Observational Study

Medicine

OPEN

Investigating the relationship between plant-based dietary protein indices and depression score in the elderly of Shiraz City

A cross-sectional study

Mehrdad Behzadi, MSc[a], Mehran Nouri, PhD[b], Mehraban Navaei, MSc[c], Amirhossein Asadi, MSc[a], Atefeh Kohansal, MSc[a], Zahra Sohrabi, PhD[d,*]

Abstract

Depression is an important and common disorder in the elderly. Plant-based dietary patterns are often considered "healthy" and associated with various health benefits. However, the association between plant-based dietary indices and depression is largely ambiguous. This cross-sectional study aimed to investigate the relationship between plant protein indices and depression in the elderly population. In this cross-sectional study, conducted on 80 elderly people living in Shiraz City, food intake information was collected using a 147-item food frequency questionnaire. Plant-based diet index (PDI), healthy PDI (hPDI), and unhealthy PDI (uPDI) were used to assess dietary patterns. Also, depression was evaluated using the Beck Depression questionnaire. A linear regression method in crude and 2 adjusted models was used to investigate the relationship between dietary indicators and depression. $P < .05$ was considered significant. Higher PDI and uPDI scores were related to lower intakes of vitamin B12 ($P = .04$, .03). Also, higher hPDI and uPDI scores were associated with lower saturated fatty acids intakes ($P = .04$, .01). A significant positive relationship between depression and hPDI was observed in both crude ($P = .01$), and adjusted ($P = .01$) models. While, for PDI and uPDI, no significant relationship was observed in any of the models. Plant-based dietary patterns could be possibly related to depression in the older population. However, the evidence is inconsistent and more investigations with larger sample sizes and appropriate designs are needed to clarify this relationship.

Abbreviations: FFQ = Food Frequency Questionnaire, hPDI = healthy plant-based diet index, PDI = plant-based diet index, SFA = saturated fatty acid, uPDI = unhealthy plant-based diet index.

Keywords: dietary patterns, elderly, mental health, vegetarian

1. Introduction

Depression is one of the cognitive disorders with a 3.8% prevalence in the entire population, 5% in the adult population, and 5.7% in the population over 60 years old.[1] It is different from short-term emotional responses to daily life challenges and mood swings. Particularly, when depression is severe, it may become a serious and health-threatening situation. This situation can cause suffering and torment in the person and affects the person's work, academic, and family performance. In the most extreme case, depression can lead to suicide.[2] In low- and middle-income countries, >75% of people do not receive mental health treatment, despite the fact that there are effective and known treatments. Treatment obstacles include lack of health education and resources, and social stigma associated with mental disorders. The amount of mental health disorders is increasing and greatly impacts society's health and the economic burden in the field of health.[3] Changeable lifestyle behaviors, such as physical inactivity and smoking, play a significant role in mental health disorders.[4] Recently, more attention has been paid to the association between diet and depression.[5] Some evidence indicates that eating vegetables and fruit can reduce the risk of depression,[6–8] while other studies did not show a significant relationship, and some reported an inverse

AK and ZS contributed to this article equally.

The study was supported by a grant from Shiraz University of Medical Sciences (grant number: 30460).

The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

[a] *Student Research Committee, School of Nutrition and Food Sciences, Shiraz University of Medical Sciences, Shiraz, Iran,* [b] *Health Research Institute, Babol University of Medical Sciences, Babol, Iran,* [c] *Student Research Committee, School of Public Health, Iran University of Medical Sciences, Tehran, Iran,* [d] *Nutrition Research Center, School of Nutrition and Food Sciences, Shiraz University of Medical Sciences, Shiraz, Iran.*

** Correspondence: Zahra Sohrabi, Department of Community Nutrition, School of Nutrition and Food Sciences, Shiraz University of Medical Sciences, Razi Blvd, Shiraz, Iran (e-mail: Zahra_2043@yahoo.com).*

How to cite this article: Behzadi M, Nouri M, Navaei M, Asadi A, Kohansal A, Sohrabi Z. Investigating the relationship between plant-based dietary protein indices and depression score in the elderly of Shiraz City: A cross-sectional study. Medicine 2025;104:11(e41777).

Received: 11 June 2024 / Received in final form: 26 January 2025 / Accepted: 28 January 2025

http://dx.doi.org/10.1097/MD.0000000000041777

relationship.[9–11] Due to the increasing prevalence of vegetarian diets around the world, there has recently been an increasing interest in studying the relationship between vegetarianism and depression.[12] A vegetarian diet is based on compounds derived from plants such as vegetables, whole grains, seeds, nuts, legumes and fruits, or some nonmeat animal products (such as dairy foods, eggs, or honey). Vegans, do not consume any animal products, including eggs, dairy and honey, and refrain from consuming animal products in ready-made products.[13] It was reported that a vegetarian or vegan diet may be associated with an increased risk of depression; as vegan diets lack vitamin B12 and long-chain omega-3 polyunsaturated fatty acids, both of which play a role in brain health and function.[14] However, vegetarian diets are rich in antioxidants, including beta-carotene, vitamins E and C which may counteract depression-associated brain inflammation.[15–17]

Considering the unclear relationship between a vegetarian diet and depression and the lack of studies in this regard in the Iranian elderly population, this study aimed to investigate the relationship between plant-based dietary protein indices and depression in the elderly.

2. Materials and methods

In this cross-sectional study, using the study of Lee et al,[18] the sample size was determined considering the diet evaluation index. Considering stratified sampling and design effect equal to 0.8 ($R = 0.25$, power = 80 percent, and $\alpha = 0.05$), the sample size was estimated to be 80 participants. Sampling for the present study was done at Jahandidehgan Center (Elderly Health Research and Monitoring Center in Shiraz). It was done from different classes of older adults referred to this center. A total of 80 participants who were referred to this center were selected by a simple random method.

The protocol of this study was reviewed and approved by the Ethics Committee of Shiraz University of Medical Sciences (IR.SUMS.REC.1403.229). After explaining the steps of the study to the participants, a written consent form was presented to them. If they signed it, they entered the study. All participants were assured that they would not incur any costs during the study. In addition, all their information would remain confidential and at the end of the study and they would benefit from individual nutrition counseling. Then, a questionnaire (checklist) of demographic information including age, education, occupation, etc was completed for all participants, and anthropometric indicators such as weight, height, waist circumference, and hip circumference were measured. Dietary evaluation was also done for all participants. In addition, to investigate the relationship between depression status and diet indicators, patients' depression status was also evaluated by a questionnaire. People who could understand the contents and questions and had the ability to answer the questions, did not use a special diet or special dietary supplements, have not been hospitalized in the past month, or have not been infected with any infectious disease, entered the study. In addition, those with special movement disabilities, digestive problems, mental-psychological problems, Alzheimer or forgetfulness, and those who lived in an elderly center were not included in the study. People who, for any reason, were on a special diet or abstaining from food that greatly affected their diet were not included in the study as well (such as low protein diets, etc).

The weight of people with minimal clothing and without shoes was measured and recorded with a Seca-type scale with a minimum of 0.1 to a maximum of 150 kg and with an error of 100 grams in the morning, and the height was recorded with a meter installed on the wall, while standing next to the wall without shoes, while the shoulders were in normal conditions and the hips, shoulders, and heels were tangent to the wall and the head was facing the front. Body mass index was obtained by dividing weight (kg) by square of height (meter). The measurement of waist circumference at the midpoint between the last rib and the iliac crest and the circumference of the hips in the largest area was measured with the help of an inflexible tape measure without applying pressure to the body with an accuracy of 0.1 cm.

A food frequency questionnaire (FFQ) with 147 items was used to check food intake.[19] All information was collected through face-to-face interviews with trained and experienced nutritionists. The participants were asked to indicate the amount and frequency of consumption of food items mentioned in the FFQ that they consumed during the past year, on a daily, weekly, monthly, and yearly basis. Then the amount reported by each participant was converted to grams per day.

Satija et al.'s method[20] was used for calculating plant-based dietary indices. This method includes 3 general indices, plant-based diet index (PDI), healthy PDI (hPDI), and unhealthy PDI (uPDI). Food items were divided into 18 groups according to the similarity of components. These groups include 3 main classifications of animal foods, healthy and unhealthy plant foods. Healthy plants include vegetable oils, legumes, fruits, vegetables, nuts, whole grains, and tea/coffee, while unhealthy foods (plant-based ones) were considered those containing fruit juice, sugar-sweetened beverages, potatoes, pastries/desserts, and refined grains. In addition, animal foods included meat, dairy, eggs, animal fat, fish/seafood, and other foods of animal origin. Then these food items were converted into 10 consumer groups and a score of 1 to 10 was considered for each item. For the PDI score, the numbers 1 to 10 were considered the lowest and the highest scores for plant foods, respectively. For obtaining hPDI, scores of 1 and 10 were used in the same order as before. The highest consumption of unhealthy vegetable and animal foods would achieve score 1 and the lowest consumption would achieve 10. For calculating uPDI, a score between 10 and 1 was assigned to the lowest and highest consumption of unhealthy plant foods. In addition, a score between 1 and 10 was considered for the participants who had the most to least consumption of animal foods and healthy plant foods. For all plant-based dietary indices, the sum of the total scores was estimated between 18 and 180. For each index, higher total scores indicate greater adherence to that dietary pattern. The Beck Depression Inventory, which is one of the most common and reliable tests to assess depression severity, was used to evaluate the level of depression. This 21-item questionnaire is based on 5 factors composed of symptoms and signs of depression, including 1-pessimism, a feeling of failure, self-hatred, suicidal thoughts and lack of decision making, 2-guilt and expectation of punishment and blame, 3-crying, change in Self-image, unhappiness and sadness, 4-weight loss, physical complaints and fatigue and 5-irritability, insomnia, and anorexia. Each question in this questionnaire is graded based on a 4-option scale of mental health, mild, moderate disorder, or severe disorder.[21] In addition, previous studies have measured the validity and reliability of this questionnaire.[22]

The obtained data were analyzed by SPSS software, version 21 (SPSS Inc., Chicago). The normality of the data was checked by the Kolmogorov–Smirnov test. Considering the normality of all data, 2 groups were considered to compare quantitative data with each other. Independent t test was used to compare quantitative data and χ^2 analysis was used for qualitative variables. In order to investigate the relationship between dietary indicators and depression, a linear regression method was used in crude and 2 adjusted models; model 1: adjusted for age and sex, and model 2: adjusted for age and sex, plus for education level, body mass index and energy. P values <.05 were considered significant.

3. Results

Information about the basic characteristics of the participants is presented in Table 1. No significant difference was observed

between the 2 groups of depression scores, except for the average Beck score (P<.001) and the average hPDI score ($P = .03$).

Table 2 presents information about the average intakes of micro and macronutrients and energy, based on the PDI, hPDI, and uPDI classifications. In the group with a higher PDI score, carbohydrate ($P = .02$), vitamin B9 ($P = .02$), vitamin C ($P = .006$), and copper ($P = .04$) intakes were significantly higher while vitamin B12 was significantly lower ($P = .04$). A higher hPDI score was associated with lower saturated fatty acids (SFA) intake ($P = .04$). Also, in the group with higher uPDI scores, protein ($P = .005$), fat ($P = .02$), SFA ($P = .01$), monounsaturated fatty acids ($P = .003$), vitamin E ($P = .004$), B6 ($P = .001$), B12 ($P = .03$), vitamin C ($P = .01$), magnesium ($P = .005$) and zinc ($P = .003$) intakes were significantly lower.

Table 3 shows the results of linear regression analysis between the depression score and the score of each of the 3 plant protein indices. A significant positive relationship between depression and hPDI was observed in both crude ($P = .01$) and adjusted ($P = .01$) models, while, for PDI and uPDI, no significant relationship was observed in any of the models.

4. Discussion

Elderly people are at a higher risk of developing affective disorders, which are on the rise. Globally, researchers and healthcare professionals are trying to recognize and eliminate modifiable causal factors.[23] Diet is a crucial and controllable factor that affects the mental health of the elderly, which is why the prospect of improving mental health through dietary changes is particularly attractive.[24] However, nutritionists have not agreed on which diet would be effective in preventing or alleviating the symptoms of late-life depression. There has been a tendency to advocate abstinence from meat, and dairy products, or at least limiting their intake for decades in order to prevent depression from developing.[18,25,26] The present cross-sectional study investigated the relationship between plant food patterns and depression scores in the elderly population. Results revealed that a higher PDI score was significantly related to more carbohydrates, vitamin B9, vitamin C, and copper intakes. Besides, higher hPDI scores were associated with lower SFA intakes. However, higher uPDI scores were related to lower intakes for all micro and macronutrients and most of them were statistically significant. Higher PDI and uPDI scores were associated with lower vitamin B12 intakes. Moreover, a significant relationship was found between the hPDI and the depression score in all crude and adjusted models.

The results of the present study regarding the positive association between depression scores and hPDI are in line with some other studies. An observational retrospective study by Marche et al which was conducted on the elderly population in 2024, revealed that depression was more likely to occur in those who consumed plant-based foods.[27] Furthermore, in Pes et al's study[28], which was performed on the long-lived population of Sardinia, consumption of fruit was significantly correlated with depression, while consumption of meat and lard was negatively correlated. A recent study of the ELSA-Brasil cohort found that people eating a meatless diet were more likely to suffer from depression.[29] Also, a meta-analysis by Ocklenburg et al[30] reviewed 9 studies, and found that vegetarians were more likely to suffer from depression than nonvegetarians. However, in contrast, several studies indicated that there is a negative relationship between a plant-based diet and depression.[18,31–33] In order to explain the biological mechanism by which plant-based dietary patterns may affect depression, numerous hypotheses have been proposed. Some mechanisms advocate the hypothesis of the beneficial effects of vegetarian diets on improving mental health and decreasing depression. A plant-based diet is rich in fiber content. This could enhance and improve the gut's useful microbiota, which leads to reduced oxidative stress and inflammation that are related to depression.[34] In addition, plant-based diets could affect the production of neurotransmitters like dopamine and serotonin, which are crucial behavior and mood regulators.[35] Furthermore, vegetarian diets contain fewer cholesterol and SFAs, which are related to depression.[36,37] However, due to the cross-sectional design of the study, no cause-and-effect relationship can be obtained and further investigations especially interventional studies are warranted to elucidate this relationship better. Hence, the data associated with the relationship between depression and plant protein intake should be interpreted cautiously.

Table 1

Characteristics of the study participants.

Variables	Beck score (≤13), (n=44)	Beck score (˃13), (n=37)	*P* value
Age (yr)	66.18 ± 5.67	65.18 ± 6.90	.48
Weight (kg)	70.97 ± 10.84	69.66 ± 12.73	.61
Height (cm)	164.75 ± 10.98	161.67 ± 10.50	.20
BMI (kg/m^2)	26.46 ± 5.40	26.66 ± 4.55	.85
WC (cm)	87.54 ± 11.78	88.50 ± 12.80	.72
HC (cm)	98.06 ± 14.45	100.10 ± 15.00	.53
Beck score	6.68 ± 3.70	20.64 ± 8.02	**<.01**
PDI score	100.59 ± 12.97	96.24 ± 13.78	.14
hPDI score	102.27 ± 14.20	95.18 ± 14.72	**.03**
uPDI score	97.09 ± 12.39	100.91 ± 15.23	.21
Gender (%)			.49
Male	22 (50.0)	17 (47.2)	
Female	22 (50.0)	19 (52.8)	
Marital status (%)			.53
Single	10 (22.7)	9 (24.3)	
Married	34 (77.3)	28 (75.7)	
Education status (%)			.19
Under diploma	14 (34.1)	17 (45.9)	
Diploma and higher	29 (65.9)	20 (54.1)	

Data are presented as mean ± standard deviation for quantitative variables and as frequency (percentages) for qualitative variables.

Independent samples *t* test was used for quantitative variables and χ^2 for qualitative variables.

$P < .05$ was considered significant.

BMI = body mass index, HC = hip circumference, hPDI = healthy plant-based diet index, PDI = plant-based diet index, uPDI = unhealthy plant-based diet index, WC = waist circumference.

Table 2

Average nutrient intake according to PDI, hPDI, and uPDI scores in the study participants

	PDI			hPDI			uPDI		
Variables	**<99 (n = 43)**	**≥99 (n = 38)**	***P* value**	**<100 (n = 42)**	**≥100 (n = 39)**	***P* value**	**<101 (n = 43)**	**≥101 (n = 38)**	***P* value**
Energy (Kcal/d)	1945.66 ± 96.96	2144.01 ± 213.45	.38	2123.22 ± 204.13	1947.70 ± 79.87	.43	2246.40 ± 189.89	1815.05 ± 81.94	.05
Protein (g/d)	69.77 ± 7.31	57.71 ± 8.61	.28	72.47 ± 9.70	55.11 ± 4.90	.12	78.90 ± 9.88	48.19 ± 3.34	.005
Carbohydrate (g/d)	98.90 ± 12.64	284.28 ± 35.87	.02	238.75 ± 33.54	239.18 ± 14.41	.99	260.69 ± 33.17	215.54 ± 14.44	.22
Fat (g/d)	65.36 ± 4.96	59.91 ± 5.81	.47	67.69 ± 6.61	57.54 ± 3.21	.18	70.75 ± 6.46	54.25 ± 3.19	.02
Fiber (g/d)	22.96 ± 3.63	33.09 ± 5.43	.11	27.94 ± 5.10	27.47 ± 3.90	.94	22.51 ± 4.66	33.31 ± 4.31	.09
Saturated fatty acids (g/d)	21.03 ± 1.67	18.84 ± 2.07	.41	22.57 ± 2.25	17.24 ± 1.13	.04	23.17 ± 2.30	16.59 ± 0.90	.01
Monounsaturated fatty acids (g/d)	25.11 ± 1.86	23.04 ± 1.88	.44	25.80 ± 2.33	22.35 ± 1.07	.19	27.81 ± 2.22	20.18 ± 1.06	.003
Polyunsaturated fatty acids (g/d)	17.93 ± 1.21	17.24 ± 1.52	.72	18.15 ± 1.63	17.03 ± 0.93	.56	18.89 ± 1.58	16.22 ± 0.99	.16
Vitamin E (mg/d)	13.54 ± 0.75	16.11 ± 1.35	.09	13.89 ± 1.29	15.67 ± 0.72	.24	16.83 ± 1.25	12.50 ± 0.67	.004
Vitamin B6 (mg/d)	2.27 ± 0.14	2.41 ± 0.24	.61	2.41 ± 0.25	2.26 ± 0.10	.60	2.77 ± 0.24	1.87 ± 0.06	.001
Vitamin B9 (µg/d)	567.82 ± 24.57	694.97 ± 52.54	.02	639.59 ± 48.55	614.42 ± 28.76	.66	641.51 ± 49.17	612.35 ± 27.45	.61
Vitamin B12 (µg/d)	3.41 ± 0.33	2.31 ± 0.41	.04	3.16 ± 0.42	2.61 ± 0.31	.30	3.43 ± 0.47	2.31 ± 0.20	.03
Vitamin C (mg/d)	66.02 ± 19.02	216.24 ± 51.67	.006	110.66 ± 47.63	164.32 ± 24.80	.33	198.72 ± 48.06	69.49 ± 19.43	.01
Calcium (mg/d)	794.46 ± 66.04	751.75 ± 131.19	.76	849.55 ± 124.89	693.52 ± 56.46	.27	893.15 ± 127.43	464.57 ± 44.39	.08
Magnesium (mg/d)	485.62 ± 23.00	528.41 ± 39.49	.12	489.04 ± 39.32	493.87 ± 19.85	.91	550.92 ± 37.68	427.23 ± 18.23	.005
Iron (mg/d)	19.67 ± 0.65	22.02 ± 1.79	.20	21.19 ± 1.65	20.31 ± 0.70	.63	21.87 ± 1.59	19.59 ± 0.80	.21
Selenium (mg/d)	120.07 ± 6.13	124.06 ± 9.59	.72	127.79 ± 8.35	115.65 ± 7.09	.27	131.38 ± 8.20	111.79 ± 7.07	.07
Zinc (mg/d)	12.38 ± 0.70	12.88 ± 1.16	.70	13.14 ± 1.13	12.05 ± 0.60	.41	14.45 ± 1.14	10.63 ± 0.42	.003
Copper (mg/d)	1.98 ± 0.09	2.40 ± 0.19	.04	2.17 ± 0.18	2.19 ± 0.09	.90	2.29 ± 0.18	2.05 ± 0.009	.25

Numbers were presented as mean ± standard error.

The independent samples *t* test statistical test was used.

$P < .05$ was considered significant.

hPDI = healthy plant-based diet index, PDI = plant-based diet index, uPDI = unhealthy plant-based diet index.

Table 3

Crude and adjusted odds ratios and 95% confidence intervals for depression versus healthy and unhealthy plant-based diet scores.

		Depression		
Variables		**Crude model**	**Model 1**	**Model 2**
PDI				
<99		Reference	Reference	Reference
>99	β	0.76	0.73	0.66
	95% CI	0.31–1.83	0.3–1.8	0.25–1.72
P value		.54	.50	.40
hPDI				
<100		Reference	Reference	Reference
>100	β	0.30	0.31	0.28
	95% CI	0.12–0.75	0.12–0.81	0.1–0.75
P value		**.01**	**.01**	**.01**
uPDI				
<101		Reference	Reference	Reference
>101	β	1.54	1.63	1.62
	95% CI	0.64–3.73	0.66–3.98	062–4.2
P value		.33	.28	.32

Crude model: crude coefficient.

Model 1: adjusted for age and sex.

Model 2: adjusted for age and sex, plus for education level, body mass index, and energy.

$P < .05$ was considered significant.

CI = confidence interval, hPDI = healthy plant-based diet index, PDI = plant-based diet index, uPDI = unhealthy plant-based diet index.

However, the current study showed the harmful effects of plant protein on depression, even for healthy plant proteins. To justify the results of the present study, some probable mechanisms were proposed to explain the association between vegan diets and depression. The nutritional deficiencies of vegetarians, such as a lack of B12, make them more depressed and neurotic than nonvegetarians.[38,39] Based on the findings of the German Nutrition Society, a strict plant-based diet fails to adequately supply certain nutrients or does so only with difficulty. Vegan diets may lack certain nutrients including vitamins (vitamin E, vitamin B6, and vitamin B12) and minerals (magnesium, zinc, etc). Vitamin B12 is undoubtedly the most important nutrient related to vegan diets.[40] In line with expectations, vitamin B12 intake was significantly lower in the higher PDI and uPDI scores. A plant-based diet strongly recommends supplementing vitamin B12 since it is an essential nutrient in numerous metabolic pathways.[41] On the other hand, affective disorders may lead to vegetarianism for 2 reasons. As a result of suffering from an affective disorder, an individual may become more aware of their health because they will try to positively influence their depressive thoughts, and they may perceive a vegan diet as being healthier than a meat-based diet. In addition, depression may result in enhanced sensitization to the suffering of animals, resulting in a reduction in the consumption of animal-based products.[30] Hence, due to the all aforementioned reasons, a possible relationship between depression and plant protein intake could exist, emphasizing the importance of animal protein for mental health.

There are some limitations to the current study that should be noted. First, this study had a small sample size. Also, the cross-sectional design of the study prevents any inference of cause and effect from the relationship obtained between the indicators, and it is necessary to investigate these relationships within a cohort study. In addition, the existence of different questionnaires and the issue of completing questionnaires by the elderly population can be a limitation that has affected the final data collection. On the other hand, self-administration of antidepressants when selecting patients was not considered which can be another limitation of the current study. Some strengths also existed for the present study. As compared with the previous surveys, this study sampled a specific age group. Moreover, a 147-item FFQ version was used that covered a greater number of PDI items. The results of the current study were also adjusted for several confounders to draw better conclusions.

5. Conclusion

Dietary intake of plant protein could be possibly related to depression in older adults. This evidence is inconsistent and uncertain for the sample size and speculations, more appropriate studies are needed to clarify this relationship and a direct relationship between macronutrients and depression. Further studies in various populations are warranted to better elucidate the exact relationship between dietary patterns and mental health, especially depression.

Author contributions

Investigation: Mehrdad Behzadi, Atefeh Kohansal, Zahra Sohrabi.
Writing—original draft: Mehrdad Behzadi, Mehraban Navaei, Amirhossein Asadi, Atefeh Kohansal.
Writing—review & editing: Mehrdad Behzadi, Mehraban Navaei, Amirhossein Asadi, Atefeh Kohansal, Zahra Sohrabi.
Formal analysis: Mehran Nouri.
Methodology: Mehran Nouri, Atefeh Kohansal, Zahra Sohrabi.
Software: Mehran Nouri.
Conceptualization: Atefeh Kohansal, Zahra Sohrabi.

References

[1] Prohan M, Amani R, Nematpour S, Jomehzadeh N, Haghighizadeh MH. Total antioxidant capacity of diet and serum, dietary antioxidant vitamins intake, and serum hs-CRP levels in relation to depression scales in university male students. Redox Rep. 2014;19:133–9.
[2] Jacka FN, Mykletun A, Berk M. Moving towards a population health approach to the primary prevention of common mental disorders. BMC Med. 2012;10:1–6.
[3] Vigo DV, Patel V, Becker A, et al. A partnership for transforming mental health globally. Lancet Psychiatry. 2019;6:350–6.
[4] Jacka FN, Maes M, Pasco JA, Williams LJ, Berk M. Nutrient intakes and the common mental disorders in women. J Affect Disord. 2012;141:79–85.
[5] Bideshki MV, Jowshan MR, Sherafati N, et al. Association between Dietary Inflammatory Index, Mean Adequacy Ratio, Dietary Energy Density and Mental Health among Iranian Women. Int J Nutr Sci. 2024;9:109–17.
[6] Akbaraly TN, Sabia S, Shipley MJ, Batty GD, Kivimaki M. Adherence to healthy dietary guidelines and future depressive symptoms: evidence for sex differentials in the Whitehall II study. Am J Clin Nutr. 2013;97:419–27.
[7] Khalid I, Khalid TJ, Qabajah MR, Barnard AG, Qushmaq IA. Healthcare workers emotions, perceived stressors and coping strategies during a MERS-CoV outbreak. Clin Med Res. 2016;14:7–14.
[8] McMartin SE, Kuhle S, Colman I, Kirk SF, Veugelers PJ. Diet quality and mental health in subsequent years among Canadian youth. Public Health Nutr. 2012;15:2253–8.
[9] Chi SH, Wang JY, Tsai AC. Combined association of leisure-time physical activity and fruit and vegetable consumption with depressive symptoms in older T aiwanese: Results of a national cohort study. Geriatr Gerontol Int. 2016;16:244–51.
[10] Hintikka J, Tolmunen T, Honkalampi K, et al. Daily tea drinking is associated with a low level of depressive symptoms in the Finnish general population. Eur J Epidemiol. 2005;20:359–63.
[11] Mihrshahi S, Dobson A, Mishra G. Fruit and vegetable consumption and prevalence and incidence of depressive symptoms in mid-age women: results from the Australian longitudinal study on women's health. Eur J Clin Nutr. 2015;69:585–91.
[12] Le LT, Sabaté J. Beyond meatless, the health effects of vegan diets: findings from the adventist cohorts. Nutrients. 2014;6:2131–47.
[13] Alcorta A, Porta A, Tárrega A, Alvarez MD, Vaquero MP. Foods for plant-based diets: challenges and innovations. Foods. 2021;10:293.
[14] Clarys P, Deliens T, Huybrechts I, et al. Comparison of nutritional quality of the vegan, vegetarian, semi-vegetarian, pesco-vegetarian and omnivorous diet. Nutrients. 2014;6:1318–32.
[15] Orlich MJ, Fraser GE. Vegetarian diets in the adventist health study 2: a review of initial published findings. Am J Clin Nutr. 2014;100:353S–8S.
[16] Dantzer R, O'connor JC, Freund GG, Johnson RW, Kelley KW. From inflammation to sickness and depression: when the immune system subjugates the brain. Nat Rev Neurosci. 2008;9:46–56.
[17] Kaur C, Kapoor HC. Antioxidants in fruits and vegetables–the millennium's health. Int J Food Sci Technol. 2001;36:703–25.
[18] Lee MF, Eather R, Best T. Plant-based dietary quality and depressive symptoms in Australian vegans and vegetarians: a cross-sectional study. BMJ Nutr Prev Health. 2021;4:479–86.
[19] Mirmiran P, Esfahani FH, Mehrabi Y, Hedayati M, Azizi F. Reliability and relative validity of an FFQ for nutrients in the Tehran lipid and glucose study. Public Health Nutr. 2010;13:654–62.
[20] Satija A, Bhupathiraju SN, Spiegelman D, et al. Healthful and unhealthful plant-based diets and the risk of coronary heart disease in US adults. J Am Coll Cardiol. 2017;70:411–22.
[21] Beck AT, Steer RA, Brown G. Beck depression inventory–II. Psychological assessment; 1996.
[22] Bahrami M, Dehdashti A, Karami M. Investigation depression prevalence and related effective factors among students at health faculty Semnan University of Medical Sciences in 2017, Iran. 2017;
[23] Firth J, Solmi M, Wootton RE, et al. A meta-review of "lifestyle psychiatry": the role of exercise, smoking, diet and sleep in the prevention and treatment of mental disorders. World Psychiatry. 2020;19:360–80.
[24] Adan RAH, van der Beek EM, Buitelaar JK, et al. Nutritional psychiatry: towards improving mental health by what you eat. Eur Neuropsychopharmacol. 2019;29:1321–32.
[25] Beezhold BL, Johnston CS. Restriction of meat, fish, and poultry in omnivores improves mood: a pilot randomized controlled trial. Nutr J. 2012;11:9.
[26] Matta J, Czernichow S, Kesse-Guyot E, et al. Depressive symptoms and vegetarian diets: results from the constances cohort. Nutrients. 2018;10:1695.
[27] Marche C, Poulain M, Nieddu A, Errigo A, Dore MP, Pes GM. Is a plant-based diet effective to maintain a good psycho-affective status in old age? Results of a survey of a long-lived population from Sardinia. Nutr Neurosci. 2024;27:382–91.
[28] Pes GM, Poulain M, Errigo A, Dore MP. Evolution of the dietary patterns across nutrition transition in the Sardinian longevity blue zone and association with health indicators in the oldest old. Nutrients. 2021;13:1495.
[29] Kohl IS, Luft VC, Patrão AL, Maria del Carmen BM, Nunes MAA, Schmidt MI. Association between meatless diet and depressive episodes: a cross-sectional analysis of baseline data from the longitudinal study of adult health (ELSA-Brasil). J Affect Disord. 2023;320:48–56.
[30] Ocklenburg S, Borawski J. Vegetarian diet and depression scores: a meta-analysis. J Affect Disord. 2021;294:813–5.
[31] Li Y, Lv MR, Wei YJ, et al. Dietary patterns and depression risk: a meta-analysis. Psychiatry Res. 2017;253:373–82.
[32] Mousavi SM, Ebrahimi-Mousavi S, Hassanzadeh Keshteli A, Afshar H, Esmaillzadeh A, Adibi P. The association of plant-based dietary patterns and psychological disorders among Iranian adults. J Affect Disord. 2022;300:314–21.
[33] Zamani B, Daneshzad E, Siassi F, Guilani B, Bellissimo N, Azadbakht L. Association of plant-based dietary patterns with psychological profile and obesity in Iranian women. Clin Nutr. 2020;39:1799–808.
[34] Xie J, Liu L, Guo H, et al. Orally administered melanin from Sepiapharaonis ink ameliorates depression-anxiety-like behaviors in DSS-induced colitis by mediating inflammation pathway and regulating apoptosis. Int Immunopharmacol. 2022;106:108625.
[35] Bjørke-Monsen AL, Varsi K, Ulvik A, Sakkestad ST, Ueland PM. A vegetarian diet significantly changes plasma kynurenine concentrations. Biomolecules. 2023;13:391.
[36] Key TJ, Papier K, Tong TYN. Plant-based diets and long-term health: findings from the EPIC-Oxford study. Proc Nutr Soc. 2022;81:190–8.
[37] Zou L, Tian Y, Wang Y, et al. High-cholesterol diet promotes depression-and anxiety-like behaviors in mice by impact gut microbe and neuroinflammation. J Affect Disord. 2023;327:425–38.
[38] Forestell CA, Nezlek JB. Vegetarianism, depression, and the five factor model of personality. Ecol Food Nutr. 2018;57:246–59.
[39] Hibbeln JR, Northstone K, Evans J, Golding J. Vegetarian diets and depressive symptoms among men. J Affect Disord. 2018;225:13–7.
[40] Richter M, Boeing H, Grünewald-Funk D, et al. Vegan diet. Position of the German nutrition society (DGE). Ernahrungs Umschau. 2016;63:92–102.
[41] Dressler J, Storz MA, Müller C, et al. Does a plant-based diet stand out for its favorable composition for heart health? dietary intake data from a randomized controlled trial. Nutrients. 2022;14:4597.