged 11 to 96 years) concluded: "The majority of studies, and especially the higher quality studies, showed that those who avoided meat consumption had significantly higher rates or risk of depression, anxiety, and/or self-harm behaviors".⁴⁴ One study found that meat-avoiders had approximately 2-fold increased risks for unipolar depressive disorder, and anxiety disorders.⁴⁵ A longitudinal cohort study of 4181 German citizens, ages 18 to 65 years found that 1.3% were "strict vegetarians," and 4.5% were "semi-vegetarians." After controlling for other relevant variables, the vegetarians had significantly higher rates of depression, anxiety, and eating disorder (Fig. 5).⁴⁶

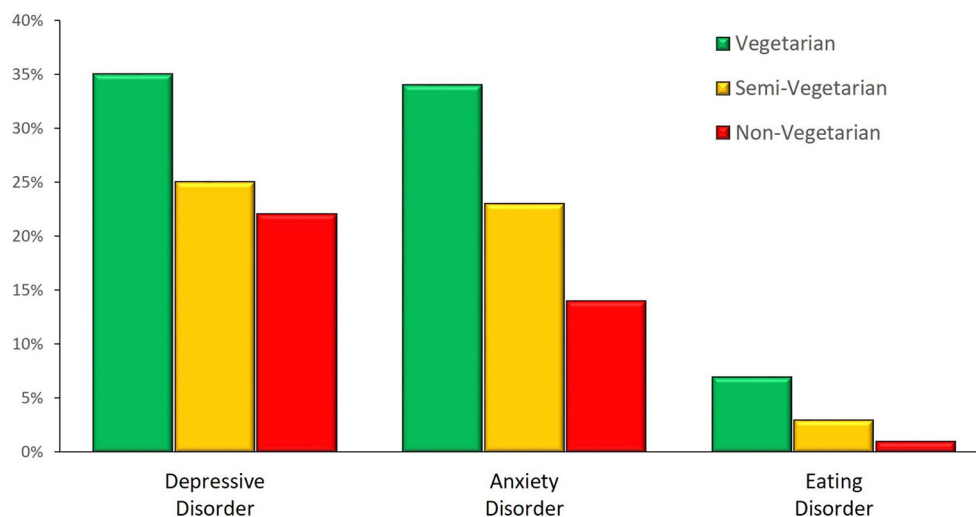


Fig. 5. Lifetime incidence of psychiatric diagnoses among 4181 adults.⁴⁶

Nose-to-tail eating

For most of *Homo sapiens* evolution, animal kills were eaten “nose-to-tail”, whereby virtually all the edible portions were consumed. In contrast, today many animal foods are exclusively in the form of muscle meat, which is comprised of a narrower range of nutrients. Organ meat like liver is much more nutrient-dense than muscle meat, being rich in vitamin B₁₂, folate, iron, magnesium, selenium, zinc, and fat-soluble vitamins.

Skin and bones are rich in collagen and calcium hydroxyapatite respectively, which when consumed are effective for nourishing the skin and building/maintaining a strong skeleton.⁴⁷ Similarly, chondroitin (found in animal connective tissues) and glucosamine (from shellfish) may be beneficial for joint and bone health.⁴⁸ Many of these nutrients not only cannot be obtained from plant foods, but also are not found in sufficient quantities in muscle meat.

Some of these whole-animal food sources are widely available today in the modern food supply as sardines (with skin and bones intact), bone marrow, bone broth, shellfish, skin from poultry and fish, liver and other organ meats. Ideally, these nutrients should be obtained through diet alone, and current guidelines do not recommend routine supplementation. However, supplementation with products such as collagen, organic bone meal, omega-3 fatty acids, and glucosamine/chondroitin may be helpful in some people, particularly if they eat a diet deficient in these nutrients.⁴⁷

Plant-forward omnivorous diet

National dietary recommendations consistently include meat and dairy products as essential components of a healthy balanced diet.⁴⁹ Maintaining ideal health while adhering to vegan diets requires a sophisticated understanding of potential pitfalls, and close attention to detail regarding supplementation and medical testing.⁵⁰ A more logical and evolutionarily congruent approach is to simply include modest amounts of nutritious animal-sourced foods.

The main nutritional problem in the US today is chronic excess consumption of calories, with 73% of American adults being overweight (31%) or obese (42%); severe or Class III obesity present in 9% of the adult US population.¹² Meat and other animal foods are typically high in protein and often high in fat as well, and so can promote weight gain. Moreover, the instinctive tendency to eat meat first means that it is often consumed in preference to vegetables, fruit, legumes, etc.⁵¹ Many individuals in modern Western societies consume excess

amounts of meat that often is high in salt and preservatives, sourced from animals typically raised in cruel conditions, fed unnatural foods, and treated with hormones and/or antibiotics.¹⁰ Frequent consumption of processed meat and overcooked or burned meat, particularly in the context of a standard American diet, is associated with a vast array of chronic illnesses that are endemic in our culture including CVD, diabetes, and cancers of the GI tract.^{14,52}

Curtailling the consumption of processed meat would likely improve longevity.^{12,50} This was confirmed in a recent comprehensive study based on meta-analyses that estimated the effects of dietary changes on life expectancy for someone eating a typical Western diet. Eating less red meat, processed meats, sugar and refined grains, while eating more nuts, fish and unprocessed whole plants were estimated to be the most effective dietary approach to improve life expectancy.⁵³

Fermented foods also played an important role in our nutrition throughout human evolution, as partially spoiled or fermented foods were consumed regularly.⁵⁴ Long chain menaquinones such as vitamin K₂ are derived solely from bacterial synthesis. Recently, pork tissues have been discovered to be one of the richest sources of long chain menaquinones, presumably because pigs consume spoiled food which contains bacteria-produced long chain menaquinones.⁵⁵

Fermentation of dairy foods and beverages has been utilized for millennia as a method of food preservation. Consumption of fermented dairy, such as unsweetened yogurt, cheese, and kefir, is associated with better health outcomes than unfermented dairy products such as milk and butter, probably because the lactobacilli and bifidobacteria break down lactose and function as beneficial probiotics.⁵⁶

The order in which food is eaten significantly influences the amount of food consumed during the meal. Eating low-energy-density foods, like non-starchy vegetables or soup at the start of a meal reduces total energy intake during that meal.^{57–59} For example, eating a low calorie salad before, rather than with, the main course increases total vegetable intake during a meal.⁵⁸ Moreover, studies done on Japanese children show that a routine of eating vegetables first was associated with significantly lower risk of being overweight or obese compared to eating the meat or fish first.⁵⁹ Additionally, consumption of fiber-rich vegetables before carbohydrate-rich foods like rice or bread reduces glycemic excursions and blunts post-prandial glucose and insulin peaks.^{57,60}

So, while the consumption of animal-sourced food is necessary for ideal human health, excess meat intake can predispose to obesity, cancer and T2D. Therefore, prioritizing the consumption of vegetables, nuts, and fruits—plant-forward eating—is ideal, since most people tend to choose highly processed foods and meats if they are simply eating for taste preference.⁵¹

Conclusion

The supposition that human health is optimized by eliminating all animal-based food from the diet does not have rigorous scientific support. Rather than veganism, a plant-forward, omnivorous, whole-foods diet that emphasizes generous intake of natural, unprocessed foods predominantly from plants, ideally consumed at the start of the meal, is more compatible with evolutionary human biology. This diet should be rich in vegetables, nuts, seeds, avocados, olive oil, berries, and other fruits, along with some whole grains and legumes. Importantly, animal foods are essential to balance this diet, but these should be preferentially wild-caught fish/seafood, pasture-raised meats, and eggs, and fermented unsweetened dairy. Future prospective studies are needed to assess the CV effects of such a diet.

Declaration of Competing Interest

JHO has a major ownership interest in CardioTabs. The remaining authors have nothing to disclose.

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