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Plant-based dietary quality and depressive symptoms in Australian vegans and vegetarians: a cross-sectional study

Megan Frances Lee ,[1] Ryan Eather,[2] Talitha Best [2]

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[1]Faculty of Society and Design, Bond University, Robina, Queensland, Australia
[2]School of Health, Medical and Applied Sciences, NeuroHealth Lab, Appleton Institute, Central Queensland University, Brisbane, Queensland, Australia

Correspondence to
Dr Talitha Best, Central Queensland University, Brisbane, Queensland, Australia; t.best@cqu.edu.au

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ABSTRACT

Plant-based dietary patterns (vegan and vegetarian) are often considered 'healthy' and have been associated with broad health benefits, including decreased risk of obesity and ill health (cardiovascular disease, blood glucose and type II diabetes). However, the association between plant-based diets and mood disorders such as depression remains largely equivocal. This cross-sectional study of 219 adults aged 18–44 (M=31.22, SD=7.40) explored the associations between an estimate of overall plant-based diet quality and depression in vegans (n=165) and vegetarians (n=54). Overall plant-based diet quality was associated with depressive symptoms in vegans and vegetarians $F(1, 215)=13.71$, $p<0.001$ accounting for 6% of the variation in depressive symptoms. For those without depression, higher diet quality was protective against depressive symptoms $F(1, 125)=6.49$, $p=0.012$. Conversely, for those with depression no association with diet quality was found $F(1, 89)=0.01$, $p=0.963$. These findings suggest that a high-quality plant-based diet may be protective against depressive symptoms in vegans and vegetarians. In line with emerging research between food and mental health, higher-quality dietary patterns are associated with a reduced risk of depressive symptoms. Given the rapidly increasing rate of vegan and vegetarian food products within Australia, understanding the potential mechanisms of effects through which a plant-based diet may influence depressive symptoms is required.

What this paper adds

- ► A quantitative survey of vegan and vegetarians that explores a measure of overall plant-based dietary quality and its association with depression.
- ► The results show that high quality plant-based diets are associated with lower risk of depression in vegans and vegetarians.
- ► The association between plant-based dietary quality and depression to support mental well-being and mood in vegan and vegetarians should be investigated further.

INTRODUCTION

Over 300 million people globally experience symptoms of depression.[1] Mood disorders, including depression, are significant predictors of suicide and suicidal ideation and are responsible for over 800 000 global suicide-related deaths per year.[1] In Australia, 1 in 10 people (10.4%) report experiencing symptoms of depression. In younger adults, the prevalence rate of depression is higher at 13.9%, with suicide the leading cause of death for individuals aged 15–44.[2] The most common treatments for depression are pharmacology and psychotherapy. However, approximately one-third of patients do not respond to conventional treatments and can develop treatment-resistant depression.[3] Increasingly, lifestyle changes such as diet and exercise have been shown to impact symptoms of depression positively and could be both a cost-effective and modifiable adjunct treatment to current traditional treatment options.[4]

Both poor diet and mood disorders are known leading causes of morbidity and mortality.[5 6] Diet quality is 'The nutritional adequacy of an individual's dietary pattern and how closely this aligns with (Australian) national dietary guidelines'.[7] However, there is confusion surrounding the term 'diet quality' with minimal agreement on a valid diet quality measurement.[8] Dietary patterns include the variety and quality of foods and beverages in a diet and the quantity and frequency they are habitually consumed.[9] Dietary patterns are most often evaluated based on their inclusion or exclusion of healthy and unhealthy foods and beverages. Healthy dietary patterns, including traditional and Mediterranean diets, are loosely defined as a healthy intake of fresh fruit, vegetables, nuts, seeds, legumes, whole grains, water, lean meats and dairy.[10 11] Plant-based dietary patterns are commonly divided into two

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main categories, vegan and vegetarian, with several subcategories low in animal food consumption.[12] As such, a healthy plant-based dietary pattern is characterised by high consumption of fresh fruit, vegetables, nuts, seeds, legumes, whole grains and water, but may omit lean meats and dairy.[13 14] Conversely, unhealthy dietary patterns are characteristic of a large consumption of ultraprocessed, refined and sugary foods, despite the inclusion or exclusion of animal-based products.[15–18] In Australia, there has been a surge of people choosing to follow plant-based lifestyles with over 2.5 million Australians choosing to go meat-free. This equates to 12% of the total population, with the largest proportion of plant-based dieters being young adults between 18 and 45.[19]

Dietary intervention studies highlight healthy dietary patterns rich in fresh fruits, vegetables, nuts, seeds, whole grains and legumes as promising in reducing symptoms of depression.[4 20] However, the evidence of the association between plant-based dietary patterns and depression is inconsistent and conflicting.[21] Some studies suggest that plant-based diets (PBD) are associated with improved mood and mental health.[22] Others suggest that PBDs are associated with a greater risk of depressive symptoms,[23 24] while others find no relationship.[25–27] A meta-analysis of 13 studies by Iguacel *et al*[28] found that vegans and vegetarians were at increased risk of depression (OR=2.14, 95% CI: 1.11 to 4.15). Another systematic review and meta-analysis of ten observational studies by Askari *et al*[29] found no association between those who consumed a vegetarian diet and depression symptoms (pooled effect size: 1.02, 95% CI: 0.84 to 1.25). While a narrative review of 19 studies by Jain *et al*.[30] found conflicting information, some studies suggesting that those who adhered to vegan and vegetarian dietary patterns had higher depression rates, while others indicated they were associated with decreased depressive symptoms. Other primary research studies suggest that young adult vegetarians are at higher risk of depression[31] and suicide[32] than omnivores in the same age group. The reasons for these conflicting findings are not yet fully understood but may be due to the lack of heterogeneity of the measurement of dietary patterns (self-report), and that quality rather than dietary patterns needs to be further explored in this population.[33] Indeed a recent meta-analysis showed an increased risk of depression in vegetarians,[34] however, the interpretation of the findings is limited due to the lack of methodological clarity in vegetarian diets being of 'low' or 'no' meat consumption. As such, diet quality measures in PBD is critical for exploring the association between diet and mental health. This study explores the association between vegan and vegetarian dietary patterns and depressive symptoms in adults by exploring the overall dietary quality of these patterns. The research hypothesises that a high-quality PBD is associated with a lower risk of depressive symptoms.

METHOD

Research design

A cross-sectional online, anonymous survey was conducted between July 2020 and September 2020, using the Strengthening the Reporting of Observational Studies in Epidemiology checklist for cross-sectional studies.[35]

Procedure and participants

Vegan and vegetarian adults aged between 18 and 44 years and living in Australia were invited to complete an online survey through social media platforms Facebook, Twitter and LinkedIn. This age range was used as it is a high-risk population for depression[2] and identified as more likely to follow a plant-based dietary pattern.[19] Respondents were excluded if they were outside this age range or did not self-report a predominantly PBD intake. Invitations to participate were posted within PBD Facebook groups, and permission was sought from each group's administrators prior to posting. Based on a priori sample size calculations, N=185 was identified using G*Power to detect a medium effect size with 85% power. A total of 409 participants responded to the study. Of these, 190 reported consuming some form of meat product and were excluded from the data analysis, leaving 219 participants, resulting in a response rate of 53%. Of these, 165 self-identified as vegan and 54 as vegetarian. There was no remuneration for participation. The research team piloted the survey prior to distribution.

MATERIALS

Participant characteristics

Demographic characteristics, including age (years), gender (female, male or non-binary), education levels (high school, university degree, trade certificate) and marital status (partnered or unpartnered), were collected. Participants also reported health-related characteristics such as single-item measures to assess daily physical activity levels over the last month ranging from 0 'never exercise' to 31 'everyday',[36] and health compared with peers ranging from 1 'very good' to 5 'poor'.[37] Self-reported height and weight were used to calculate body mass index (BMI).

Centre for Epidemiological Studies Depression

The 20-item Centre for epidemiological studies depression (CESD) was used to measure symptoms associated with depression during the past week.[38] Response items are measured on a four-point Likert scale ranging from 0 (none of the time) to 3 (most of the time). Scores range from 0 to 60, with high scores (16 or greater) suggesting greater symptoms of depression. The CESD-20 measures symptoms of depression in the general population rather than a clinical diagnosis and is not recommended as a

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diagnostic tool. The CESD-20 has high internal consistency, test-retest reliability and concurrent validity with other depression scales such as the Beck Depression scale.[38 39] The CESD-20 has been used in previous dietary patterns and depression research . The CESD-20 has high internal consistency (α>0.8) across young adult populations[40 41] and for those who adhere to a plant-based dietary pattern.[42 43]

Dietary Screening Tool

The Dietary Screening Tool (DST) is a 20-item questionnaire that asks participants to provide an estimate of intake frequency of specific food categories.[44] Scoring was based on the frequency of each food group based on the 2005 Dietary Guidelines for Americans,[45] with changes made to the wording of items to reflect food choices more readily available in an Australian context.[46] The DST has been used to explore the association between diet quality and mood disorders in an Australian population.[4 47]

Dietary indices calculate diet quality in populations by nominating scores for consumption of healthy food items to provide a total score, with higher scores indicating healthier diet quality.[48] However, to date, self-reported dietary quality measures do not differentiate scores for those who do not eat food items such as meat, dairy and eggs, and as such, plant-based dietary patterns will have lower quality scores using these indices. Consequently, in this study, the DST was adapted to integrate an index of diet quality for PBD used in other studies.[12]

Consequently, food item scores were reweighted for PBD using the PBD[12] so that positive scores were assigned to healthful plant foods, and negative scores were assigned to unhealthful plant foods. This adaptation involved reversing any questions in the DST that awarded high scores for meat or meat-based products such as eggs and dairy. DST scores range from 0 to 105, with higher scores suggesting greater diet quality. Assigning the maximum scores in this way for a vegan and vegetarian population allowed them to achieve a maximum possible score as intended by the original DST. Higher diet quality scores meant that participants were consuming more fresh fruits, vegetables, legumes, whole grains, nuts, seeds, tofu, soy products and less plant-based processed food items or take away options.

Data analysis strategy

Frequency descriptives were calculated for all variables, with analysis of variance and χ^2 statistics used for continuous and categorical variable comparisons, respectively. Correlations were conducted to establish the relationship between depressive scores (CESD-20) and all other variables (DST, BMI, age, gender, physical activity levels, marital status) and to assess multicollinearity across predictor variables. Pearson's correlation analysis on continuous variables and Spearman's correlation analysis on categorical variables determined that only the DST and BMI were significantly correlated with CESD-20, and these were included in the final model. Before analysis was performed, the assumptions of multiple linear regression were checked (online supplemental material). There were no standardised residuals greater than three, indicating no outliers were influencing the data, and the assumptions of heteroscedasticity and normality of the residuals were met. There was no evidence of multicollinearity in the correlation matrix, and the variance inflation factor and tolerance rates were within normal limits. Multiple linear regression was used to determine whether diet quality (DST) was a significant predictor of depressive symptoms (CESD-20). The DST was entered into the model first, followed by BMI.

RESULTS

The mean age of the 219 participants was 31.22 (*SD*=7.40), with 93% of participants identifying as female. Table 1 outlines the demographic and health-related characteristics of the population split by diet type (vegan or vegetarian). In the overall sample, the majority of participants were partnered (68%), had a university degree (80%) and felt they had good health compared with their peers (76%). The mean DST score was 72.72 (*SD*=12.36), and the mean CESD-20 score was 19.22 (*SD*=13.23), which meets the cut-off criterion score of 16 for depressive symptoms.

Pearson's correlations on continuous variables and Spearman's correlations on categorical variables (table 2) show a significant relationship between diet quality scores, BMI and depressive symptoms, but no significant relationship for any other variables.

A multiple linear regression model was used to predict DST (continuous score) in CESD-20 (continuous score). Table 3 outlines the results of the multiple linear regression models. The model shows that at step one, diet quality significantly contributed to the regression model $F(1, 215)=13.71$, $p<0.001$ and accounted for 6% of the variation in depressive symptoms. At step two, adding BMI to the model added a further 3% variation in depressive symptoms. This change in R^2 was also significant $F(2, 215)=10.27$, $p<0.001$. Together diet quality and BMI accounted for 9% of the variance in depressive symptoms. After adjusting for BMI in the final model, as diet quality increased, depressive symptoms decreased by $\beta=-0.20$.

A multiple linear regression model was used to predict DST in CESD-20, splitting the overall population by clinical cut-off score of 16+ for depressive symptoms in the CESD-20. Table 4 outlines the results of the multiple linear regression models. The model shows that for those without depressive symptoms at step one, diet quality significantly contributed to the regression model $F(1, 125)=6.49$, $p=0.012$ and accounted for 5% of the variation in depressive symptoms. At step two, adding BMI to the model did not add a further variation in depressive symptoms $F(2, 125)=3.44$, $p=0.035$. After adjusting for BMI in the final model, as diet quality increased, depressive symptoms

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Table 1 Sociodemographic, health, and lifestyle characteristics per dietary pattern category

Dietary pattern	Vegetarian (n=54)	Vegan (n=165)	Full sample (n=219)	Test statistic
Gender (n, %)				χ^2=1.33
Female	51 (23.3)	152 (69.4)	203 (92.7)	
Male	3 (1.4)	9 (4.1)	12 (5.5)	
Transgender/non-binary	0 (0.0)	4 (1.9)	4 (1.9)	
Marital status (n, %)				χ^2=1.37
Partnered	33 (15.1)	115 (52.5)	148 (67.6)	
Unpartnered	21 (9.6)	50 (22.8)	71 (32.4)	
Highest educational level (n, %)				χ^2=3.10
High school	4 (1.8)	28 (12.8)	32 (14.6)	
University degree	46 (21.0)	128 (58.4)	174 (79.5)	
Trade certificate	4 (1.8)	9 (4.1)	13 (5.9)	
Health compared with peers (n, %)				F=7.90
Very good	12 (5.5)	70 (32.0)	82 (37.4)	
Good	25 (11.4)	60 (27.4)	85 (38.8)	
Fair	7 (3.2)	18 (8.2)	25 (11.4)	
Sometimes good sometimes poor	8 (3.7)	13 (5.9)	21 (9.6)	
Poor	2 (0.9)	4 (1.8)	6 (2.7)	
Age (years; M, SD)	33.39 (7.53)	30.52 (7.25)	31.22 (7.40)	F=6.28*
BMI (kg/m^2; M, SD)	26.76 (8.78)	24.51 (5.18)	25.06 (6.30)	F=5.20*
DST (M, SD)	72.72 (12.36)	77.69 (10.23)	76.47 (10.98)	F=8.63**
Physical activity (days per month; M, SD)	13.70 (8.90)	13.90 (9.94)	13.85 (9.67)	F=0.02
CESD-20 (M, SD)	19.22 (13.23)	15.31 (11.09)	16.27 (11.74)	F=4.59*

*P<0.05, **p<0.01.
BMI, body mass index; CESD, Centre for Epidemiological Science Depression Scale; DST, dietary screening tool; M, Mean.

decreased by β=−0.22. This analysis indicates that higher PBD quality may be protective against depressive symptoms.

In comparison, for those with depressive symptoms, the association with diet quality was not significant at step one F(1, 89)=0.01, p=0.963 or step two F(2, 89)=2.40, p=0.097. BMI was a significant contributor in the model, suggesting that those plant-based followers above the clinical cut-off score for depressive symptoms had higher BMI's and this covarying factor could play a role in diet quality.

DISCUSSION

This cross-sectional survey of adult vegans and vegetarians aged 18–44 years found that high PBD quality was

Table 2 Correlation matrix

	CESD-20	DST	BMI	Age	Gender	Physical activity	Marital status
DST	−0.25**						
BMI	0.22*	−0.25**					
Age	−0.13	0.07*	0.25**				
Gender	0.15	−0.11	0.09	0.11			
Physical activity	−0.14	0.29**	−0.15	−0.07	−0.08		
Marital status	0.07	−0.04	−0.01	−0.12	−0.02	0.03	
Education level	0.02	0.12	0.05	0.15*	0.01	−0.07	0.02

*P<0.05, **p<0.01.
BMI, body mass index; CESD-20, Centre for Epidemiological Studies Depression; DST, Dietary Screening Tool.

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Table 3 Coefficients of the model predicting DST in CESD-20

Variable	β	t	sr^2	R	R^2	Adj.R^2
Step 1						
DST	−0.25	−3.70**	−0.25	0.25	0.06	0.06
Step 2						
DST	−0.20	−3.00*	−0.20	0.30	0.09	0.08
BMI	0.17	2.54*	0.17			

*P<0.05, **p<0.01.
BMI, body mass index; CESD-20, Centre for Epidemiological Studies Depression; DST, Dietary Screening Tool.

associated with decreased risk of depressive symptoms. This study is the first to highlight an association between a self-report plant-based dietary quality measure and depression in Australian adult vegans and vegetarians.

As such, our findings are in line with broad data regarding the protective role of diet in mental health and brain function across young and older adulthood. Research indicates that plant foods are high in complex carbohydrates,[49] fibre, probiotics[50] and antioxidants such as polyphenols,[51] which have been found to decrease symptoms of depression.[52–54] However, despite the intake of a PBD in this study of Australian vegans and vegetarians, the overall mean depression score was above the clinical cut-off for depressive symptoms and, as such, indicates an overall sample experiencing depression.[39] Given that the targeted age range is also considered to be at high risk of depression in Australia,[2] the current finding may reflect a broad population trend.

An association between vegan and vegetarian diets and depression has been largely disparate. Systematic review findings have shown no association between vegan and vegetarian diets and mental health outcomes, including depression and anxiety.[28–30] Other empirical and systematic reviews have shown associations between vegetarian diets and depression in adults across the lifespan.[22 34] While other meta-analyses suggest that following a vegetarian diet is associated with a decreased risk of depression.[34] As such, in line with our findings that show an association between diet quality and non-clinical depressive symptoms. However, no association between diet quality and depression for those meeting the criterion for depressive symptoms. Overall dietary quality could be important for reducing risk. This is especially important considering vegan and vegetarian diets are typically high in plant foods with a range of health benefits for improved mood and mental health.[49–55] However, nutritional deficiencies are also common in these diets, such as lower intake of vitamins B_2, B_3, B_5 and B_{12}, zinc, iodine and long-chain fatty acids that could negatively impact mental health and brain function.[56 57]

There is a diverse body of research investigating the biological mechanism of effect that links dietary intake and mental health. While not yet fully characterised, there are a range of nutrients and foods within vegan and vegetarian diets that positively affect the pathophysiology of mood, including decreased chronic inflammation and oxidative stress,[58–60] and improvements in the gut microbiome brain axis.[61–63] For example, sources of fibre through greens, nuts, seeds, legumes and grains, which are prevalent features of vegan and vegetarian diets, are important for managing inflammation, glucose regulation, and promotion of gut microbiota changes.[64 65] Conversely, consumption of nutrients such as amino acids tryptophan and tyrosine, and omega-3 polyunsaturated fatty acids (PUFA's) which have protective effects for neurotransmitter regulation of serotonin and dopamine essential for mood, is highest in fish-eating vegetarians but is limited in vegan diets.[66 67]

The current study shows that following a PBD does not necessarily mean the individual consumes a 'healthy'

Table 4 Coefficients of the model predicting DST, split by clinical cut-off of CESD-20

Variable	β	t	sr^2	R	R^2	Adj.R^2
No depressive symptoms						
Step 1						
DST	−0.22	−2.55*	−0.22	0.22	0.05	0.04
Step 2						
DST	−0.22	−2.48*	−0.22	0.23	0.05	0.04
BMI	0.06	0.66	0.06			
Depressive symptoms						
Step 1						
DST	0.01	0.05	0.01	0.01	0.00	−0.01
Step 2						
DST	0.07	0.78	0.08	0.23	0.05	0.03
BMI	0.29	2.19*	0.23			

*P<0.05,.
BMI, body mass index; CESD-20, Centre for Epidemiological Studies Depression 20 Items; DST, Dietary Screening Tool.

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dietary pattern. This finding is an important extension of the literature that has predominately compared diet type instead of dietary quality. As with other dietary patterns such as low-quality meat-based diets, low-quality Mediterranean dietary patterns and low-quality Ketogenic dietary patterns, this study highlights that there are also low-quality PBD. Low-quality PBDs include plant-based products that are high in ultra-processed ingredients, refined vegetable oils, fried food, salt, refined grains, alcohol, sugary snacks and drinks.[29 68] The consumer distinction between low and high-quality plant-based foods is important given that based on 2020 data, the expanding value of packaged vegan food in Australia is projected to reach approximately $A215 million.[69] Consequently, individuals may inadvertently be consuming a diet high in processed plant foods consistent with a low diet quality, which is broadly a known risk factor for increased depression.[18 70 71]

Strengths and limitations

This is the first known study to test the association between a PBD quality measure and depressive mood within adults aged 18–44. The adaptation of the DST might encourage researchers to conduct further studies on plant-based dietary quality in populations at risk of depression and promote its further use in empirical and intervention studies.

Some limitations are worthy of noting. First, the study had a cross-sectional design, and therefore causation cannot be implied. The sample data were also collected during the COVID-19 pandemic, where health behaviours such as increased social concern, limited exercise, increased intake of processed foods and increased alcohol consumption are likely to have negatively influenced mood.[72] Consequently, the current study offers an interesting insight into a time period and age group that is highly ecologically reflective of the times. The data were collected via self-report questionnaires, and therefore potential social desirability or recall bias might exist that relates to adherence to the diet. One aspect of cross-sectional studies is that they cannot determine if a plant-based vegan/vegetarian diet influences mental health outcomes or if, perhaps, choice and motivation to adhere to a dietary type reflect mental health status. For example, Michalak *et al*[27] showed that adoption of a vegetarian diet followed the onset of mental disorders, and by examining the motives for dietary adherence, the authors hypothesised that a mental disorder increases the likelihood of choosing a vegetarian diet to positively influence the course of the condition.[26] Similarly, food choice motives and eating behaviours of those who follow PBD may also influence mental health. For example, vegans and vegetarians are likely to have concerns regarding animal welfare, environmental sustainability, climate change and carbon footprints,[73 74] which carries a burden of awareness that contributes to depressive symptoms.

Finally, in this sample, 93% of the respondents were female; therefore, it may limit the generalisability of interpretation. However, this is unlikely as research shows that vegetarianism and veganism are more popular with women than men in Western countries[75] and females play a predominant role in guiding eating behaviours and food choices, motivated by weight control and 'healthy eating' than men.[76]

The research field would benefit from longitudinal studies exploring the length of time on a particular diet and adherence level to determine whether the time and level of adherence impact the quality of association with depression. Well powered intervention studies with broad community samples are needed to determine associations between vegan/vegetarian dietary quality and depression. Further research into attitudes and motivations to adhere to a PBD can also support informed practices for healthcare professionals and the community at large to consider when following a plant-based dietary type.

In conclusion, the specific quality of vegan and vegetarian diets has not been explicitly explored in studies of diet and depression. As such, there is limited research available on the association between vegan and vegetarian diets and depression, and the small amount of available data is inconsistent and conflicting,[21 22 25–27 34 77 78] with divergent measures of vegan and vegetarian diets including scoring for meat and dairy-based food products.[25–27] This study adapted the DST using a validated PBD index for a vegan and vegetarian population. From this adaptation, our findings align with the direction of evidence for an association between high quality vegan and vegetarian diets and decreased depressive symptoms.

Twitter Megan Frances Lee @MeganLeePhD and Talitha Best @besttalitha, nh_lab

Contributors All authors contributed to the study conception, design and data collection. Data analyses were performed by MFL and TB. The first draft of the manuscript was written by MFL and TB and all authors reviewed and refined drafts of the manuscript. All authors read and approved the final manuscript. TB is the guarantor.

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ORCID iDs
Megan Frances Lee http://orcid.org/0000-0001-7531-5312
Talitha Best http://orcid.org/0000-0001-8849-1411

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