PIETRUSIŃSKA, Patrycja, DZIEWIERZ, Anna, SOBIŃSKI, Adam, MIŚKEWICZ, Joanna, DUDEK, Aleksandra, SADOWSKA, Aleksandra, MODER, Jakub, WELKIER, Aleksandra, KWAŚNIEWSKA, Paula and ŚLIWA-TYTKO, Patrycja. Plant-based diet - influence on general health. Quality in Sport. 2025;41:60086. eISSN 2450-3118.
https://doi.org/10.12775/QS.2025.41.60086
https://apcz.umk.pl/QS/article/view/60086

The journal has been awarded 20 points in the parametric evaluation by the Ministry of Higher Education and Science of Poland. This is according to the Annex to the announcement of the Minister of Higher Education and Science dated 05.01.2024, No. 32553. The journal has a Unique Identifier: 201398. Scientific disciplines assigned: Economics and Finance (Field of Social Sciences); Management and Quality Sciences (Field of Social Sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).
The authors declare that there is no conflict of interest regarding the publication of this paper.
Received: 05.04.2025. Revised: 25.04.2025. Accepted: 06.05.2025. Published: 11.05.2025.

Plant-based diet - influence on general health

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Abstract

Introduction

An increasing number of individuals worldwide are adopting a plant-based diet, which has been highlighted for its health benefits in various scientific studies. Nevertheless, research indicates that an improperly balanced plant-based diet, excluding animal products, may lead to nutrient deficiencies and disrupt the proper functioning of various bodily systems through multiple pathways

Aim

The aim of this review is to consolidate and summarize the existing research and literature regarding the effects of a plant-based diet on general health.

Review methods

The review was based on publicly available PubMed and Google Schola databases using the following phrases: plant-based diet, vegan diet, vegetarianism.

Conclusion:

When properly planned and supported by appropriate supplementation, a plant-based diet can positively influence both female and male reproductive health, improve sleep quality, enhance overall well-being, aid in weight management, and contribute to the prevention of diabetes and cardiovascular diseases. However, as the number of dietary exclusions increases, so does the risk of deficiencies in essential vitamins and minerals. Inadequate levels of these nutrients

may lead to physiological abnormalities and adverse health outcomes, underscoring the critical importance of balanced dietary planning and monitoring.
Keywords: plant-based diet, vegan diet, vegetarianism.

Introduction

Commonly vegetarianism is understood as the elimination of meat from one's diet. It encompasses several types of diets, categorized depending on how many food groups are excluded.[1]

Conscious reduction in meat consumption, is gaining popularity in meat-heavy countries.[2] The prevalence of vegetarianism varies globally, with North America having a relatively low rate, as only 6% of the population follows a vegetarian diet. In contrast, Asia has the highest proportion of vegetarians, largely due to India, where nearly 40% of the population adheres to a vegetarian lifestyle.[3] The number of people globally reporting adherence to a plant-based diet is on the rise.

The terms "plant-based diet" and "vegan diet" are often used interchangeably, implying the avoidance of animal meats and products. However, some sources argue that a plant-based diet is not necessarily vegetarian or vegan. This difference contributes to the controversy surrounding its definition. Some diets that include moderate animal products are also considered healthy plant-based diets.[4]

Individuals following a flexitarian diet should not express dissatisfaction with excessive restrictions, as this dietary pattern incorporates plant-based foods, dairy, and eggs, while significantly reducing meat consumption. The definition of a flexitarian diet varies in frequency of meat consumption. For example, it can range from a decision not to eat meat at every meal giving up meat one day per week or eating a mainly plant based diet with piece of meat consumption as an exception.[5]

People on a pescatarian diet, in addition to eating dairy products and eggs like lacto-ovo-vegetarians, also eat seafood[6], while vegans avoid all animal products[7]. They exclude meat, fish, dairy items, eggs, honey, and foods that include ingredients obtained from the processing of muscle or dairy products, like gelatin and rennet.[8]

People choose a vegetarian or vegan lifestyle for assorted reasons, including health, environmental concerns, socioeconomic factors, ethical beliefs, and spiritual or religious views. According to the American Dietetic Association (ADA), a well-planned vegetarian diet

is safe for individuals of all ages and physiological conditions, including children, adolescents, pregnancy, and lactation.[9]

Overall, research on vegetarian and vegan adults has demonstrated various health advantages, including a reduced risk of obesity, cardiovascular diseases, and diabetes.[10]

Although, according to existing scientific literature, the most frequent deficiencies observed in vegans and vegetarians include vitamin B12, iron, calcium, zinc, vitamin D, and omega-3 fatty acids.[11]

This review aims to outline the current state of knowledge on the impact of vegetarianism on overall health and various aspects of life.

State of knowledge

Well-being

Adopting a vegetarian lifestyle goes beyond merely selecting a dietary preference; it provides individuals with a distinct social identity that shapes their thoughts, actions, and interactions with others. Following a plant-based diet can contribute to enhanced well-being and greater satisfaction, which may lead to an overall improvement in a person's quality of life (QoL).[12]

Obeidat et al. used cross-sectional survey to examine associations between vegetarian diet health-related quality of life among female undergraduate college The Vegetarian Quality of Life Questionnaire (VEGQOL) was used to assess how common vegetarian diet consumption is among participants and to evaluate the life quality of individuals following a vegetarian diet. Although a vegetarian diet is generally linked to higher intake of fiber, vitamins, and minerals, which support overall health and enhance quality of life, this study found no significant relationship between diet type and Quality of Life (QoL).[13]

Barnard et al. conducted a study where postmenopausal women with hot flashes were recruited via social media and screened by phone. Participants were aged 40-65, experienced moderate-to-severe hot flashes at least twice daily, and were willing to follow a low-fat vegan diet, including soybeans. They were assigned randomly to either the intervention or control group. Using the My Luna app, participants tracked their hot flashes, noting onset, cessation, and intensity for 7 days. The Menopause-Specific Quality of Life Questionnaire (MENQOL) assessed quality of life across four domains: vasomotor, psychosocial, physical, and sexual. The intervention group followed a low-fat, plant-based diet, and significant reductions in hot flash frequency and intensity were reported, with 59% of participants becoming free from moderate-to-severe hot flashes. Body weight decreased by 3.5 kg in the intervention group, while it increased by 0.8 kg in the control group.[14]

Also Beezhold et al. surveyed mood, diet, and lifestyle factors among an online sample of adult vegans (n = 283), vegetarians (n = 109), and omnivores (n = 228), all recruited through diet-related social networks. The majority of the study participants were women (78.5%), and an inverse relationship was observed between age and all DASS scores. Average DASS-A (anxiety) and DASS-S (stress) scores varied across groups, with VG (vegans) showing lower scores compared to OMN (omnivores), suggesting reduced mood disturbances.[15]

The combination of a low-fat, plant-based diet and whole soybeans was linked to a decrease in the frequency and intensity of hot flashes. Additionally, it led to improvements in quality of life across various areas, including vasomotor, psychosocial, physical, and sexual health.[16]

Agarwa et al. carried out a study involving 292 participants with a body mass index (BMI) of ≥25 kg/m² and/or a prior diagnosis of type 2 diabetes. Over an 18-week period, participants either received weekly guidance on adopting a vegan diet or no dietary guidance at all. The intention-to-treat analysis revealed that the intervention group experienced significantly greater improvements compared to the control group in several areas, including health-related impairments, overall work-related and non-work-related activity impairments, depression, anxiety, fatigue, emotional well-being, daily functioning linked to physical health, and general health.[17]

A strict plant-based diet does not seem to have a negative effect on mood; in fact, reducing animal product consumption may offer mood-enhancing benefits.[18]

Sleep

Sleep is essential for the overall well-being of people at all stages of life, including children, teenagers, and adults[19] Getting enough sleep of good quality helps reduce the risk of accidents and injuries caused by drowsiness and fatigue, such as workplace incidents and car accidents.

This connection between diet and sleep quality is particularly relevant when considering conditions like obstructive sleep apnea (OSA), a disorder characterized by intermittent collapse of the upper airway during sleep.[20] It is estimated that nearly one billion people around the world are affected by obstructive sleep apnea (OSA).[21]

Malaku et al. (2024) conducted a study involving data from 14,210 participants in the National Health and Nutrition Examination Survey, who provided dietary information through the 24-hour recall method. The Plant-Based Diet Index (PDI), which includes the healthy (hPDI), unhealthy (uPDI), and pro-vegetarian diet index (PVDI), was calculated. The risk of obstructive sleep apnea (OSA) was assessed using the STOP-BANG questionnaire. Logistic regression was employed to explore the connection between dietary indices and OSA risk.

The findings in this study underscore the strong connection between plant-based diets and the risk of obstructive sleep apnea (OSA), particularly emphasizing the protective benefits of diets such as the healthy plant-based diet. These results suggest the need to reconsider current dietary guidelines, advocating for a focus on promoting plant-based diets that are abundant in anti-inflammatory and antioxidant nutrients, while being low in harmful dietary elements.[22]

Pourreza et al. (2021) carried out a cross-sectional study with 390 overweight and obese women aged 18 to 48, discovering a link between poor sleep quality and unhealthy plant-based diets.[23]

Observational studies across various countries consistently reveal a positive link between sleep quality and adherence to plant-based diets. These studies also indicate that individuals who consume higher quantities of fruits and vegetables tend to have a lower dietary inflammatory index. Conversely, those whose diets are characterized by higher energy density, added sugar, and caffeine often experience poorer sleep quality. Furthermore, reducing intake of dairy products and unsaturated fats has been linked to improved sleep quality.[24]

Piekarska et al. observed a positive relationship between the consumption of fruits and vegetables and the occurrence of insomnia, indicating that a higher intake of these foods was associated with a reduced frequency of insomnia.[25]

In one of the cross-sectional studies, the aim was to examine the association between vegetarian diet consumption and sleep quality, academic performance, and health-related quality of life among female college students. A sample of 158 students was surveyed using validated instruments, including the Pittsburgh Sleep Quality Index (PSQI).The results showed that vegetarians had a significantly lower BMI compared to non-vegetarians ($p=0.015$), while those on a vegan diet had the lowest vegetarian quality of life ($p=0.04$). Most students reported good to excellent general health, but poor sleep quality (mean PSQI score = 8.04). No significant association was found between diet type HRQoL, or sleep quality.[26]

Vegetarian diets have been associated with improved physical and mental health, a lower risk of diseases, and better sleep quality. For example, foods such as cherries, kiwis, and milk can aid in sleep. These foods are rich in tryptophan and B vitamins (including B12), which support the production and release of melatonin, a neuromodulator that helps regulate the body's sleep-wake cycles.[27]

Weight

Obesity, being a long-term and multifaceted condition, requires maintaining dietary changes over an extended period to avoid regaining weight after its initial loss.[28] Plant-based diets can

help prevent weight gain and support effective weight management.[29] Cross-sectional studies revealed that vegetarians had a lower body weight compared to individuals who consume meat.[30]

In the randomized controlled trial by Campbell et al., participants were randomly assigned to either the plant-based diet group or a control group, and their health parameters were monitored over a set period. The average body mass in the intervention group decreased from 177.5 lbs. to 165.7 lbs. after 8 weeks, representing a 6.6% reduction, which corresponds to an average loss of about 1.5 lbs. per week. After accounting for baseline values, participants in the intervention group lost 9 lbs. more than participants in the control group and 1.7 kg/m² more from their BMI.

The results showed that the plant-based diet led to significant weight loss and improvements in cardiometabolic markers such as cholesterol levels and blood pressure.[31]

Another study showed that non-meat eaters had a lower mean BMI compared to meat eaters across all age groups, with adjusted BMIs of 22.05 kg/m² for men and 21.32 kg/m² for women, compared to 23.18 kg/m² and 22.32 kg/m² in meat eaters, respectively. The difference in BMI was influenced by factors such as dietary fiber, animal fat intake, social class, smoking, alcohol consumption in men, and parity in women. After adjusting for these factors, the BMI difference between meat eaters and non-meat eaters was reduced by 36% in men and 31% in women, suggesting that lower animal fat intake, higher fiber consumption, and, in men, lower alcohol intake contribute to the lower BMI in non-meat eaters.[32]

Despite the small size of the vegetarian sample (106), Bedford et al. found that vegetarian women had lower age-adjusted BMI, waist circumference, and rates of overweight/obesity, which may be attributed to higher physical activity levels, as energy intake was similar between vegetarians and non-vegetarians.[33]

Fertility

Lifestyle and diet are key factors affecting fertility by influencing hormonal and physiological processes. A balanced diet with essential nutrients is vital for reproductive health in both men and women. Adopting healthy habits, such as proper nutrition, regular exercise, and stress management, can improve fertility chances for those trying to conceive. Although there is limited and unclear information available regarding female fertility and these diets. It is important to recognize that while vegan and vegetarian diets are often considered healthy, they can also be unhealthy depending on their composition and the intake of specific foods, like refined grains and highly processed items. This could potentially impact fertility.[34]

The impact of vegetarian or vegan diets on fertility remains a subject of ongoing debate.[35]

One perspective suggests that a vegetarian diet may lead to nutrient deficiencies, such as iron or essential fatty acids, which could raise the risk of infertility. Additionally, the soy-based foods common in vegetarian diets contain isoflavones, which mimic estrogen and may contribute to male infertility by affecting sperm. On the other hand, vegetarian and vegan diets are high in antioxidants like carotenoids, vitamins C and E, flavonoids, and polyphenols, which can improve fertility by reducing oxidative stress and enhancing sperm and egg quality.[36]

Women

The menstrual cycle typically lasts 28 days, ranging from 21 to 35 days, and involves hormonal changes in estrogen and progesterone. The cycle has three phases: follicular (FSH and LH stimulate follicle growth), ovulation (estrogen triggers release), and luteal (corpus luteum produces hormones). If fertilization does not occur, the corpus luteum degenerates, hormone levels drop, and menstruation begins.[37,38] Menstrual disorders encompass conditions such as irregular cycles, infrequent or frequent menstruation, heavy or prolonged bleeding, absence of menstruation, intermenstrual bleeding, amenorrhea, dysmenorrhea, and premenstrual syndrome (PMS).[39]

Low BMI can negatively impact both male and female fertility, as fat loss and hormonal imbalances increase the risk of fertility issues. In men, being underweight is often linked to malnutrition and poor lifestyle choices, leading to hormonal disruptions and decreased semen quality.[40] In the case of a poorly planned iron-poor diet may negatively affect ovulation in women.[41]

On the other hand, for overweight women before conception, losing weight plays a crucial role in improving fertility by restoring hormonal balance, which ultimately leads to spontaneous ovulation.[42]

High BMI is often considered a detrimental factor for male fertility, prompting many researchers to investigate the impact of weight loss on sperm quality through dietary interventions. Some studies highlight that weight reduction can be an effective treatment for infertility in obese individuals.[43]

Men

Kljajic et al. conducted a study aimed at evaluating sperm quality parameters in men following a vegan diet (10 males on a strictly plant-based diet with no animal products) and comparing them with non-vegans (10 males with no dietary restrictions). Semen quality was assessed according to the World Health Organization (2010) guidelines, and the acrosome reaction and DNA integrity were evaluated using the immunofluorescence method**.**

In this study, twenty semen samples were collected from volunteers at the Department of Reproductive Medicine in Homburg, Germany. The participants, primarily Saarland University students, were split into two groups: ten vegans following a strict plant-based diet (including soy and no animal products for over a year) and 10 non-vegans with no dietary restrictions. All participants had a normal BMI (18.5–24.9 kg/m²), were aged 18-35, and did not smoke or consume alcohol. They were instructed to avoid alcohol and maintain consistent physical activity during the study period.

The study found no significant differences between vegan and non-vegan groups in terms of age, BMI, sample volume, sperm viability, or morphology ($P > 0.05$). Although sperm concentration was higher in the vegan group, this difference was not statistically significant.

Significant differences were observed in other sperm parameters. Vegans had significantly lower sORP values, indicating less oxidative stress ($P < 0.0001$). Total sperm count was also significantly higher in the vegan group ($P = 0.011$), along with better sperm motility ($P = 0.011$). The percentage of rapidly motile sperm (PR-A) was significantly higher in the vegan group ($P < 0.0001$).

On the other hand Orzylowska et al. investigated the impact of a life-long vegetarian diet on male fertility, focusing on vegetarians from the Loma Linda blue zone, known for longevity. The goal was to compare sperm characteristics between vegetarians and non-vegetarians.

The cross-sectional study analyzed semen samples from 474 males, who identified as life-long lacto-ovo vegetarians (N=26), vegans (N=5), or non-vegetarians (N=443). Sperm quality was assessed using a computer-aided sperm analyzer, with strict morphology and chromatin integrity manually evaluated.

Results showed that lacto-ovo vegetarians had lower sperm concentration. Motility was lower in the vegetarian groups, with vegans showing the lowest hyperactive motility. However, strict morphology was similar across all groups, and no differences were found in rapid progression or chromatin integrity.

The study concluded that a plant-based diet may decrease sperm quality, particularly in male fertility patients, and could require clinical attention. The low hyperactivation in vegans suggested possible membrane calcium channel issues.[44]

The Acridine Orange (AO) test revealed that the percentage of sperm with DNA denaturation was significantly higher in the non-vegan group. However, no significant differences were found in the acrosome reaction between the groups. [45]

From this study, we can conclude that a plant-based diet may have a positive impact on sperm count, motility, and oxidative stress, but does not significantly affect sperm morphology or

acrosome reaction. However, due to the small sample size, further studies with adequate statistical power, including larger cohorts, are needed to better investigate the impact of a plant-based diet on infertility.

Diabetes

Diabetes leads to various health issues in multiple organ systems due to its significant impact on nearly all cellular metabolic processes. Chronic complications typically result from insulin deficiency or resistance, persistent high blood sugar, dyslipidemia, and disruptions in other metabolic pathways. These complications are the primary cause of the disease's morbidity and mortality. Traditionally, complications have been categorized as either macrovascular (e.g., cardiovascular disease) or microvascular (e.g., retinopathy, nephropathy, neuropathy). However, this classification is increasingly viewed as inadequate, since many complications, like neuropathy, involve both microvascular and nerve dysfunction.[46]

Previous research has focused on both preventing and managing diabetes through the use of a vegetarian diet.

In one od the studies, where women with cancer following a plant-based diet were examined, insulin level was within the normal range (3–25 uIU/mL), a decrease in its level was observed in the intervention group, from 16.8 uIU/mL to 11.2 uIU/mL ($p<0.01$). Insulin resistance, calculated using the HOMA-IR index, decreased in the intervention group, from 4.4 to 2.7 ($p=0.01$).[47]

Li et al., in their study of two large prospective cohorts, which included 108,681 postmenopausal women without type 2 diabetes at baseline from the Women's Health Initiative (primary cohort) and 34,616 adults without type 2 diabetes from the U.K. Biobank (replication cohort), confirmed the notion that substituting 5% of energy from plant protein for animal protein was associated with a 21% decrease in type 2 diabetes risk mainly by reducing obesity-related inflammation.[48]

Würtz et al. followed 27,634 males in the Health Professionals Follow-up Study, 46,023 females in the Nurses' Health Study, and 75,196 females in the Nurses' Health Study II. They utilized distinct, repeated dietary assessments to compare participants based on their dietary changes over time. In statistical models adjusted for total energy intake (both initial and changes), the study compared those who increased their red meat consumption with those who increased their intake of other protein sources, to predict the effects of these substitutions on the risk of type 2 diabetes. Substituting red meat with other protein sources was linked to a reduced risk of developing type 2 diabetes.[49]

Cardiovascular system

Cardiovascular disease (CVD), primarily caused by ischemic heart disease (IHD) and stroke, remains the leading cause of death and disability worldwide, despite a decline in CVD rates in recent years.[50,51] Hypertension is also a key contributor to cardiovascular disease, and it has been shown to improve with a vegetarian diet.[52]

One example of the positive impact of a plant-based diet on heart health is the Lifestyle Heart Trial This study tested a comprehensive program, including a 10% fat whole foods vegetarian diet, exercise, stress management, smoking cessation, and psychosocial support in 48 CHD patients. After five years, 20 of 28 patients in the experimental group showed a significant 7.9% improvement in coronary atherosclerosis and reduced myocardial ischemia.[53]

In another study, randomized crossover trial adults aged 18 to 79 years at borderline to high risk for atherosclerotic cardiovascular disease (ASCVD) were recruited.

Participants followed either a high or low extra virgin olive oil (EVOO) wholefood, plant-based diet for 4 weeks, with a 1-week washout period in between. The primary outcome was the change in low-density lipoprotein cholesterol (LDL-C), with secondary outcomes including additional cardiometabolic markers. Both diets led to similar reductions in LDL-C, total cholesterol, apolipoprotein B, HDL-C, glucose, and high-sensitivity C-reactive protein. LDL-C reductions were more significant after the low-to-high EVOO phase, with diet order influencing glucose, total cholesterol, and HDL-C changes.[54]

Additionally, a study comparing high and low plant-based diets (PBD), was found that the high-PBD group had higher levels of energy, fat, protein, cholesterol, fiber, sodium, calcium, vitamins C and D, and flavonoids than the low-PBD group. Additionally, the high-PBD group exhibited a lower risk of metabolic syndrome, waist circumference, hyperglycemia, hypo-HDL-cholesterolemia and hypertriglyceridemia.[55]

In yet another study the average total cholesterol level decreased by 17.7%, and the average LDL level decreased by 21.4%, reaching 82.2 mg/dL in the intervention group. When compared to the control group, the intervention group showed a mean reduction in total cholesterol by 35.3 mg/dL and LDL-C by 23.5 mg/dL.[56]

Conclusion

This review highlights the significant potential of plant-based diets to improve various aspects of human health and well-being. When carefully planned, these diets can enhance quality of life, support reproductive health by restoring hormonal balance, and improve fertility outcomes, particularly in individuals with excess weight. Evidence suggests that plant-based

diets may positively influence sperm parameters, although some studies report mixed findings regarding sperm concentration and motility.

Furthermore, plant-based diets have demonstrated notable benefits in diabetes management, including reductions in insulin resistance, insulin levels, and prevention of weight gain, while supporting effective weight control. They may also promote better sleep quality through the consumption of foods rich in tryptophan and B vitamins, which regulate melatonin production. However, poorly planned vegetarian or vegan diets can lead to deficiencies in critical nutrients, such as vitamin B12, calcium, iron, zinc, vitamin D, and long-chain omega-3 fatty acids. Addressing these potential gaps is essential, particularly for women, as adequate nutrient intake is vital for regular ovulation and reproductive health.

The mixed findings presented in this review emphasize the need for further research with larger, well-designed studies to fully understand the comprehensive impact of plant-based diets on human health. Ensuring balanced dietary planning and appropriate supplementation remains crucial to maximize the benefits and minimize potential risks.

Declarations

Funding

This research received no external funding.

Institutional Review Board Statement

Not applicable.

Statement of Informed Consent

Not applicable.

Conflicts of Interest

The authors declare no conflicts of interest.

Disclosure

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