EJSIT
European Journal of Science, Innovation and Technology
ISSN: 2786-4936
www.ejsit-journal.com
Volume 3 | Number 4 | 2023

Plant Based Diet for Better Immunity, Elderly Health and Environment: Indian Insights

Hema Kulkarni[1], Utkarsh Ghate[2*]
[1]Government Model College, Dhanora, Durg city, Chhattisgarh, India
[2]Ecologist BAIF, Trustee, RANWA NGO, Kothrud, Pune city, Maharashtra, India

ABSTRACT

As globally shown by cohort studies, plant based diets improve health, especially of elderly population, and life span. We present the evidence that COVID-19 mortality and prevalence rates were lower in India and many less developed nations than the western countries, indicating better immunity in the former. This can be attributed to predominance of natural, home cooked, fresh and plant based diets, including spices rich in bioactive ingredients, compared to the packed foods and hoteling, more meat based diets in the later. Plant based diets can potentially reduce the intensity of the gut microbiota dysbiosis and several associated "lifestyle/ diet linked" inflammatory diseases such as inflammatory bowel disease (IBD) and certain cancers. Plant based diets possess all micro nutrients except notably vitamin B12 as evident in India but its effects are not prominent and food supplements can provide it. Calcium, iron and zinc deficiency is not specific to vegetarian diet, especially in India. Antinutrients such as phytates in legumes reduce the absorption of micronutrients such as iron and zinc. Vegan health supplements can meet any nutrition gaps. Superfoods, millets and biofortification can be the future focus of agriculture development, being highly nutritive. Soil nutrient deficiency and climate change pose risks to diet deficiencies in future. So sustainable and precision farming is the key to nutrition. Low environmental impact, non-violence and animal rights are other principles causing recent surge in vegetarian or vegan diet globally.

Keywords: vegan, vegetarian, wellbeing, micronutrients, sustainability

INTRODUCTION

The famous Nobel laureate of 1921 and the most intelligent person ever Prof. Albert Einstein wrote (1930) "Although I have been prevented by outward circumstances from observing a strictly vegetarian diet, I have long been an adherent to the cause in principle. Besides agreeing with the aims of vegetarianism for aesthetic and moral reasons, it is my view that a vegetarian manner of living by its purely physical effect on the human temperament would most beneficially influence the lot of mankind." There has been a list of celebrities that are/ were vegetarian or vegan their share in population is growing from a low 2-3% in Europe (France, Switzerland, Austria) and 4% in Americas (USA, Canada) to 9% in Italy, Germany and U.K (Leitzmann, 2014). In India, the ratio is high – 35% as the predominant religion "Hindu" largely advocates non-violence and vegetarian lifestyle, further endorsed by sects such Jainism and Buddhism in the country (Brodt, 1994). Many people worldwide are adopting meat-less or vegan diet (no animal product such as milk or honey) globally today fully or partly such as celebrating "meatless Monday" (Greg, 2012). The debate on if the humans evolved as vegetarians ranges long with some arguing that the human ancestors were nearly all (largely) vegetarians due to the presence of amylase and lactase genes (Dunn, 2012). Some human populations evolved extra copies of amylase genes, for better digestion of starchy foods, with agriculture. Several human populations independently evolved gene variants that coded for the lactase persistence (to break down

*Corresponding Author

lactose) to digest milk, not just as babies but also as adults. The microbial species in human guts also evolved as some populations of humans in Japan host a gut bacteria with seemingly stolen genes for breaking down seaweed, local popular foodstuff (Ledford, 2010). However, some others disagree, pointing that the tapeworm found in the human gut entered when humans like in the carnivores (e.g. lion or hyena) began consuming the deer, the main host of the tapeworm (Grube, 2021). They argue that early hominins butchered animals and ate meat based on the ancient cutmarks, by seemingly stone tools, on the fossilized bones of large wild mammals in Africa dating to ~3.4 and 2.5 million years.

Others suggest "dietary diversity" from largely meat eating to tubers in African savanna region based on dental structure (Teaford, 2000). The australopithecines were not preadapted for eating meat due to the dietary shift from apes to early hominids that did not involve an increase in the consumption of tough foods. This view is countered by (*i*) recent isotope work suggesting that the australopithecines did in fact consume significant amounts of meat (and (*ii*) nutritional work suggesting that meat may have provided critical nutrients for both young and old hominids. There are 3 three different alternative explanations to this contradiction. First, only craniodental features related to diet are explored. Australopithecines may have processed meat more efficiently than the craniodental evidence suggests if they used tools for ingesting and processing meat (*ibid.*). Second, the heavy C3 signature found in australopithec *africanus* may reflect the consumption of underground roots of C3 plants (trees) rather than meat.

The dietary diversity hypothesis states that the changes usually occurred within the context of broader transitions in human ecology (Luca et al., 2021). Consequently, diet changes during hominin evolution may be correlated with other aspects of the environment that are not internally related to diet, e.g. climate, pathogen load, and mode of subsistence. Thus, dissecting the specific impact of dietary changes as a selective pressure is complex. For instance, lactase-persistence (LP) individuals benefit from the nutritional properties of milk, but milk consumption may also have protected against dehydration and water borne parasites caused enterobacteric diseases. Hot geographic areas favoured this advantage where lactose-intolerant individuals could not use milk to compensate for water loss. LP proved advantageous at high latitudes, where low vitamin D caused by low sunlight and associated rickets and osteomalacia prevail as in Europe. Lactose promotes the absorption of calcium present in milk, and this may reduce the breakdown of vitamin D in the liver, and compensate for the less sunlight in the northern Europe. Climate influenced human lifestyle regarding not just diet, but also other aspects of human physiology, such as energy balance. Leptin hormone, for instance, is involved both in the control of appetite as well as in energy balance.

Ecological history book reviewed by Brodt (1994) suggested that as human may have migrated to Indian plains and began cultivating crops, the bull was found more efficient for farming than consuming it and hence vegetarianism evolved to replace bull in the nomadic phase in prehistoric times with the symbolic ceremonial, ritualistic cutting of pumpkin or ashgourd, as still prevalent in southern India.

Some adopt veganism or vegetarianism as ethical, non-violent lifestyle as Einstein or Mahatma Gandhi Ji, the father of Indian independence said while many cite environmental cause to its meat eating consumes 2.5 environmental resources than plant based foods (Ciati & Ruini, 2008).

We discuss here 3 aspects based on literature review:

a) Does plant based diet confer advantages for health, longevity or in some diseases?
b) What nutritional advantages or ingredients plant foods possess or may lack?
c) What may be the future trends in plant based diets to overcome the nutritional challenges?

We speak of not just vegan but predominantly plant based diets and some animal products may be occasionally consumed. There are 5 main types in plant based diets (McManus, 2016):

- *pescatarian:* plant-based foods as well as fish, eggs, milk and dairy products;
- *lacto-ovo vegetarian:* plant-based foods supplemented with eggs, milk and dairy products;
- *ovo vegetarian:* plant-based foods and eggs;
- *lacto vegetarianism:* plant-based foods in combination with milk and dairy products;
- *vegan:* plant-based foods only, no animal food and additives.

HEALTH

COVID-19

Table 1 below shows the extent of average COVID-19 deaths in the 3 continents and income levels of about top 8-12 countries per continent. Our analysis here is based on public data on WHO & World Bank websites. It is seen that Europe & American countries daily per capita income 8-12 times ($50) than in Asia & Africa ($4-6). The COVID-19 prevalence (27% of population diagnosed) is also 9 times that in Asia (3% of population diagnosed) and 54 times that in Africa (0.5% of population diagnosed).

Table 1: Income levels & COVID-19 death rate across continents

Region	Income $/head/day	COVID-19 deaths/ million people	% mortality COVID-19	COVID-19 cases/ million people#
EU-America	50	**1815**	**0.08**	**270683**
Asia	6.3	393	0.15	31135
Africa	4.5	103	1.77	5209

Source: COVID-19- https://covid19.who.int/, income- https://data.worldbank.org/ #- prevalence

Figure 1 shows the pattern across continents with the above stark difference evident, with 1st world nations very high prevalence and mortality, than the middle (Asia) and low income countries (Africa). This is hardly noted in the literature except by International Monetary Fund (IMF) who described economic hardship of the poor nations as well as larger loss in terms of life years lost in the richer countries (Ferreira, 2021). But this disparity and its biological basis is unexplored in the literature. We argued that the high spice consumption in India and Asian countries than the western world explained the lower damage here than the western world as healthy phytochemicals such as polyphenols in Asian diet guard against viral infections such as SARS (Ghate & Kulkarni, 2021). The 5-6 times higher prevalence and death rate as seen above in the developed nations, was evident in the 1st year of the Corona then and it reflected the natural immunity as no drug or vaccine was developed then. We also argued there that immunity compromising foods such as meat, alcohol, tobacco, refined carbs are much less consumed in India and Asia than the developed countries (WHO, 2002), which explains the lower immunity of the later. But Africa has low spice consumption and meat consumption is common vide a global study of the regional patterns of non-communicable diseases by Korean researchers (Kang et al., 2021). Thus, we postulated that the higher share of packed foods in the western diet may lower their immunity due to preservatives etc. and HFSS (high fat, sugar, salt) content as “immunity busters” (Ghate & Kulkarni, 2022).

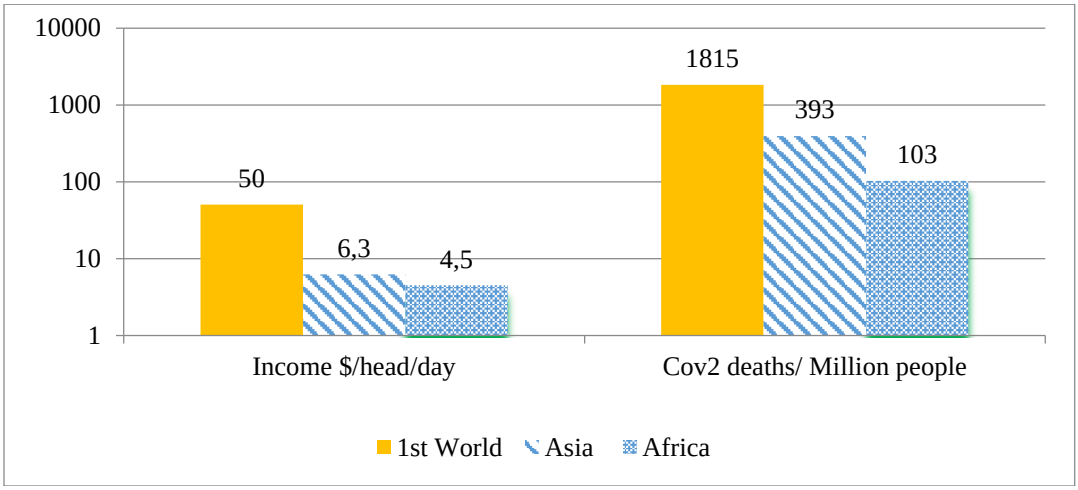

Figure 1: COVID-19 death rate & income levels

We mentioned in the above study other factors too responsible for lower immunity at higher latitudes such as perhaps lower vitamin D status in European population due to less sunlight exposure (both by natural factors such as lower hot period and artificial ones such as mostly indoor lifestyle and using sunscreens if outdoors) than the tropical countries such as in Asia or Africa. Indeed studies show 40% Europeans to be vitamin D deficient but only 20% of Indians (Amrein et al., 2020).

Longevity

Vegan diet received boost in the west after seminal research publication about a decade ago in the prestigious Journal of American Medical Association stating that vide study of 73,308 seventh-day Adventist people during 2002 and 2007, the vegetarian men lived 10 years longer on average than the non-vegetarians—83 years and 73 years respectively (Orlich et al., 2013). Vegetarian women, lived 6 years longer with 85 years life span on average they showed. Significant associations with vegetarian diets were detected for cardiovascular mortality, non-cardiovascular non-cancer mortality, renal mortality, and endocrine mortality. Associations in men were larger and more often significant than were those in women in that study.

On the contrary a recent meta-analysis research publication is based on literature search using mainly UN agencies data such as FAO (Food and Agricultural Organisation) and WHO (World Health Organisation) besides the income data from the world bank, states that the meat consumption is positively related to life expectancy (You, 2022). However, the study mentions strong correlation of GDP (Gross Domestic product) i.e. national correlation with longevity so we think that higher healthy diet ingredients and better medical facilities may also improve longevity. Hence, the data needs to be normalized by removing the confounding factor viz. income. This is what 2 studies quoted below do- and contrast the finding of the said meta-analysis. First is a study in Finland (Ginter, 2008) with only the rich people. Further, a meta-analysis of the global regional diet pattern by Kang et al. (2021) mentions higher consumption of both healthy and risky foods in richer nations and this may obscure the global health markers pattern as presented in the Box 1.

Box 1: Diet difference between the rich and poor nations (Kang et al., 2021)

High income countries' citizens consume nearly 40% more protein (101 g/day/head) than the low income countries (59 g/day/ head). The rich nations' people consumed 50% more fruits (108 g/day/ head) than the poor ones (70 g/day/ head), and 1.7 times more vegetables (80 g/day/ head) helping their health than the later ones (30 g/day/ head) besides 5 times milk (286 g/day/litre and 62 resp. g/day/litre).

However, among the diet risk factors, the rich nations population also consumed 5 times meat (370 g/day/ head) than the poor ones (70 g/day/ head) and 9 times animal fat (134 and 15 g/day/ head resp.) while3.5 times the vegetable oil (238 & 156 g/day/ head resp.). The rich nation people have 50% more energy intake than the poor nations (3,355 and 2,274 kcal/day/ head respectively).

Similarly unhealthy foods such as sugar and sweetener consumption by rich country people was 4 times the poor nation residents (415 & 99 g/ day/ head respectively). Stimulants, such as beverages consumption was 10 times in the rich nation population (25) than the poor ones (2.4 g/day/ head).

Unhealthy food/ behaviour habits differed less between the countries by income levels- smoking was 32 units in rich nations (40% more) than in poor nation (23 units). Similarly, inactivity is 2 times in rich nations (28 units) than the poor nations (14 units). Alcohol consumption was similar in both the country categories (38 and 41 units resp.).

Coronary Heart Disease

Heart disease is the leading cause of deaths in USA, and high processed meat was related to 8% in it while low nuts/ seeds- 8%, low vegetables- 7.6%, low fruits- 7.5%; the last 3 plant based foods comprising 23% altogether (all 4 totalling to 31% of total) (Micha et al., 2017). Among other factors, high sodium foods accounted for 9.5% and sugar sweetened beverages (SSB)- 7.4% the authors showed and also that between 2002 and 2012, population-adjusted US cardio-metabolic deaths per year decreased by 26.5%. The greatest increase was notably linked to unprocessed red meats (+14.4%).

A desk meta-analysis by researchers in Norway largely confirmed this pattern and found that vegetarian diets are associated with reduced risk of coronary and ischemic heart disease, but not stroke that warranted more study (Dybvik et al., 2023). However, a clinical cohort study in Taiwan found that Taiwanese vegetarian diet is associated with a lower risk of ischemic and hemorrhagic strokes. It was based on 9 years follow up of a 13,352 patients (2005-2014) (Chiu et al., 2020a). Similarly, a review by University of Rochester, USA asserts that increasing the intake of fruits, vegetables, whole grains and minimizing intake of meat and processed foods is associated with decreased prevalence of obesity, hypertension, dyslipidemia, and diabetes (Campbell, 2017). Intervention studies have demonstrated benefits from very low-fat, high-fiber plant-based diets in treating the above conditions. This dietary pattern also has the ability to halt or reverse atherosclerosis via multiple mechanisms. This is vital as stroke is a leading cause of death and disability in the United States and globally. Each year, approximately 795,000 Americans experience a stroke. Total annual costs of stroke, both direct and indirect, amount to $33 billion. Ischemic stroke is predicted to cost more than $2.2 trillion between 2005 and 2050, the above study argued!

A study in USA found that the pro-vegetarian diet had a 16%, 31% to 32%, and 18% to 25% lower risk of cardiovascular disease, cardiovascular disease mortality, and all-cause mortality, respectively, after adjusting for important confounders (Kim et al., 2019a). It was

based on a community-based cohort of middle-aged adults (n=12 168) in the ARIC (Atherosclerosis Risk in Communities) study who were followed up from 1987 through 2016.

Eating plant based diet also needs to be a cautious approach and follow the standard dietary recommendations so as to avoid the calorie overdose or run other risks (Baden et al., 2021). Thus, healthy diet recommendations are today common in many developed countries such as USA (www.heart.org/en/healthy-living/healthy-eating) and UK (www.nhs.uk/live-well/eat-well/).

Glycation

A crucial factor inducing the above inflammatory ailments is the body's advanced glycation/ lipoxidation end products (AGE/ALE) pool and a varied diet rich in fresh vegetables and fruits, non-added sugar beverages reduces glycation which improve the health (Leitzmann, 2014). For, fruits-vegetables contain inhibitors of the Maillard reaction, that causes glycation and further, foods prepared by steaming and poaching as culinary techniques is also recommended (Tamanna & Mahmood, 2015). High AGE and thus unhealthy food items include eggs, meat, almond, nuts and bakery. The Maillard reaction is a chemical reaction between amino acids and reducing sugars giving browned food its distinctive colour and flavor. Many foods that undergo this reaction include steaks, fried dumplings, cookies and other kinds of biscuits, breads and toasted marshmallows. The reaction is a form of non-enzymatic browning at very high temperatures, causing acidity from the burning/ charring of the sugar. To reduce the AGEs, the Spanish Society of Community Nutrition (SENC) and Harvard University recommend Intake of supplements and novel foods with low sugars, low fats, enriched in bioactive compounds that can modulate carbohydrate metabolism (Castillo et al., 2021). An Australian study showed that high meat diet (HMD) has higher AGE content than high whole foods diet (HWD, Kim et al., 2020). Glycation and overheating is undesirable as it can modulate AGE formation by modifying the concentrations of phytochemicals such as polyphenols (phenolic acids, flavonoids, stilbenes and lignans). They constitute the major group of plant-derived compounds with anti-AGE activity. For instance, culinary preparation plays a significant role in the final polyphenol content in processed foods, which can act as Maillard reaction inhibitors. The quercetin content of tomatoes and onions can be reduced by up to 80 % from boiling, 65 % from microwaving, and 30 % from frying (Cory et al., 2018).

Cancer

Cancer is among the most dreaded diseases due to the enormous pain and rapid progress sometimes and is a major killer globally, including in the USA and EU vide Global Burden of Disease study (GBD, 2019). It is mainly caused by genetic factor besides some environmental factors and mutation but diet can be crucial in both causing and controlling it vide a study of 40 dietary ingredients in USA (Schoenfeld & Loannidis, 2013). It identified fruits, vegetables, beverages and milk as low risk food ingredients while high risk elements are Bakery/ meat/ flavouring agents (Table 2).

Table 2: Cancer – high and low risk food ingredients

Low risk foods (risk index <0.5)	High risk foods (risk index > 1)
Tomato, lemon, mustard, nuts, wine, peas, onion, celery, carrot, parsley, mace, olive, pepper spice, cayenne, orange, tea, coffee, rum, milk	Veal, egg, bread, potato, mushroom, tripe, bacon, lobster, beef, pork, lamb, corn, sugar, salt, butter, cheese.

The link of diet to cancer is investigated long ago and it is estimated that 30–40% of all cancers can be prevented by lifestyle and dietary measures alone (Donaldson, 2004). Cancer risk factors include impaired glucose metabolism (which leads to diabetes), low fiber intake, consumption of red meat, and imbalance of omega 3 and omega 6 fats all contribute to excess cancer risk. Its causal factors include obesity, nutrient sparse foods such as concentrated sugars and refined flour products. Cancer risk lowering diet includes flax seed, especially its lignan fraction, and abundant portions of fruits and vegetables. Allium (Onion/ garlic) and cruciferous vegetables are especially beneficial, with broccoli sprouts being the densest source of sulforophane (Hemamalini & Babitha, 2016). Selenium, folic acid, vitamin B-12, vitamin D, chlorophyll, and antioxidants such as the carotenoids (α-carotene, β-carotene, lycopene, lutein, cryptoxanthin) are protective dietary elements to prevent cancer (Donaldson, 2004) and ascorbic acid (vitamin C) has benefits intravenously, if not much orally. The study further says that supplementary use of oral digestive enzymes and probiotics also has merit as anticancer dietary measures. Recommended diet adoption can reduce 60–70 % cases of breast, colorectal, and prostate cancers, and even a 40–50 % decrease in lung cancer, and similar reductions in other cancers. Such a diet can favour early recovery from cancer as well (*ibid.*).

A global meta-analysis noted the following significant association of diet factors with different cancer types (Papadimitriou et al., 2011):

(i) red and/or processed meat consumption and risk of colon cancer is positively related,
(ii) total dietary and soluble fiber is inversely associated with the risk of breast cancer,
(iii) serum retinol and α-carotene concentrations and fruit, folate, and vitamin C consumption is inversely related to the risk of lung cancer,
(iv) alcohol and red/processed meat is positive associated with lung cancer,
(v) coffee consumption is inversely associated with melanoma risk in women,
(vi) alcohol consumption and serum vitamin D with is related to cell carcinoma of skin, and
(vii) pickled vegetables and salty foods and risk of stomach cancer is positively correlated.

The study further quoted 3 decades old suggestion that diet and nutrition could account for 20–25% of the worldwide cancer burden (Blot & Tarone, 2015) which said that the obesogenic effects of a high calorie diet and lack of physical activity may share 10–15% of the cancer burden, about 5% attributable to alcohol and another 5% to dietary factors (e.g. red meat, whole grains, calcium).

Alzheimer's disease

Neurodegenerative ailments such as dementia, Alzheimer's and Parkinson's' disease are a leading and growing global burden of disease (GBD) and may shadow the future, especially the well being of the elder (GBD, 2019). Recent European study indicated that vegan diet can aid in preventing the neurodegenerative disorders, including Alzheimer's disease (AD) (Katonova et al., 2013). A vegan diet includes low levels of saturated fats and cholesterol, contributing to a healthy blood lipid profile to manage AD. Furthermore, it is rich in phytonutrients, such as vitamins, antioxidants, and dietary fiber that may help prevent cognitive decline. Moreover, a vegan diet contributes to the assumption of quercetin, a natural inhibitor of monoamine oxidase (MAO), which can contribute to maintaining mental health and reducing AD risk. Nonetheless, the data available do not allow an assessment of whether strict veganism is beneficial for AD prevention compared with vegetarianism or other diets. A vegan diet lacks specific vitamins and micronutrients and may result in

nutritional deficiencies. Vegans not supplementing micronutrients are more prone to vitamin B12, vitamin D, and DHA deficiencies, which have been linked to AD.

A review in USA also indicates that diet is one of the most important targets for lifestyle modification to prevent AD (Khalsa & Perry, 2017). It argues that many still blindly follow the Standard American Diet, or SAD. According to the US Government, about 75 % of all Americans do not consume an adequate amount of vegetables and fruits, while most exceed the recommended amount of sugars, saturated fats, sodium, and calories. Shifting from a fat- and meat-heavy diet to mainly plant-based diet can slow and possibly reverse memory loss. A healthy diet may enhance cognitive performance in multiple ways: affecting synaptic plasticity, synaptic membrane fluidity, glucose utilization, mitochondrial function, or reducing oxidative stress.

The above study in USA further highlights the importance of Mediterranean diet in mental health as it is rich in vegetables, fruit, nuts, olive oil, and fish or seafood. Mediterranean people had lower levels of AD's hallmark amyloid-beta plaques in the spaces between their brain nerve cells, along with fewer telltale tangles of tau protein—meaning that the important cell connections were firing properly. The study quotes that the researchers at the Mayo Clinic, found using MRI scans, that the participants who followed the Mediterranean diet for a year had greater thickness in parts of their brain's cortex that play a role in memory. Those on the SAD diet, on the other hand, lost cortex. Positive associations of the Mediterranean Diet scores were observed with average cortical thickness in parietal and frontal lobes, and in regions of the brain that mediate or support elements such as memory, executive function, and language. Americanized versions of the Mediterranean diet, as well as the MIND (Mediterranean-DASH Intervention for Neuro-degenerative Delay) and DASH (Dietary Approaches to Stop Hypertension) diets, have also shown promising results. Research from Rush University, where the MIND diet was developed by nutritional epidemiologist Martha Clare Morris, revealed that the MIND diet could turn back your mental aging clock the equivalent of up to 7.5 years (Morris et al., 2014). The above lifestyle review also highlights the importance of meditation, yoga and religious singing and psychological health through entertainment, physical activities and social relations in reducing the risk of neurodegenerative disorder.

Box 2: The Alzheimer's nutrition plan (Morris et al., 2014)

- *Vegetarian foods:* full of fruits and vegetables, nuts and seeds, legumes and soy—improves focus and begets higher productivity. Wild-caught salmon is the only animal protein recommended for its brain-friendly omega-3 fats, for only 2 to 3 times a week.
- *Juicing:* Fresh juices are alive with the vitamins, minerals, trace elements, and phytonutrients needed to strengthen the brain (however, consuming fruits, rich in fibre is better to juice).
- *Supplements*: high-potency multivitamin and multi-mineral supplement that includes folic acid. Memory specific supplements of omega-3 oils, phosphatidyl-serine, coenzyme Q10, alpha lipoic acid, huperzine-A, and resveratrol are also recommended.

Diabetes

Diabetes is global epidemic and leading cause of global disease burden, similar to heart disease and hypertension (GBD, 2019). Type 2 diabetes (acquired by diet and environmental factors, while type 1 is genetic) is primarily driven by diet high in sugars, fats and carbohydrates, beyond the body's digestive ability, which is also compromised by diet and environment of modern life. Cohort studies in USA at the New York University School of

Medicine strongly support the role of plant-based diets, and food and nutrient components of plant-based diets, in reducing the risk of type 2 diabetes (McMacken & Shah, 2017). It reports that the type and source of carbohydrate (unrefined versus refined), fats (monounsaturated and polyunsaturated versus saturated and trans), and protein (plant versus animal) play a major role in the prevention and management of type 2 diabetes. Multiple potential mechanisms underlie the benefits of a plant-based diet in ameliorating insulin resistance, including promotion of a healthy body weight, increases in fiber and phytonutrients, food-microbiome interactions, and decreases in saturated fat, advanced glycation end products (AGE), nitrosamines, and heme iron. Plant-based diets and lifestyle changes are effective tools to prevent and manage of type 2 diabetes. Legumes, whole grains, vegetables, fruits, nuts, and seeds are encouraged and most animal products are discouraged.

An Indian study also corroborates this based on cross-sectional data of 156,317 adults aged 20–49 years who participated in India's third National Family Health Survey (2005–06, Agrawal et al., 2014). It was seen that lacto, lacto-ovo and semi-vegetarian diet was associated with a lower likelihood of diabetes than a non-vegetarian diet in the adjusted analyses.

A global meta-analysis of literature in USA also pointed that the vegetarian diets are inversely associated with risk of developing diabetes independent of the positive association of meat consumption with diabetes development (Olfert & Wattick, 2018). Vegetarian diets range from vegan (no animal products), lacto-ovo-vegetarian (no animal meat, but consumes milk and eggs), pesco-vegetarian (consumes fish), and semi-vegetarian (occasional meat consumption). The 3 diet types differed in the extent of preventative and therapeutic effects but all emphasized the whole grains, fruits and vegetables, legumes, and nuts and reducing saturated and trans fats.

Kidney

Diabetes mellitus (DM) is a pathological hyperglycemic state related to the dysregulation of insulin. Chronic kidney disease (CKD) is a common chronic complication in diabetic patients. A vegetarian diet could be one of the preventive strategies for the occurrence of CKD in patients with diabetes mellitus. A retrospective study was conducted at Taipei Tzu Chi Hospital (2005-2016, Hou et al., 2022). Subjects with an HbA1c level > 6.5% or previous history of diabetes mellitus elder than 40 years were grouped as vegetarians, lacto-ovo vegetarians and omnivores. Structural equation modeling (SEM) was applied to estimate the direct and indirect effects of variables on the occurrence of chronic kidney disease of the 2,797 subjects. The incidence of overall CKD was higher in the omnivore group (36.6%) than the vegans (30.4%) or lacto-ovo vegetarian 28.5% ($p< 0.001$). In the SEM model, after adjusting for age and sex, the lacto-ovo vegetarian and vegan groups both had a lower risk of CKD occurrence than the omnivore group. The vegan diet and lacto-ovo diet lowered the risk related to a high BMI and hyperuricemia.

In a Chinese study, healthy adult vegetarians had better renal function than omnivores, and the higher dietary fiber intake associated with vegetarian diets may have contributed to the protective effect on renal function (Xu et al., 2020). A total of 269 vegetarians and 269 sex- and age-matched non-vegetarian omnivores were enrolled in this cross-sectional study. Blood samples were collected, and renal function was assessed by measuring blood urea nitrogen (BUN), serum creatinine (SCr), uric acid (UA) and the estimated glomerular filtration rate (eGFR). Blood pressure, fasting blood glucose and blood lipid profiles were also assessed. Compared with omnivores, vegetarians had lower BUN, and UA levels and higher eGFRs sans confounding factors. Dietary fibre intake was significantly negatively associated with BUN, SCr, and UA levels and positively associated with the eGFR.

A randomized control study was made in Italy with 107 clinically healthy subjects (82 women, 25 men; median age 52) lacto-ovo-vegetarian diet (VD, n= 53), compared to a Mediterranean diet (MD, n= 54), on kidney function in a group of subjects with medium-to-low cardiovascular risk profile as a first dietary intervention in the CARDIVEG study, a randomized, open, crossover trial (Dinu et al., 2021). A significant reduction in creatinine (-5.3%; P < .001), urea nitrogen levels (-9%; P = .001), blood urea nitrogen (BUN) (-8.7%; P = .001) and BUN/creatinine ratio (-5.8%; P < .001), and an increase in estimated glomerular filtration rate (eGFR) (+3.5%; P = .001) was observed in the VD period. On the contrary, no significant changes were noted in the MD group. Variations obtained were significantly different (P < .0001) for creatinine levels, BUN/creatinine and eGFR, and the trends in the VD and MD groups were opposite. Thus, significant improvements in kidney function markers were observed in the VD segment.

In a study examining over 1 million people in USA, the rate of cardiovascular events progressively increased as estimated glomerular filtration rate (eGFR) declined. Even mild to moderate kidney impairment was associated with an increased cardiovascular mortality (Kim et al., 2019b).The CARDIVEG study above said that the adoption of plant-based diets, such as the Mediterranean diet (MD) or the lacto-ovo-vegetarian diet (VD), has potential benefits in both primary prevention and early stages of CKD, due to reduced protein and sodium intake, decreased phosphorus load and increased intake of fibre, vitamins, antioxidants linked to improved outcomes in CKD patients. It may also help in the CKD metabolic complications viz. dyslipidaemia, hypertension, inflammation and bone disorders. Higher adherence to healthy plant-based diets and a vegetarian diet was associated with favourable kidney disease outcomes in a clinical trial in USA with a median follow-up of 24 years, 4,343 incident CKD cases.

That plant proteins may exert beneficial effects on blood pressure, proteinuria, and glomerular filtration rate, as well as results in milder renal tissue damage when compared to animal proteins so the Polish National Kidney Foundation recommends vegetarianism, or part-time vegetarian diet as being beneficial to CKD patients (Gluba-Brzózka & Rysz, 2017). They mention the support of the results of studies demonstrating that a plant-based diet may hamper the development or progression of some complications of chronic kidney disease, such as heart disease, protein loss in urine, and the progression of kidney damage. They cite few reports that suggest that a vegan diet is inappropriate for CKD patients and those undergoing dialysis due to the difficulty in consuming enough protein and in maintaining proper potassium and phosphorus levels. Nevertheless, a vegetarian diet may benefit due to the associated cardio-protective, anti-oxidant, and lipid-lowering properties.

Arthritis

Musculoskeletal disorders including joint pain is among the top health issues globally and most prominent among the elders (GBD, 2019).

a) *Rheumatoid arthritis:* Vegetarian diet may help in managing rheumatoid arthritis (RA), an auto immune disease, common among the elders, and hard to cure though less common than the other 2 types described further. In a controlled, single-blind trial researchers in Norway tested the effect of fasting for 7-10 days, then consuming an individually adjusted, gluten-free, vegan diet for 3.5 months, and then consuming an individually adjusted lactovegetarian diet for 9 month on patients with RA (Kjeldsen-Kragh, 2017). For all the clinical variables and most laboratory variables measured, the 27 patients in the fasting and vegetarian diet groups improved significantly compared with the 26 patients in the control group who followed their usual omnivorous diet throughout the study period. One year after the patients completed the trial, they were re-examined. Compared with baseline, the improvements measured were significantly

greater in the vegetarians who previously benefited from the diet (diet responders) than in diet non-responders and omnivores.

A Sweedish study randomized rheumatoid arthritis patients to a Mediterranean diet—which emphasized fruits, vegetables, whole grains, legumes, and nuts—or to continue their normal diet (Skoldstam et al., 2003). After 12 weeks, the Mediterranean diet group showed decreased disease activity, had fewer swollen joints, and had less pain compared with those who did not make the dietary changes.

b) *Osteoarthritis:* A 2006 study in Boston, USA found that eating meat just once per week (compared with eating no meat) was associated with an increased risk of osteoarthritis by 31% in women and 19% in men. Meat consumption above once per week posed 49% and 43% higher risk respectively (Hailu et al., 2006). Osteoarthritis is common today and often treated with knee replacement surgery but can affect shoulder joint also or back pain.

In another USA study, researchers used data from two large cohorts and found that those who consumed the highest amounts of fibre had a 30 % lower risk of knee osteoarthritis in one cohort, and a 61 % lower risk in the other cohort (Dai et al., 2016).
To evaluate the effectiveness of a whole-foods, plant-based diet (WFPB) to reduce symptoms of osteoarthritis, a study was done in USA (Clinton et al., 2015). Six-week, prospective randomized open-label study of patients aged 19–70 with osteoarthritis. Forty participants were randomized. Thirty-seven of them, 18 control and 19 intervention, completed the study. The intervention group reported a significantly greater improvement than the control group in SF-36v2 energy/vitality, physical functioning, role physical, and the physical component summary scale. The differences between the intervention and control the "Patient Global Impression of Change"- PGIC scales were statistically significant over time. Intervention group improvement in "Visual Analog Scale"- VAS weekly mean was also significantly greater than that of the control group from week 2 onward. Study results suggest that a whole-foods, plant-based diet significantly improves self-assessed measures of functional status among osteoarthritis patients.

Although not completely understood, the effect of a healthy diet on osteoarthritis may be mediated through reduced inflammation and promotion of healthy body weight. Overweight and obese individuals are over 2 times as likely to develop osteoarthritis compared to normal weight individuals, and even minimal weight loss can substantially reduce that risk. Because plant-based diets are linked to with lower body weight, this may help to manage osteoarthritis.

c) *Gout* is an inflammatory disease caused by urate crystals depositing in various tissues of the body, especially joints. Uric acid is a breakdown product of compounds called purines, which are found in high concentrations in meat, seafood, and alcohol. At high levels in the body and under certain circumstances, uric acid can form crystals that trigger a painful inflammatory response. Due to differences in purine content among foods and its role in the disease process, extensive research has been done on the effect of diet on gout risk.

A study in Taiwan included 2 cohorts with 13,935 people in total followed for over 8 years on average and found that those eating a vegetarian diet were a 1/3rd as likely to suffer from gout than the non-vegetarians, after accounting for differences in other risk factors (e.g., age, smoking, alcohol use) statistically (Chiu et al., 2020b).

A large study in USA followed 47,150 men over a period of 12 years and found that those eating the highest amount of meat and seafood were, 41 % and 51 % more likely to develop gout respectively than those eating it the least amount (Choi et al.,

2004). Interestingly, they found that high purine vegetables were not associated with an increased risk of gout.

Inflammation

Most of the above ailments are related or due to inflammation, so development of anti-inflammatory agents is crucial (Calhela et al., 2023). Among the existing anti-inflammatory drugs, non-steroidal and glucocorticoids are commonly used; however, these compounds have been described as responsible for the increased risk of upper gastrointestinal complications and many other side effects. Therefore, ethnobotany leads most modern studies on the discovery of anti-inflammatory agents obtained from natural molecules such as Curcumin, a flavonoid from Turmeric roots. It is a common spice in India that has high antioxidant value and maybe responsible for 50% lower Cancer incidence (89 per 0.1 million) in India than the global average (197) which is 25% of the EU (363) or USA (387), indicating better immunity in India (Aggarwal et al., 2011).

NUTRITION

Vegan diets may face some nutrition deficiencies, but less likely for vegetarians, it is well known such as vitamin B12, Omega 3, Zinc, iron, Calcium and protein (Bakaloudi et al., 2021; Truss & Surholt, 2022). Table 3 depicts such likely nutrition gaps and plant based sources to manage them.

Table 3: Common nutrition deficiencies in vegan diets and their plant based option (Anon, n.d.)

Component	Function	Food Sources	Vegan Sources	Remark
Calcium	Bones, teeth	Milk, dairy products	Dark green vegetables, millets, kale, broccoli, soy	
Vitamin D	Bone, immunity	Milk, curds (yogurt)	Soy (milk, tofu), rice milk*, margarine*	Sun exposure is crucial
Vitamin B12	Red blood cells, prevent anaemia	Milk, meat	-	Folate can mask its deficiency#
Protein	Skin, bones, muscles	Eggs, dairy products, meat	Legumes, soy, whole grains, nuts, seeds	
Omega-3 fatty acids	Brain, heart function, pregnancy	Fish	Canola oil, soy oil, walnuts, flaxseed, kidney beans	Phytates** in legumes can affect bioavailability
Iron##	Blood, strength	Meat	Beans and peas, lentils, enriched cereals, whole-grains, dark leafy green vegetables, dried fruit, black bean	Plant based iron absorption is less than animal sources

Zinc	Immunity, vision, make protein, cell growth	Fish, crab, shrimp, cheese, yogurt	Grains, soy products, lentils, beans, nuts, wheat germ	
Iodine	Make thyroid hormones$, goiter	Seafood, dairy	Seaweed, iodized salt	

Note: *- fortified, #- found in vegan diet **- anti-nutrients that can hamper absorption of iron etc.; ##- Vitamin C-rich foods help in iron absorption peppers, strawberries, citrus fruits, tomatoes, cabbage and broccoli; $- help in metabolism and in muscle growth

Iron and zinc are 2 important minerals in preventing anemia and building immunity- a global priority today. Prevalence of inadequate absorbable zinc intake has increased from 17.1% (15.3%-19.0%) in 1983 to 24.6% (22.3%-27.1%) of people in 2011-12, corresponding to an additional 82 million people consuming inadequate zinc (Smith et al., 2019). For, relatively constant zinc intake being increasingly insufficient to meet a 5% growth in zinc requirements due to the aging of the population. Rising carbon di oxide to 550 ppm by 2050 could increase the prevalence of inadequate zinc intake by another 3.9 % (2.1-5.8), implying 65 million more people with inadequate zinc intake, requiring zinc supplementation. However, another study found Indian vegetarian diets to be adequate to sustain nutritional demands according to recommended dietary allowances with less fat, except lower vitamin B12 status (Shridhar et al., 2014).

Phytate content in the Indian diet such as pulses can inhibit iron and zinc absorption but their depleting soil stocks is a growing concern and needs precision fertilizer inputs and sustainable agriculture practices (Ganeshamurthy et al., 2013; Chander et al., 2014). Biofortification by adding essential minerals through plant breeding is emerging rapidly (Wani et al., 2017), besides precision farming techniques to improve the secondary metabolites in the crops for higher health benefits (Ghate et al., 2019). Pearl millet Biofortification with iron for instance is most promoted for instance (Manwaring et al., 2016). Millets i.e. coarse cereals once common in rainfed farming across globe are also vital in ensuring nutrition and 2023 is thus declared by the UN as “international millets year” (Anon, 2023). Millets now join the rank of “Superfoods” i.e. healthy diet ingredients earlier enjoyed only by the European or American fruits and vegetables such as blueberries and hazelnuts (MacManus, 2021).

Spices are considered as health guardians in traditional Indian diet due to their “bioactive” ingredients such as polyphenols and saponins besides alkaloids (Aruna et al., 2014; Vasanthi et al., 2010). Traditional Indian medicinal systems such as Ayurveda and Siddha thus focus on not just therapy but also diet (Deshpande et al., 2023). Ayurveda and Indian diet prevalent in plant based foods popularity and business is thus growing globally today on health grounds. But it will also help in environmental sustainability (Salonen & Helne, 2012). Further, plant based diets are crucial from a “Quality of life” (QOL) view stressing the psychology and animal rights perspective besides Violence as an evolutionary feature (Hargreaves et al., 2021), besides many health issues with meat based diets as shown in a study in UK (Papier et al., 2021).

Gut Microbe Importance

An imbalance or alteration in microbial composition and activity, also called “gut microbiotadysbiosis”, is linked to several ailments, although its causal or consequential role is unclear (Sakkas et al., 2020). Disorders included here are obesity, type-2 diabetes mellitus, neurological and neuropsychiatric cormobidities (Alzheimer’s and Parkinson’s diseases,

hepatic encephalopathy, autism spectrum disorder, depression, amyotrophic lateral sclerosis), allergy, carcinogenesis, autoimmune diseases (celiac disease, systemic lupus erythematosus, rheumatoid arthritis, psoriasis, atopic dermatitis), infectious diseases (clostridium difficileinfection), cardiovascular disease, and chronic kidney, hepatic, and gastrointestinal diseases. Gastrointestinal tract ailments commonly related to gut microbiotadysbiosis include inflammatory bowel disease (IBD), ulcerative colitis and Crohn's disease, Irritable bowel syndrome, diverticular disease, and colorectal cancer. The study enlists the many benefits of vegan diets while also cautioning about few constraints, by affecting the gut microbiota.

CONCLUSIONS

We present literature based evidence that plant based diets can improve the human health and especially of elderly population and increase the life span, besides immunity. COVID-19 mortality and prevalence rates are lower in India and many less developed nations than the western world, indicating better immunity. Predominance of natural, home cooked, fresh and plant based diets, including spices can explain it as the developed countries diets abound in packed foods and hoteling, meat consumption. Plant based diets possess all micro nutrients except notably vitamin B12 but health supplements can meet it. Calcium, Iron and Zinc deficiency is not specific to vegetarian diet, especially in India. Superfoods, millets and biofortification can be the future focus of agriculture development being nutritive. Risk of malnutrition in future include the growing soil nutrient gap and climate change, requiring adoption of the sustainable and precision agriculture practices.

ACKNOWLEDGMENTS

We acknowledge the kind encouragement by our institutions management in this research.

CONFLICT OF INTEREST

We declare that there is no conflict of interest and that this research was not funded.

REFERENCES

Aggarwal, B., Prasad, S., Reuter, S., Kannappan, R., R Yadav, V., Park, B., ... & Sung, B. (2011). Identification of novel anti-inflammatory agents from Ayurvedic medicine for prevention of chronic diseases: "reverse pharmacology" and "bedside to bench" approach. *Current Drug Targets*, *12*(11), 1595-1653. https://doi.org/10.2174/138945011798109464

Agrawal, S., Millett, C. J., Dhillon, P. K., Subramanian, S. V., & Ebrahim, S. (2014). Type of vegetarian diet, obesity and diabetes in adult Indian population. *Nutrition Journal*, *13*, 89. https://doi.org/10.1186/1475-2891-13-89

Amrein, K., Scherkl, M., Hoffmann, M., Sommeregger, S.N., & Kostenberger, M. (2020). Vitamin D deficiency 2.0: an update on the current status worldwide. *Euro. J Clini Nutri*, *74*, 1498-1513. https://doi.org/10.1038/s41430-020-0558-y

Anon. (2023). 2023 declared as "international millets year" by the UN. Retrieved March 10, 2023, from https://www.smartfood.org/international-year-of-millets-2023/

Anon. (n.d.). Vegetarian diet: How to get the best nutrition, Mayo Clinic. Retrieved March 10, 2023, from https://www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/in-depth/vegetarian-diet/art-20046446

Aruna, R., Sathiyarajeswaran, P., Gopakumar, K., & Ramaswamy, R. S. (2014). Cardioprotective effects of kitchen culinaries mentioned in Siddha literature. *Journal of Pharmacognosy and Phytochemistry*, *3*(3), 71-79.

Baden, M. Y., Shan, Z., Wang, F., Li, Y., Manson, J. E., Rimm, E. B., ... & Rexrode, K. M. (2021). Quality of plant-based diet and risk of total, ischemic, and hemorrhagic stroke. *Neurology*, *96*(15), e1940-e1953. https://doi.org/10.1212/WNL.0000000000011713

Bakaloudi, D. R., Halloran, A., Rippin, H. L., Oikonomidou, A. C., Dardavesis, T. I., Williams, J., ... & Chourdakis, M. (2021). Intake and adequacy of the vegan diet. A systematic review of the evidence. *Clinical Nutrition*, *40*(5), 3503-3521. https://doi.org/10.1016/j.clnu.2020.11.035

Blot, W. & Tarone, R. (2015). Doll and Peto's quantitative estimates of cancer risks: holding generally true for 35 years. *J Natl Cancer Inst*, *107*(4), djv044. https://doi.org/10.1093/jnci/djv044

Brodt, S. (1994). Book review: This Fissured Land: An Ecological History of India. Madhav Gadgil and Ramachandra Guha. Berkeley: University of California Press, 1992.*Journal of Political Ecology*, *1*(1), 7-9. https://doi.org/10.2458/v1i1.21162

Calhela, R., Haddad, H., Ribeiro, L., Heleno, S., & Barros, C. M. (2023). Inflammation: What's There and What's New? *Appl. Sci.*, *13*, 2312. https://doi.org/10.3390/app13042312

Campbell, T. A. (2017). Plant-based diet and stroke. *J Geria Cardiol.*, *14*(5), 321–326. https://doi.org/10.11909/j.issn.1671-5411.2017.05.010

Castillo, M., Iriondo-DeHond, A., Iriondo-DeHond, M., Gonzalez, I., Medrano, A., Filip, R. & Uribarri, J. (2021). Healthy eating recommendations: good for reducing dietary contribution to the body's advanced glycation/lipoxidation end products pool? *Nutrition Research Reviews*, *34*, 48–63. https://doi.org/10.1017/S0954422420000141

Chander, G., Wani, S., Kanwar, L., Sahrawat, Dixit, S., Venkateswarlu, B., & Rajesh, C. (2014). Soil test-based nutrient balancing improved crop productivity and rural livelihoods: case study from rainfed semi-arid tropics in Andhra Pradesh, India. *Archives of Agronomy and Soil Science*, *60*(80), 1051–1066. https://doi.org/10.1080/03650340.2013.871706

Chiu, T., Chang, H., Wang, L., Chang, C., & Lin, M. (2020a). Vegetarian diet and incidence of total, ischemic, and hemorrhagic stroke in 2 cohorts in Taiwan. *Neurology*, *94*(11), e1112–e1121.

Chiu, T., Liu, C., Cahnag, C., Lin, M., & Lin, C. (2020b). Vegetarian diet and risk of gout in two separate prospective cohort studies. *Clin Nutr*, *39*(3), 837-844. https://doi.org/10.1016/j.clnu.2019.03.016

Choi, H., Atkinson, K., Karlson, E., Willet, W., & Curhan, G. (2004). Purine-rich foods, dairy and protein intake, and the risk of gout in men. *N Engl J Med*, *350*(11), 1093-103. https://doi.org/10.1056/NEJMoa035700

Ciati, R. & Ruini, L. (2010). Double Pyramid: Healthy Food for People and Sustainable for the Planet. In FAO (Eds.), *Sustainable Diets and Biodiversity Directions and Solutions for Policy, Research and Action* (pp. 280-294). Food & Agriculture Organization, Rome.

Clinton, C., O'brian, S., Law, J., Renier, C., & Wendt, M. (2015). Whole-Foods, Plant-Based Diet Alleviates the Symptoms of Osteoarthritis. *Arthritis*, *2015*, 708152. https://doi.org/10.1155/2015/708152

Cory, H., Passarelli, S., Szeto, J., Tamez, M., & Mattei, J. (2018). The role of polyphenols in human health and food systems: A mini-review. *Frontiers in Nutrition*, *5*, 87. https://doi.org/10.3389/fnut.2018.00087

Dai, Z., Niu, J., Zhang, Y., Jacques, P., & Felson, D. (2017). Dietary intake of fibre and risk of knee osteoarthritis in two US prospective cohorts. *Ann Rheum Dis.*, *76*(8), 1411-1419. https://doi.org/10.1136/annrheumdis-2016-210810

Deshpande, M. (2023). Culinary to Therapeutics: Ayurved Perspectives. In Verma S. (Ed.), *Indian Medicinal Plants: Advancement in the Traditional Medicine, Sustainable Utilization and Conservation* (pp. 99-106). ABS Books, Delhi.

Dinu, M., Colombini, B., Pagliai, G., Giangrandi, I., Cescari, F., & Gori, A. (2021). Effects of vegetarian versus Mediterranean diet on kidney function: Findings from the CARDIVEG study. *Europ J Clini Invest*, *51*(9), e13576. https://doi.org/10.1111/eci.13576

Donaldson, M. (2004). Nutrition and cancer: A review of the evidence for an anti-cancer diet. *Nutrition Journal*, *3*, 19. https://doi.org/10.1186/1475-2891-3-19

Dunn, R. (2012). Human Ancestors Were Nearly All Vegetarians. *Scientific American Blogs.* Retrieved April 2, 2023, from https://blogs.scientificamerican.com/guest-blog/human-ancestors-were-nearly-all-vegetarians/

Dybvik, J. S., Svendsen, M., & Aune, D. (2023). Vegetarian and vegan diets and the risk of cardiovascular disease, ischemic heart disease and stroke: a systematic review and meta-analysis of prospective cohort studies. *Europ J Nutri*, *62*, 51–69. https://doi.org/10.1007/s00394-022-02942-8

Einstein, A. (1930). Translation of letter to Hermann Huth, December 27. *Einstein Archive*, 46-756. Retrieved April 2, 2023, from https://ivu.org/history/northam20a/einstein.html

Ferreira, F. (2021). Inequality in the Time of Covid-19. *Finance & Development*, June, pp. 20-23. Retrieved April 2, 2023, from https://www.imf.org/external/pubs/ft/fandd/2021/06/inequality-and-covid-19-ferreira.htm

Ganeshamurthy, A., Kalaivanan, D., & Manjunath, B. (2013). Nutrients removed from the soil decide the nutritional security of a nation: the case of iron and zinc in India. *Current Science*, *113*(6), 1167-73. https://doi.org/10.18520/cs/v113/i06/1167-1173

GBD. (2019). Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet*, *396*(10258), 1204-1222. Retrieved March 10, 2023, from https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)30925-9/fulltext (GBD data: https://www.healthdata.org/node/7843)

Ghate, U. & Kulkarni, H. (2021). Polyphenols, Spices and Vegetarian Diet for Immunity and Anti-Inflammatory Drug Design. In Zepka et al. (Eds.), *Bioactive Compounds - Biosynthesis, Characterization and Applications* (pp. 63-76). Intechopen, London. https://doi.org/10.5772/intechopen.97661

Ghate, U. & Kulkarni, H. (2022). Packed Foods Related to COVID-19. *J Ecol Natu Reso*, *6*(4), 000309. https://doi.org/10.23880/jenr-16000309

Ghate, U., Kulkarni, H., & Arunachalam, A. (2019). Spices in the eastern Indian laterite soil have more polyphenols? *Ind. Jr. Hill Farming*, *32*(2), 236-238.

Ginter, E. (2008).Vegetarian diets, chronic diseases and longevity. *Bratisl Lek Listy*, *109*(10), 463-6.

Gluba-Brzózka, A. & Rysz, J. (2017). Vegetarian Diet in Chronic Kidney Disease—A Friend or Foe. *Nutrients*, *9*(4), 374. https://doi.org/10.3390/nu9040374

Greg, M. (2012). Making the Most of Monday. *Syracuse University Magazine*, *29*(1), 36–39.

Grube, N., Garcia, H. & Perry, G. (2021). Human Diet Evolution: Meat, Fire, and Tapeworms. *Front. Young Minds*, *9*, 555342. https://doi.org/10.3389/frym.2020.555342

Hailu, A., Knutsen, S., & Fraser, G. (2006). Associations between meat consumption and the prevalence of degenerative arthritis and soft tissue disorders in the Adventist health study, California U.S.A. *J Nutr Health Aging*, *10*(1), 7-14.

Hargreaves, S., Raposo, A., Saraiva, A., & Zandonadi, R. (2012). Vegetarian Diet: An Overview through the Perspective of Quality of Life Domains. *Int J Environ Res Public Health*, *18*(8), 4067. https://doi.org/10.3390/ijerph18084067

Hemamalini, K., & Babitha, B. (2016). Effectiveness of Dietary Habits in Women Cancer Patients. *Intl. Jr of Home Science*, *2*(3), 156-158.

Hou, Y. C., Huang, H. F., Tsai, W. H., Huang, S. Y., Liu, H. W., Liu, J. S., & Kuo, K. L. (2022). Vegetarian Diet was Associated with a lower risk of chronic kidney Disease in Diabetic Patients. *Frontiers in Nutrition*, *9*, 843357. https://doi.org/10.3389/fnut.2022.843357

Kang, S., Kang, M., & Lim, H. (2021). Global and Regional Patterns in Noncommunicable Diseases and Dietary Factors across National Income Levels. *Nutrients*, *13*(10), 3595. https://doi.org/10.3390/nu13103595

Katonova, A., Sheardova, K., Amlerova, J., Angelucci, F., & Hort, J. (2022). Effect of a Vegan Diet on Alzheimer's Disease. *Int. J. Mol. Sci.*, *23*, 14924. https://doi.org/10.3390/ijms232314924

Khalsa, D. S., & Perry, G. (2017, March). The four pillars of Alzheimer's prevention. In *Cerebrum:* Mar 1: Cer-03-17.

Kim, H., Caulfield, L. E., Garcia-Larsen, V., Steffen, L. M., Coresh, J., & Rebholz, C. M. (2019a). Plant-based diets are associated with a lower risk of incident cardiovascular disease, cardiovascular disease mortality, and all-cause mortality in a general population of middle-aged adults. *Journal of the American Heart Association*, *8*(16), e012865. https://doi.org/10.1161/JAHA.119.012865

Kim, H., Caulfield, L. E., Garcia-Larsen, V., Steffen, L. M., Grams, M. E., Coresh, J., & Rebholz, C. M. (2019b). Plant-based diets and incident CKD and kidney function. *Clinical journal of the American Society of Nephrology: CJASN*, *14*(5), 682-691. https://doi.org/10.2215/CJN.12391018

Kim, Y., Keogh, J. B., Deo, P., & Clifton, P. M. (2020). Differential effects of dietary patterns on advanced glycation end products: A randomized crossover study. *Nutrients*, *12*(6), 1767. https://doi.org/10.3390/nu12061767

Kjeldsen-Kragh, J. (1999). Rheumatoid arthritis treated with vegetarian diets. *Clinical Trial-Am J Clin Nutr.*, *70*(3 Suppl), 594S-600S. https://doi.org/10.1093/ajcn/70.3.594s

Ledford, H. A. (2010). Genetic gift for sushi eaters. *Nature*, *2010*. https://doi.org/10.1038/news.2010.169

Leitzmann, C. (2014). Vegetarian nutrition: past, present, future. *The American Journal of Clinical Nutrition*, *100*(1_suppl.), 496S–502S.

Luca, F., Perry, G. H., & Rienzo, A. D. (2010). Evolutionary Adaptations to Dietary Changes. *Annu Rev Nutr.*, *30*, 291–314. https://doi.org/10.1146/annurev-nutr-080508-141048

MacManus, K. (n.d.). 10 superfoods to boost a healthy diet. Retrieved March 10, 2023, from https://www.health.harvard.edu/blog/10-superfoods-to-boost-a-healthy-diet-2018082914463

Manwaring, H., Bligh, H., & Yadav, R. (2016). The Challenges and Opportunities Associated with Biofortification of Pearl Millet (*Pennisetum glaucum*) with Elevated Levels of Grain Iron and Zinc. *Front. Plant Sci. (Sec. Plant Nutrition)*, *7*, 1944. https://doi.org/10.3389/fpls.2016.01944

McMacken, M. & Shah, S. (2017). A plant-based diet for the prevention and treatment of type 2 diabetes. *J Geriatr Cardiol.*, *14*(5), 342–354. https://doi.org/10.11909/j.issn.1671-5411.2017.05.009

McManus, M. (2021). What is a plant-based diet and why should you try it? *Harvard Health Blog.*, Nov. 16. Retrieved April 2, 2023, from

https://www.health.harvard.edu/blog/what-is-a-plant-based-diet-and-why-should-you-try-it-2018092614760

Micha, R., Peñalvo, J., Cudhea, F., Imamura, F., Rehm, C., & Mozaffarian, D. (2017). Association between Dietary Factors and Mortality from Heart Disease, Stroke, and Type 2 Diabetes in the United States. *JAMA, 317*(9), 912–924. https://doi.org/10.1001/jama.2017.0947

Morris, M. C., Tangney, C. C., Wang, Y., Barnes, L. L., Bennett, D., & Aggarwal, N. (2014). O2-02-04: MIND diet score more predictive than DASH or Mediterranean diet scores. *Alzheimer's & Dementia*, *10*, 166. http://dx.doi.org/10.1016/j.jalz.2014.04.164

Olfert, M. & Wattick, R. (2018). Vegetarian Diets and the Risk of Diabetes. Current Diabetes Reports. *Curr Diab Rep.*, *18*(11), 101. https://doi.org/10.1007/s11892-018-1070-9

Orlich, M., Singh, P., Sabate, J., Jaceldo-Siegl, K., Fan, J., & Knutsen, S. (2013). Vegetarian Dietary Patterns and Mortality in Adventist Health Study 2. *JAMA Intern Med.*, *173*(13), 1230-1238. https://doi.org/10.1001/jamainternmed.2013.6473

Papadimitriou, N., Markozannes, G., Kanellopoulou, A., Critselis, A., Alhardan, S., & Karafousia, V. (2021). An umbrella review of the evidence associating diet and cancer risk at 11 anatomical sites. *Nature Communications, 12*, 4579. https://doi.org/10.1038/s41467-021-24861-8

Papier, K., Fensom, G.K. & Knuppel, A. (2021). Meat consumption and risk of 25 common conditions: outcome-wide analyses in 475,000 men and women in the UK Biobank study. *BMC Med, 19*, 53. https://doi.org/10.1186/s12916-021-01922-9

Sakkas, H., Bozidis, P., Touzios, C., Kolios, D., Athanasiou, G., Athanasopoulou, E., Gerou, L., & Gartzonika, C. (2020). Nutritional Status and the Influence of the Vegan Diet on the Gut Microbiota and Human Health. *Medicina, 56*, 88. https://doi.org/10.3390/medicina56020088

Salonen, A. & Helne, T. (2012). Vegetarian Diets: A Way towards a Sustainable Society. *J Sustainable Development, 5*(6), 10-15. https://doi.org/10.5539/jsd.v5n6p10

Schoenfeld, J. & Loannidis, J. (2013). Is everything we eat associated with cancer? A systematic cookbook review. *Am J Clin Nutr*; *97*, 127–34. https://doi.org/10.3945/ajcn.112.047142

Shridhar, K., Dhillon, P., Bowen, L., Kinra, S., Vharathi, A., & Prabhakaran, D. (2014). Nutritional profile of Indian vegetarian diets – the Indian Migration Study (IMS). *Nutr J.*, *13*, 55. https://doi.org/10.1186/1475-2891-13-55

Skoldstam, L., Hagfors, L., & Johansson, G. (2003). An experimental study of a Mediterranean diet intervention for patients with rheumatoid arthritis. *Ann Rheum Dis*., *62*(3), 208–214. https://doi.org/10.1136/ard.62.3.208

Smith, M. R., DeFries, R., Chhatre, A., Ghosh-Jerath, S., & Myers, S. S. (2019). Inadequate zinc intake in India: past, present, and future. *Food and Nutrition Bulletin*, *40*(1), 26-40. https://doi.org/10.1177/0379572118825176

Tamanna, N. & Mahmood, N. (2015). Food Processing and Maillard Reaction Products: Effect on Human Health and Nutrition. *Int J Food Sci., 2015*, 526762. https://doi.org/10.1155/2015/526762

Teaford, M. & Ungar, P. (2000). Diet and the evolution of the earliest human ancestors. *Proc Natl Acad Sci U S A.*, *97*(25), 13506–13511. https://doi.org/10.1073/pnas.260368897

Truss, L. & Surholt, B. (2022). Vegan diet: imbalanced or healthy approach? https://www.tk.de/en/i-am-tk/tk-members/vegan-diet-2099488

Vasanthi, H. & Parameswari, R. (2010). Indian Spices for Healthy Heart – An Overview. *Current Cardiology Reviews, 6*, 274-279. https://doi.org/10.2174/157340310793566172

Wani, S. & Govindaraj, M. (2017). Soil health to human and animal health through breeding biofortified cultivars and balanced nutrient management for nutrition revolution in India. In D. Reddy, V. Rao, & R. Krishna (Eds.), *Insights on Global Challenges and Opportunities for the Century Ahead* (pp. 269-274). BS Publications, Hyderabad.

WHO. (2002). *Diet, nutrition and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation*. Tech. report. No. 916. pp. 150. FAO/ WHO, Geneva.

Xu, K., Cui, X., Wang, B., Tang, Q., Cai, J., & Shen, X. (2020). Healthy adult vegetarians have better renal function than matched omnivores: a cross-sectional study in China. *BMC Nephrology, 21*, 268. https://doi.org/10.1186/s12882-020-01918-2

You, W., Henneberg, R., Saniotis, A., Ge, Y. & Henneberg, M. (2022). Total Meat Intake is Associated with Life Expectancy: A Cross-Sectional Data Analysis of 175 Contemporary Populations. *Int J Gen Med., 15,* 1833–1851. https://doi.org/10.2147/IJGM.S333004