ORIGINAL ARTICLE e-ISSN: 2349-0659 p-ISSN; 2350-0964

Vegetarian Diets: Conceptualization Health Outcomes, Nutritional Concerns, and Explicit Features – An Indian Perspective

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Abstract

Vegetarian has its origin in the Latin word "vigitore" meaning "to give strength and health." Modern concise Oxford dictionary defines a vegetarian to be "a person who doesn't eat meat or fish for moral, religious, or health reasons." Vegetarianism has very ancient roots and its history comprises many diverse characters and events. The practice has been apparent in many cultures all over the world. In Asia, particularly India, absenteeism from meat was the core of early religious philosophies such as Hinduism, Brahmanism, Zoroastrianism, and Jainism. With time and scientific advancements, there were a greater understanding and linking of vegetarian diets with health apart from its association with religion and spiritual contexts. There exist many differences between an Indian vegetarian diet and a Western vegetarian diet. Some of the prominent features of which are lower intake of fruits and vegetables, high-carbohydrate and high-glycemic diets, higher intake of milk and milk products, quality and nature of fat, and snacking behavior.

Keywords: Classification, Indian vegetarian diets, Nutritional concerns, Prevalence, Vegetarian diets

Asian Pac. J. Health Sci., (2022); DOI: 10.21276/apjhs.2022.9.4.22

Introduction

The food choice of an individual has its roots in the family and early formative years. Food preferences are learned either culturally or by personal experiences which may cause certain pleasant or unpleasant associations with the food. An individual adopts a particular type of diet due to aspects such as geographical area, religion, physiological conditions, and other ecological, economic, and nutritional aspects.[1] Two major groups into which the dietary practices of an individual can be classified are vegetarian and non-vegetarian.in India, the traditional diets were predominantly vegetarian mainly influenced by our tradition and culture.

Vegetarian has its origin in the Latin word "vigitore" meaning "to give strength and health."[2] Modern concise Oxford dictionary defines a vegetarian to be "a person who doesn't eat meat or fish for moral, religious, or health reasons."[3]

Methodology

Relevant articles were identified by searching the PubMed, Science Direct, Google Scholar, NCBI, and Medline databases. Research articles including cross-sectional, behavioral, and longitudinal studies, reviews were selected. Key words such as "vegetarian diets," "Indian vegetarian diets," and "prevalence of vegetarianism" were used in the search strategy. Articles which were not in English were translated and then used for the present review.

Since the review also attempts to highlight the conceptual and historical insight associated with the development of the vegetarian diets, attempts were made to retrieve earliest possible documentation.

Discussion

Conceptualization of Vegetarianism

Vegetarianism cannot be contemplated as a present-day phenomenon. It has very ancient roots and its history comprises many diverse characters and events. The practice has been apparent in many cultures all over the world. In Asia, particularly India, absenteeism from meat was the core of early religious philosophies such as Hinduism, Brahmanism, Zoroastrianism, and Jainism. It was encouraged in ancient verses of the "Upanishads" and also cited in "Rig Veda" – the most sacred of ancient Hindu texts. Pivotal to such religions were doctrines of non-violence and respect for all life forms. For centuries, Indian culture has embraced vegetarianism.[4] This is believed to have its roots in the pastoral Aryan culture that populated the Indus Valley sometime after 2000 BC and carried the sacred Vedas which according to some analysts emphasized on the importance of non-violence toward all bipeds and quadrupeds and mentioned that eating meat entails punishment. All great Indian saints and seers such as Vyasa, Chaitanya, and all other Sufi saints and the great preachers of peace, such as Gautama Buddha, Bhagwan Mahavir, and leaders like Mahatma Gandhi, were vegetarians and considered that thinking and spiritual acquisition are not possible with meat eating.[5]

In other parts of the world, dentitions of early ancestors in East Africa suggest that they were vegetarians as they had broad and

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How to cite this article: Kaur H, Aeri BT. Vegetarian Diets: Conceptualization Health Outcomes, Nutritional Concerns, and Explicit Features – An Indian Perspective. Asian Pac. J. Health Sci., 2022;9(4):104-111.

Source of support: Nil

Conflicts of interest: None.

Received: 02/02/2022 **Revised:** 15/03/2022 **Accepted:** 10/04/2022

flat teeth which would not have been suitable for an omnivorous diet.[6] The earliest written evidence on vegetarianism in Europe date back to the 6th century BC where admirers of the Orphic mysteries prohibited the sacrifice of animals and the consumption of meat and denied to eat anything animal based. In Greece during the classical era, "vegetarianism was called as abstinence from beings with a soul."[7] Many early Greek and Roman savants including Pythagoras, Seneca, and Porforio followed vegetarianism as a repulsion toward the sacrifice of animals to the Gods, and the majority of them were part of ethical and religious convictions. Pythagoras is considered as the father of ethical vegetarianism and his name gave rise to the phrase "Pythagorean way of life" which was enthusiastically embraced by several prominent classical philosophers and writers and influenced nutrition in Europe until the 19th century.[8]

With time and scientific advancements, there were greater understanding and linking of vegetarian diets with health apart from its association with religion and spiritual contexts. Vegetarianism emerged as a significant factor in promoting human health and its particular role in the prevention and management of chronic diseases.

To understand the same, Sabaté (2003)[9] proposed a series of models in an attempt to, sum up the historical progression of the scientific understanding of the effects of vegetarian and non-vegetarian diets which he depicted using graphical models. The three models of vegetarianism by Sabate depicted the adequacy of vegetarian diets with associated health benefits and risks. For all the three models, Sabate defined vegetarian diets as diets that exclude meats and emphasize minimally refined plant foods.

Vegetarianism comprises many dietary practices, including strict avoidance of meat, fish, and dairy products or abstinence of meat and fish with the addition of dairy products and eggs or exclusion of all meat except fish and exclusion of meat only from diet. The following section discusses the different types of vegetarian diets as explored by different researchers.

Defining Vegetarian Diets

The choice of food of an individual has its roots in the family and early formative years. Food preferences are learned either culturally or by personal experiences which may cause certain pleasant or unpleasant associations with the food. An individual adopts a particular type of diet due to aspects such as geographical area, religion, physiological conditions, and other ecological, economic, and nutritional aspects.[1] Two major groups into which the dietary practices of an individual can be classified are vegetarians and non-vegetarians.

Under the umbrella term, "vegetarian," there exist wide ranges of diets depending on certain food/food items which are included or excluded.[10,11]

i. Lactovegetarians include milk and milk products in their diet in addition to the usual plant foods (cereals, pulses, vegetables, and fruits).
ii. Ovo-lacto-vegetarians include eggs in addition to all of the foods mentioned for lacto-vegetarians.
iii. Ovo-vegetarians use eggs and all of the plant foods but forgo milk and milk products.
iv. Fruitarians eat only the parts of plants that can be obtained without destroying the plant itself (grains, nuts, and fruits, for example).
v. Vegans eat only plant foods. They abstain from all animal foods, even milk products.

Beardsworth and Keil introduced a "vegetarian scale" in 1991, where dietary restrictions ranged from least restrictive to most restrictive and suggested that a vegetarian's dietary restrictions may move along the scale, the further to the right of the scale a person is (most strict), the less likely they are to accept foods far to the left of the scale.[12]

Thus, the term vegetarianism comprises a wide spectrum of dietary practices some being more restrictive than the others.

Vegetarianism in India

India has been long associated with vegetarianism but recent data highlight that less than one-third of the Indian population is vegetarian. Although the trends show that more of the Indians are moving toward the consumption of non-vegetarian foods, it is important to consider that the frequency and amount of the non-vegetarian food consumed in India is not so high. The following section highlights the extent of vegetarianism in India.

Census 2011

According to Census (India, 2011),[13] the prevalence of vegetarianism in India is 28.4% in men while for women, it is 29.3 % (as on 1.1.2014). Although the prevalence rate varied across different states in India, it is seen that vegetarianism is more common in the case of women in comparison to men in all the states. Topmost states with the highest number of vegetarians are Gujarat, Rajasthan, Haryana, Punjab, Uttar Pradesh, Madhya Pradesh, and Delhi.

Table 1 highlights the prevalence of vegetarianism across different states for men and women in India. Furthermore, it is a less common phenomenon in southern and northeastern states lowest being Telangana where 98.55% of its population comprises non-vegetarians.

Table 1: Prevalence of vegetarianism in different Indian states-Census, 2011[13]

	Vegetarians		*Non-vegetarians*	
	Male	*Female*	*Male*	*Female*
INDIA	28.4	29.3	71.6	70.7
Andhra Pradesh	1.6	1.9	98.4	98.1
Assam	21.4	19.8	78.6	80.2
Bihar	6.8	8.3	93.2	91.7
Chhattisgarh	17.3	18.6	82.7	81.4
Delhi	36.8	42.2	63.2	57.8
Gujarat	60.1	61.8	39.9	38.2
Haryana	68.5	70	31.5	30
Jammu and Kashmir	31	31.9	69	68.1
Jharkhand	2.8	3.7	97.2	96.3
Karnataka	20.9	21.3	79.1	78.7
Kerala	2.6	3.4	97.4	96.6
Madhya Pradesh	48.9	52.3	51.1	47.7
Maharashtra	41	39.4	59	60.6
Odisha	2.3	3	97.7	97
Punjab	65.5	68	34.5	32
Rajasthan	73.2	76.6	26.8	23.4
Tamil Nadu	2.2	2.5	97.8	97.5
Telangana	1.2	1.4	98.8	98.6
Uttar Pradesh	45	49.2	55	50.8
Uttarakhand	25.5	29.2	74.5	70.8
West Bengal	1.3	1.6	98.7	98.4

Source: Census of India 2011[13]

Other surveys cited by FAO and USDA estimate 20–42% of the Indian population as being vegetarian.[14]

Vegetarians around the world are much healthier than Indians, with normal lipid levels and low cardiovascular disease incidence. In a study on Indian immigrants in the United States, nearly half of the participants were lifelong vegetarians and yet the incidence of obesity and heart disease was comparable to that observed in non-vegetarians. The rates of diabetes were higher among the vegetarians.[15] In yet another study by Gadgil *et al.*[16] (2015), it was reported that the animal protein and fried snacks, sweets, and high-fat dairy patterns were associated with adverse metabolic risk factors in South Asians in the United States, whereas the fruit, vegetable nuts, and legumes pattern were linked with a decreased prevalence of hypertension and metabolic syndrome. However, vegetarianism prevalent in India is appropriately panned as the "contaminated vegetarianism," with consumption of large amounts of unhealthy food such as fried foods, an excess of salt, sugar, and ghee. Fresh fruits and vegetable, and the protective components in the vegetarian diet are considerably lacking in Indian diet.[17,18]

Prominent Features of Indian Vegetarian Diets: How are Indian Vegetarian Diets Different from the West?

There exist many differences between an Indian vegetarian and a western vegetarian diet. The following section highlights some of the typical features of Indian vegetarian diets.

Low intake of fruits and vegetables

A WHO/FAO expert consultation update on the diet, nutrition, and chronic disease prevention established population nutrient goals and recommended consumption of at least 400 g of fruits and vegetables per day for chronic disease prevention such as heart disease, cancer, diabetes, and obesity. However, several studies show that Indian consumers do not consume the WHO recommended quantity of fruits and vegetables as only rice or Indian bread (*Chapatti*) is considered food while vegetables and fruits are always taken "on the side" and thus do not include enough raw foods, salads, and fruits, which must be central to a good vegetarian diet.[19] Interestingly, fruits and vegetables in a predominantly vegetarian nation account for only 9% of the total calorie intake. Furthermore, the pattern of consumption differs from state to state, with people living in South Indian cities consuming more fruit and vegetables than those in the north.[20]

High-carbohydrate and high-glycemic diets

While most traditional diets globally are centered on carbohydrates, particularly through cereals, Indian diets tend to have multiple staples – rice, wheat, potatoes, and pulses – coupled with high levels of sweets and sugars through sweetened drinks and bakery products. Secular trends and migration studies in Asian Indians showed replacement of refined carbohydrates for pulses, fruit, vegetables, whole grains, nuts, and seeds, thereby increasing the glycemic load which is strongly associated with increased metabolic risk.[21] A major source of refined carbohydrates in this "transition diet" is potatoes, which are included in fried foods and more recently in fast foods and snack foods (chips).[22] Interestingly, in a case–control study of CHD in urban India, Rastogi *et al.* (2004)[23] found whole plant foods to be a protective factor only after exclusion of potatoes highlighting that the beneficial impact of plant foods may be masked by consumption of carbohydrates in vegetarian diets. Overall, when considering NCDs impact, it is important to consider that total carbohydrate and the glycemic load is also associated with increased risk of Type II diabetes among Asian Indians.[24]

Intake of milk and milk products

An article by The Indian Express (June 12, 2015) that is based on NSSO data states that being vegetarian in India is "to drink milk." In India, total milk consumption (excluding butter) per kg/capita/year is 68.72 kg.[25] Dairy products are important sources of dietary fat in India. Ghee or clarified butter is one of the common sources of dietary fat and cooking medium among South Asians.[18] According to the NSSO report between 2004–05 and 2011–12, estimated per capita consumption of "milk: liquid" increased by about 470 ml/month in rural India and 315 ml/month in urban India. For 2011–2012 consumption of "milk: liquid," all India for the rural and urban population was 4.333 L and 5.422 L (per capita consumption, liters/month), respectively.[26] This increased consumption of milk and milk products though provides protein but also adds to the saturated fat intake in case of consumption of whole or full cream milk which is related to high cholesterol levels, leading to cardiometabolic health issues.

Quality and nature of fats

Trans fats (also known as trans-fatty acids or TFAs), the most harmful kind of fat, have entered our diets in a big way through commercially available snacks, biscuits, cookies, fried foods, and refined oils. Another prominent feature of the nutrition transition attributable to urbanization is an increase in the use of ghee (clarified butter) in cooking[27] – a practice that in low-resource rural areas was usually reserved for special occasions. Vegetarianism often results in reduced consumption of omega-3 fatty acids, which are found in fish products and are thought to be cardioprotective.[28] According to NSSO, 2012 data, the amount (g/month) of edible oil consumed per capita in India (for both urban and rural sectors) was estimated to be 636 g in rural India and 818 g in urban India. Mustard oil has the highest consumption (in both the sectors) followed by groundnut oil that is consumed in higher amounts in urban areas.[26]

Snacking

Snacking is a big part of the Indian diet. Traditional Indian snacks such as samosas and namkeens are made out of highly refined and processed foods such as refined flour (maida), polished rice, refined sugars, and refined oils and many use oils with trans fats. A key feature of the nutrition transition among Asian Indians also includes the increased consumption of low-cost fried foods and processed foods sold as packaged snacks or fast food products similar to those found in Western nations.[29] The higher content of trans fatty acids in these types of processed and snack foods is of note because of the association of this fatty acid with cardiovascular disease.[30]

In a cross-sectional community-based study conducted in 260 households of a purposefully identified urban slum in north-east zone of Delhi, it was observed that a quarter of households consumed >10% of the daily energy from fats in snacks. Among a

total of 29 snacks sampled and analyzed, –24 samples were high in fat content (with a median saturated fat content of 61.7% of total fatty acids) and contained trans fats, albeit in varying concentrations.[31]

Vegetarian Diets and Positive Health Outcomes

Improved health is one of the prominent reasons for people to adopt a vegetarian diet, and there are now numerous studies that indicate and support the health benefits of a vegetarian diet. Many research studies highlight that vegetarians have lower rates of health problems, mostly related to non-communicable diseases, such as for overweight and obesity, cardiovascular disease, type 2 diabetes, hypertension, certain cancers, kidney stones, gallstones, constipation, and diverticular disease.[32,33]

These benefits likely result from both decreased consumption of possibly harmful dietary components such as saturated fat, animal protein, red meat, cholesterol, and haem iron, and more consumption of beneficial dietary components, such as fruits, whole grains, vegetables, nuts, and legumes, which are rich in dietary fiber, antioxidants, and phytochemicals.[9]

Higher consumption of red meat and processed meat is linked with an increased risk of cardiovascular diseases, obesity, gestational diabetes, type-2 diabetes, and some types of cancers.[34-37] A large study examining the link of a wide range of meat consumptions with chronic disease mortality among adults in the United States observed that both red and processed meat consumptions were linked with a modest increase in CVD, cancer, and total mortality.[38] On the other hand, in an analysis of six cohort studies involving lifelong participants from the Adventist Health Study group in the United States associated low meat consumption to greater longevity.[39]

Thus, vegetarian diets have been linked with several health benefits and the role of vegetarian diets concerning specific health conditions is discussed herewith.

Hypertension

Several randomized clinical trials have revealed a relationship between diet and regulation of blood pressure. The proposed mechanisms that are involved in lowering of the blood pressure by adopting vegetarian diets include factors such as improvement in the vasodilatation, reduced blood viscosity, and improved rennin angiotensin systems.[40]

Many studies indicate that reducing sodium intake in the diet and weight loss may be linked directly to low BP.[41] The result of the EPIC-Oxford study, a cohort in the United Kingdom, addressed that non-meat eaters had a lower incidence of hypertension (that is lowered systolic and diastolic BP) than meat eaters. The age-adjusted incidence of self-reported increased BP was significantly different among the four diet groups, ranging from 15.0% in male meat eaters to 5.8% in male vegans, and from 12.1% in female meat eaters to 7.7% in female vegans.[42] These findings agree with the results of the Dietary Approaches to Stopping Hypertension (DASH) trial, which addressed that a diet high in whole grains, vegetables, fruit, and low-fat dairy products considerably reduced BP in those with normal BP or mild hypertension.[41,43]

Overweight and obesity

A vegetarian diet has been linked with low BMI and lower rates of obesity in comparison to non-vegetarians.[32] Vegetarians, predominantly vegans, are leaner than their omnivorous counterparts.[44,45] The European Prospective Investigation in Cancer and Nutrition (EPIC) Oxford study in the United Kingdom made a comparison between weight gain over 5 years in 22,000 fish eating, meat eating, vegetarian, and vegan men and women.[46] Weight gain was reported to be least in the vegan diet group and among those who, throughout follow-up, had changed to a diet consuming lesser animal foods.

Studies reported that differences in macronutrient intakes accounted for approximately half of the difference in mean BMI between meat eaters and vegetarians, with low fiber and high protein intakes most strongly associated with increasing BMI.[47] There are several probable explanations for this relationship, including the higher intake of dietary fiber, lower energy density, and lower fat intake that are classics of a vegetarian diet. Foods such as nuts and whole grains are more frequently consumed by vegetarians and have been independently linked with a reduced risk of obesity and weight gain.[48] On the other hand, higher consumption of red meat has been linked with an increased risk of weight gain.[49]

Cancer

Studies report that overall cancer rates in vegetarians appear to be reasonably lower in comparison to people consuming higher amounts of non-vegetarian foods and also their life expectancy appears to be better and higher when compared to other dietary patterns.[50]

According to the World Cancer Research Fund report (2007), consumption of processed meat and red meat increases the risk of colorectal cancer. The high fiber intakes in vegetarians may play a key role in reducing colon cancer risk.[51] The bulking effect of fiber may increase the transit rate of carcinogens through the bowel.[52] The consumption of diets rich in animal fat and cholesterol, red meat which cooked at high temperatures, or diets high in animal protein may raise the risk of developing cancer.[53] Lifelong vegetarianism may be related with a decrease in the risk of breast cancer through its connection with higher consumption of vegetables, soy, pulses and fruit, and the elimination of the red meat.[53,54] Possible reasons for a lower prevalence of breast cancer include the fact that vegetarian females have longer menstrual cycles, lower blood estrogens levels, and later onset of menstruation that results in a decrease in exposure to estrogen concentrations.[55] Health benefits of protective compounds in a plant-based diet have been associated with the delay of cancer and the retardation of cancer cell growth. Tocopherols, ascorbate, carotenoids, selenium, indoles, isothiocyanates, phenols, allium compounds, protease inhibitors, plant sterols, and other biologically active compounds are frequently referred to as phytochemicals that, among many others, have anticancer activity.[56,57]

Diabetes

Vegetarian and vegan diets offer considerable benefits for both the prevention and management of diabetes. Adventist Health Study-2 conducted on Adventist church members in the U.S. and Canada following a vegan diet showed that vegan population has approximately one-third lower prevalence of diabetes in comparison of non-vegetarians (2.9% vs. 7.6%). On the other hand, among pesco-vegetarians, lacto-ovo-vegetarians, and semi-vegetarians, diabetes prevalence was reported to be 4.8%,

3.2%, and 6.1%, respectively. After adjusting for confounding factors, the vegan diet population had an almost 50% reduction in the risk of increasing type 2 diabetes in comparison with non-vegetarians.[45] Several other observational studies have established a considerably lower risk of type-2 diabetes in individuals following a vegetarian diet in comparison of non-vegetarian counterparts.[57,58] Significant reduction in the risk of diabetes in vegetarians can be attributed to higher intakes of plant foods such as legumes, nuts, whole grains, and/or absence of meat. In a recent review article, a positive relationship between processed meats, animal protein, intake of red meat, and the incidence of type-2 diabetes has also been demonstrated.[59] The results of a systematic review and meta-analysis of 12 cohort studies on comparing the high versus low meat intake and type-2 diabetes risk were reported to be 1.21 for red meat, 1.17 for total meat, and 1.41 for processed meat.[60]

Kidney disease

Several studies reported that higher intakes of animal protein may have negative effects on those with primary kidney problems. In a crossover, a trial in Brazil of subjects with type 2-diabetes and macro-albuminuria found that eliminating red meat from the diet, either by replacing it with chicken or by following a lacto-vegetarian, low-protein diet improved renal function and blood fat levels.[61] In patients with type 1 diabetes, enhanced kidney function was established following dietary intervention in which animal protein was replaced with vegetable protein[62] and soy protein[63] in American adults undergoing hemodialysis. A study conducted on type-2 diabetics on Iranian adults with nephropathy highlighted that replacing 35% of animal protein eating with soy protein considerably reduced proteinuria and urinary creatinine.[64]

Longevity

A lifestyle intervention, including a nutrient-rich healthy diet, is an important approach to delay health-related risk and ensuring longevity. Many studies highlight that vegetarians and vegans live longer in comparison to meat-eaters. A British study involving 6000 vegetarians and 5000 meat eaters who were followed for 12 years reported that the vegetarians were 40% less likely to die from cancer or other life-threatening diseases in comparison to the non-vegetarians.[65]

Despite many health-promoting features associated with the intake of vegetarian diets, there are some nutritional concerns which are associated with the same if they are planned adequately. Some of the nutritional concerns associated with vegetarian diets are discussed in the subsequent section.

Cardiovascular diseases

Various cohort and case–control prospective studies highlight the probable beneficial effects of dietary profiles on the prevalence of cardiovascular diseases.[66,67] The Mediterranean diet has been shown to reduce cardiovascular morbidity and mortality in both primary and secondary prevention. Many other dietary patterns that have shown to confer advantage include low-fat diet for individuals at high cardiovascular risk, DASH diet for people with hypertension, and low-carbohydrate diets for overweight people and those with the metabolic syndrome.[68] Diets higher in plant foods and lower in animal foods were associated with a lower risk of cardiovascular morbidity and mortality in a general population of middle-aged men and women in the United States overall about 19% and 11% lower risk of cardiovascular disease mortality and all-cause mortality was associated with higher adherence to a balanced plant-based diet index.[69]

Nutritional Concerns of Vegetarian Diets

While individuals who consume vegetarian or vegan diets may have a lower risk of cardiovascular disease,[70] there may also be a greater risk of developing nutritional deficiencies, due to the exclusion from the diet of meat and fish in vegetarians, and all animal products in vegans.[71] Unbalanced vegetarian diets may lack nutrients that are poorly represented in vegetable foods or have low bioavailability (e.g. iron, zinc, Vitamin D, and omega-3 polyunsaturated fatty acids).[11]

Essential fatty acids (EFAs)

Vegetarian diets have been associated with significant outcomes, but paradoxically, they are low in EPA and DHA, which are important in the development of the central nervous system.[72] Concerning EFA intake and balance, vegetarian diets appear to offer no advantages over omnivorous dietary patterns. Some have suggested that vegetarians could be at a significant disadvantage, as consumption of α-linolenic acid (ALA) is low relative to linoleic acid (LA), resulting in the limited conversion of ALA to eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).[73] Besides, vegetarians consume very little EPA and DHA.[74] The n-3 PUFA EPA and DHA are obtained primarily from oily fish and, to a lesser extent, from meat and dairy products.[74] In a cross-sectional study by Rosell *et al.*,[46] plasma EPA and DHA were found to be lower in vegetarians and vegans than in meat eaters, while only small differences were seen for DPA.

Other research studies have also reported a lower level of EPA and DHA among vegetarians subjects.[75] Omega-3 fatty acid (ALA) intakes are comparable in vegetarians and non-vegetarians, eicosapentaenoic acid intakes and DHA intakes are minimal in vegetarians and completely absent in vegans. Plasma, blood, and tissue levels of EPA and DHA are lower for vegetarians than those for non-vegetarians.[76]

Iron

For vegetarian diets, where meat is completely excluded, the iron available is only in the non-haem form (unless fish is included). Furthermore, absorption may be compromised as vegetarian diets typically contain iron absorption dietary inhibitors, such as phytates, due to increased consumption of legumes and whole grains.[77] The typical Italian lacto-ovo-vegetarian and vegetarian diet may contain as much or more iron than an omnivorous diet, however, iron bioavailability is lower[78] with only 5–12% absorbed, compared to 14–18% from omnivorous diets.[79] In a meta-analysis of 24 studies by Haider *et al.* (2018),[80] it was documented that in comparison to non-vegetarian controls, adult vegetarians had significantly lower serum ferritin levels. In yet another review of 13 studies assessing the status of iron among adults, it was reported that the vegetarians had a high prevalence of depleted iron stores and in comparison, to non-vegetarians, a higher proportion of vegetarian subjects had iron deficiency anemia.[81]

Vitamin B 12

The prevalence of subclinical Vitamin B12 deficiency in vegetarians is high. The total serum Vitamin B12 concentration alone does not accurately reflect the status of Vitamin B12. Holotranscobalamin (holo-TC) II is a bioactive B12 fraction that facilitates the distinct absorption of B12 by cells and the circulating concentration reflects the intake of B12, while total homocysteine (tHcy) is indicated by metabolic capability.[82] Vitamin B12 produced in nature only by microbial synthesis, and animal products are the principal dietary sources for humans. Uncooked plant-based foods contaminated with B12 synthesizing bacteria, and fermented foods may also be important sources.[83]

In a cross-sectional study involving 689 men from the European Prospective Investigation into Cancer and Nutrition – Oxford cohort, mean serum Vitamin B12 was confirmed to be highest in omnivores, moderate in vegetarians, and lowest in vegans. About 52% of vegans, 7% of vegetarians, and one omnivore were classified as Vitamin B12 deficient (defined as serum Vitamin B12 < 118 pmol/l).[71] In a study by Ingole (2015)[84] on IT professionals in Pune, it was found that prevalence of Vitamin B12 was higher in the vegetarian subjects (47.5%) which was 20.45% in non-vegetarians.

Vitamin D

The main cause of Vitamin D deficiency is a lack of consideration of the fact that moderate exposure to sunlight is the main source of Vitamin D for most humans. Very few foods naturally contain Vitamin D, and foods which are fortified with Vitamin D are often insufficient to fulfill Vitamin D requirement.[85] Most of the dietary sources of Vitamin D have very low levels of Vitamin D content. Many food items rich in Vitamin D are of animal origin. Commonly, a dietary source of Vitamin D for vegetarians is milk, provided milk has been fortified with Vitamin D which is rarely fortified with Vitamin D in India.[86]

Plasma 25(OH)D concentrations indicated the degree of omission of the animal product and therefore the dietary consumption of Vitamin D; meat eaters had the maximum mean intake of Vitamin D; and mean plasma 25(OH)D concentrations and 25(OH)D concentrations were comparatively lower in vegetarians and vegans than in meat and fish eaters; highlighting that diet is an important factor of plasma 25(OH)D in the EPIC-Oxford study in the United Kingdom.[87]

Zinc

Vegetarians are often known to be at risk of zinc deficiency. Zinc bioavailability is decreased by binding zinc phytates, which are common components of grains, legumes, and seeds. In humans, a sensitive marker to measure zinc status has not been well established, and therefore, the effects of marginal zinc intakes are poorly understood.[88] Since plant sources of zinc contain phytates and other inhibitors of zinc absorption, vegetarians and vegans may potentially be at risk of zinc deficiency.[76] The World Health Organization estimates zinc bioavailability based on the molar ratio of phytate to zinc in the diet. It has been suggested that the requirement for dietary zinc may be as much as 50% greater for some vegetarians.[89] In a meta-analysis by Foster *et al.* (2013)[90] that aimed to investigate the effects of plant-based diets on dietary zinc intake and status in humans, it was reported that in comparison to the non-vegetarians, populations that followed habitual vegetarian diets have significantly lower dietary zinc intakes and serum zinc concentrations. Secondary analysis showed a larger impact of vegetarian diets on the zinc intake and particularly among vegetarian and vegan women, from the developing countries. Populations that usually eat vegetarian diets have low zinc intake and status.

This, it can be said that barring the risk of deficiency of a few of the nutrients, vegetarian diets are also associated with health benefits, especially related to cardiometabolic health.

Conclusion

The anticipation of influencing health through diet is one of the earliest concepts in medicine. Indian vegetarian diets have unique components that make it very different from vegetarianism that is followed in the west. The relationship between plant-based diets and health and disease prevention may vary among populations of different ages or physiological states. To maximize the health benefits of vegetarian diets, it must be well planned a well-balanced with increasing the intake of food components that have a beneficial impact on health and lowering the intake of components which may result in decreasing the potential health benefits associated with same.

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