Journal of Affective Disorders 320 (2023) 48–56

Contents lists available at ScienceDirect

Journal of Affective Disorders

journal homepage: www.elsevier.com/locate/jad

Association between meatless diet and depressive episodes: A cross-sectional analysis of baseline data from the longitudinal study of adult health (ELSA-Brasil)

Ingrid S. Kohl [a,b], Vivian C. Luft [b,c,d,*], Ana Luísa Patrão [e,f], Maria del Carmen B. Molina [g,h], Maria Angélica A. Nunes [c], Maria I. Schmidt [c]

[a] Postgraduate Program in Collective Health, Universidade do Vale do Rio dos Sinos, Brazil
[b] Postgraduate Program in Food, Nutrition and Health, Universidade Federal do Rio Grande do Sul, Brazil
[c] Postgraduate Program in Epidemiology, Universidade Federal do Rio Grande do Sul, Brazil
[d] Center for Food and Nutrition Studies (CESAN), Hospital de Clínicas de Porto Alegre, Universidade Federal do Rio Grande do Sul, Brazil
[e] Center for Psychology, Faculty of Psychology and Education Science, University of Porto, Porto, Portugal
[f] Institute of Collective Health, Federal University of Bahia, Salvador, Brazil
[g] Federal University of Ouro Preto, Minas Gerais, Brazil
[h] Federal University of Espírito Santo, Brazil

ARTICLE INFO

Keywords:
Vegetarian diet
Depression
Mental health
Meat

ABSTRACT

Background: The association between vegetarianism and depression is still unclear. We aimed to investigate the association between a meatless diet and the presence of depressive episodes among adults.
Methods: A cross-sectional analysis was performed with baseline data from the ELSA-Brasil cohort, which included 14,216 Brazilians aged 35 to 74 years. A meatless diet was defined from in a validated food frequency questionnaire. The Clinical Interview Schedule-Revised (CIS-R) instrument was used to assess depressive episodes. The association between meatless diet and presence of depressive episodes was expressed as a prevalence ratio (PR), determined by Poisson regression adjusted for potentially confounding and/or mediating variables: sociodemographic parameters, smoking, alcohol intake, physical activity, several clinical variables, self-assessed health status, body mass index, micronutrient intake, protein, food processing level, daily energy intake, and changes in diet in the preceding 6 months.
Results: We found a positive association between the prevalence of depressive episodes and a meatless diet. Meat non-consumers experienced approximately twice the frequency of depressive episodes of meat consumers, PRs ranging from 2.05 (95%CI 1.00–4.18) in the crude model to 2.37 (95%CI 1.24–4.51) in the fully adjusted model. Limitations.
The cross-sectional design precluded the investigation of causal relationships.
Conclusions: Depressive episodes are more prevalent in individuals who do not eat meat, independently of socioeconomic and lifestyle factors. Nutrient deficiencies do not explain this association. The nature of the association remains unclear, and longitudinal data are needed to clarify causal relationship.

1. Introduction

According to the World Health Organization, depression is a common mental disorder and one of the leading causes of disability worldwide. In its most severe forms, depression can lead to suicide (WHO, 2017). In addition, it is one of the main contributors to the global burden of disease and is associated with a worse prognosis in chronic diseases (Bucciarelli et al., 2020; Li et al., 2018; Wang et al., 2017). The prevalence of depression is estimated at approximately 4.5 % of the world population. In Brazil, the estimated prevalence exceeds the world estimate, reaching almost 6 % of Brazilians—around 11.5 million people (WHO, 2017). The Global Burden of Disease (GBD) study showed that

* Corresponding author at: Universidade Federal do Rio Grande do Sul, Programa de Pós Graduação em Epidemiologia, Av. Ramiro Barcelos, 2600, Sala 419, Santa Cecília, 90035-003 Porto Alegre, RS, Brazil.
E-mail address: vcluft@hcpa.edu.br (V.C. Luft).

https://doi.org/10.1016/j.jad.2022.09.059
Received 12 April 2022; Received in revised form 3 June 2022; Accepted 20 September 2022
Available online 23 September 2022

the number of incident cases of depression worldwide rose from 172 million in 1990 to 258 million in 2017, representing a 50 % increase (Liu et al., 2020).

The reasons that lead to the development of depression are not fully understood. Complex interactions between social, psychological, and biological aspects seem to facilitate the onset of this multifactorial condition. Studies show that lifestyle is related to the development of depressive disorder, with food being a possible contributor (Barros et al., 2017; Wang et al., 2019; Secretti et al., 2019).

Vegetarian diets have been associated with several health benefits, but little is known about their advantages or disadvantages in terms of mental health. Data from the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil) on the consumption of red meat and processed meat, insulin resistance, and diabetes have suggested an adverse association between high meat intake and participants' health (Aprelini et al., 2019).

Worldwide, the prevalence of vegetarianism varies widely, from 40 % in India (the country with the largest vegetarian population) to only 1 % in Portugal (Ruby, 2012). The true prevalence of vegetarianism in Brazil is unknown. The only available estimate is from a 2018 survey carried out by IBOPE, the Institute of Public Opinion and Statistics, which asked respondents the extent to which they agreed or disagreed with being considered vegetarian. In this survey, 14 % of the studied population declared themselves vegetarian. This estimate represents 75 % growth compared to 2012, when the same survey indicated that the proportion of Brazilians in metropolitan regions who self-identified as vegetarian was 8 % (IBOPE, 2018).

The association between vegetarianism and depression is still unclear. A large-scale multinational cross-sectional study reported that vegetarianism diet is not reliably related to mental health in adult Americans, Russians, and Germans, but is related to slight increases in anxiety and depression in university Chinese students (Lavallee et al., 2019). In another study, men who declared themselves to be vegetarians had higher depression scores on average than non-vegetarians (Hibbeln et al., 2018). Although vegetarians and semi-vegetarians seemed to be more open to new experiences, they were more neurotic and depressed than omnivores (Forestell and Nezlek, 2018). On the other hand, some authors found a lower frequency of depression in vegetarians (Lee et al., 2021; SHEN et al., 2021).

A systematic review that investigated the relationship between abstaining from meat and mental health (depression, anxiety, self-harm, perception of mood/stress, and affective well-being) reported controversial results, with 11 of the 18 included studies indicating worse mental health among meat non-eaters (Dobersek et al., 2021). In another systematic review with meta-analysis, only 2 out of included 11 studies categorically assessed depression, with a higher risk of depression being estimated among vegetarians (OR = 2.14, 95%CI 1.10–4.15), although no significant differences were found in depression scores in the other studies (Iguacel et al., 2020).

Significant higher depression scores among vegetarians than non-vegetarians have been described (Ocklenburg and Borawski, 2021), but controversial results are also shown in a more recent meta-analysis (ASKARI et al., 2022). In general, authors emphasize the high heterogeneity among the included studies, as previously reported by Timko et al. (2012). Inconsistencies may be related to small samples of vegetarians, lack of appropriate operational definitions of "vegetarianism", and uncertainty about the appropriateness of existing assessments of eating behaviors for semi-vegetarians (Timko et al., 2012).

Of note, none of these studies were carried out in Latin America, and both diet and mental health are influenced by setting and context. In this sense, ELSA-Brasil can contribute to widen the scope of the available information, considering specific characteristics of the Brazilian sample, which may act as confounders and mediators in the association between vegetarianism and depression.

The present study aimed to investigate whether a meatless diet is associated with a higher prevalence of having depressive episodes in adult men and women participating in the ELSA-Brasil survey. The hypothesis is that individuals who do not eat meat may present a higher frequency of depressive episodes and that nutrient deficiency may contribute to this association.

2. Methods

2.1. Study design and population

This is a cross-sectional analysis of baseline data from the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil). The ELSA-Brasil is a multicenter cohort that mainly aims to address the risk factors and progression of diabetes, cardiovascular disease, and other related chronic noncommunicable diseases (Aquino et al., 2012; Bensenor et al., 2013).

Between August 2008 and December 2010, 15,105 active and retired employees of public institutions of higher education and research located in six state capitals (Salvador, Belo Horizonte, Rio de Janeiro, São Paulo, Vitória, and Porto Alegre), aged 35 to 74 years, were included in the study. All local research ethics committees approved the study protocol, and written consent was obtained from all participants (Aquino et al., 2013; Schmidt et al., 2015).

Of the 15,105 participants, we excluded those with incomplete data in the Clinical Interview Schedule-Revised (CIS-R) questionnaire (n = 10), no food frequency data (n = 27), implausible reported food intake (<600 or >6000 kcal/day) (n = 212), a history of bariatric surgery (n = 108), or missing data on the history of chronic diseases (n = 36), other socioeconomic and lifestyle covariates (skin color, income, smoking, body mass index, alcohol use, physical activity) (n = 434), blood count (n = 50), supplement use (n = 9), and self-assessment of health and health insurance (n = 3 each). The flow diagram of participant exclusions is shown in Fig. 1. The final sample was composed of 14,216 participants.

2.2. Measurements

Standardized interviews, collection of biological specimens, and measurements of anthropometric parameters were carried out at the study centers (Bensenor et al., 2013). Participants were asked about sociodemographic characteristics (age, sex, self-reported skin color/race, educational level, household income), previous medical history, smoking (current or previous), alcohol intake (frequency and quantity), self-assessment of health status, and whether they had health insurance. Per capita household income was self-reported, calculated as the total monthly household income divided by the number of household members, and expressed as a function of the minimum wage. Participants also reported on leisure-time physical activity via the International Physical Activity Questionnaire (IPAQ) and were classified accordingly as engaging in no physical activity, low activity levels, moderate activity levels, or high activity levels, as well as in estimated metabolic equivalents (METs).

Anthropometric data were obtained following internationally standardized protocols (Lohman et al., 1988). Participants were fasted, on an empty bladder, barefoot, wearing standardized clothes, no eyeglasses or other personal objects, and their body weight was measured on an electronic scale (Toledo, São Bernardo do Campo, Brazil). The body mass index (BMI) was calculated as the participant's weight in kilograms divided by their height in meters squared (kg/m^2), and categorized as underweight (<18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), or obesity (≥30 kg/m^2). Waist circumference (WC) was measured with a 150-cm inelastic measuring tape (MABIS® Gulick tape, Mabis/Briggs Healthcare, Clive, IA, USA) at the midpoint between the lower edge of the last rib and the iliac crest at the mid-axillary line. A WC of ≥102 cm for men or ≥88 cm for women was considered indicative of central obesity.

Participants were instructed to attend the study centers after a 12-h

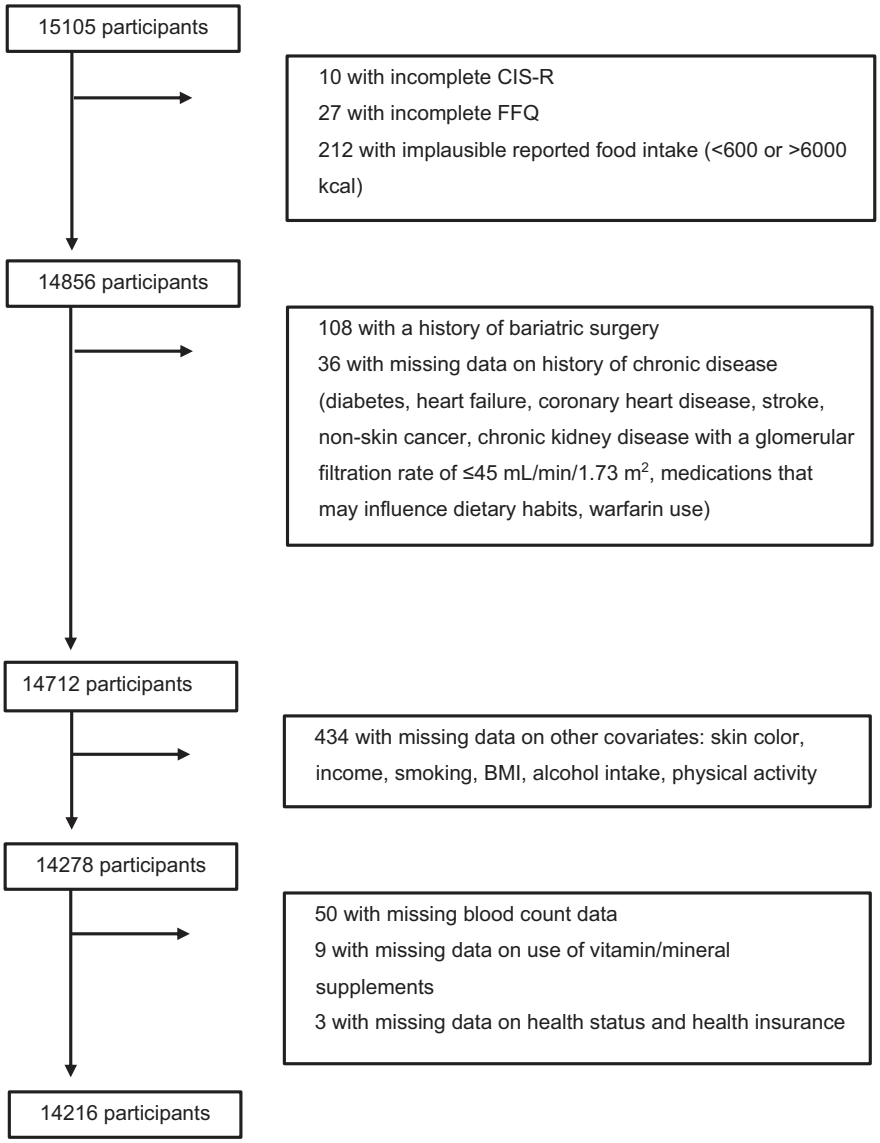

Fig. 1. Flow diagram of participant exclusions from the study. ELSA-Brasil (2008–2010).

fast (minimum 10, maximum 14 h) for blood collection. Blood counts were measured locally at the study centers. In the present study, blood counts were considered abnormal when hemoglobin levels were <13 g/dL for men or <11.5 g/dL for women, the red cell count was <4.5 × 10^{12}/L for men or <4 × 10^{12}/L for women, or the hematocrit was <40 % men or <35.5 % for women (Rosenfeld, 2019).

2.3. Assessment of dietary intake

Food consumption was assessed using the 114-item Food Frequency Questionnaire (FFQ), validated by Molina et al. (2013). Participants were asked about their intake of the foods listed in the questionnaire over the preceding 12 months, scored on a Likert-type scale with eight frequency options ranging from "more than three times a day" to "never/rarely ever", as well as the number of servings consumed, using standardized serving sizes (Molina et al., 2013).

To estimate the nutritional composition in 100 g of each food item in the questionnaire, the *Nutrition Data System for Research* (NDSR, University of Minnesota) software program was used. Daily intake of each item was quantified in g/day, and nutrient intake was calculated as the number of servings consumed at a time × serving size × frequency of intake × nutritional composition (Molina et al., 2013). These calculations were done in SAS version 9.4.

The NOVA classification was applied to categorize foods according to the nature, extent, and purpose of their processing. All foods were grouped into one of three categories: (1) unprocessed or minimally processed foods and culinary ingredients; (2) processed foods; and (3) ultra-processed foods. The relative contribution of each group was then calculated (sum of the energy in kcal imparted by the food items included) in relation to the total daily energy intake (Monteiro, 2016).

Participants were also asked about the use of vitamin and/or mineral supplements in the preceding 12 months, and whether there had been any change in their dietary habits in the preceding 6 months.

Individuals were considered to have a meatless diet if they reported a "never/rarely ever" frequency of intake of the following food items in the preceding 12 months: red meat (beef, on or off the bone), chicken (chicken breast, fried chicken, cooked chicken) pork, offal (liver/offal or tripe), sausages (sausage, hamburger meat or patties, ham, bacon), and seafood (cooked or fried fish, sardines/tuna, shrimp/shellfish, crab, seafood stew/chowder).

2.4. Assessment of depressive episodes

The presence of depressive episodes was assessed using the Clinical

Interview Schedule-Revised (CIS-R) questionnaire, applied by lay interviewers who had been previously trained by a psychiatrist with experience in epidemiological studies. This instrument was developed by Lewis et al. (1992), and has been cross-culturally adapted for Brazil and translated into Brazilian Portuguese (Nunes et al., 2011).

The CIS-R is a symptom-based, fully structured interview designed to assess common mental disorders and provide diagnostic screening of non-psychotic mental disorders in the community or in the primary health care setting. The questionnaire contains sections referring to somatic symptoms, fatigue, concentration and forgetfulness, sleep problems, irritability, worry about physical health, depression, depressive ideas, worry, anxiety, phobias, panic, compulsions, and obsessions. If symptoms are present, their frequency, intensity, persistence, and the degree of discomfort caused are assessed through these sections (Moreno et al., 2019). Total score ≥ 12 is used as a diagnosis for common mental disorder.

Lewis et al. (1992) proposed a data consolidation algorithm that uses the ICD-10 diagnostic criteria to identify and classify the presence of a depressive episode. In addition to a depressive episode, six other diagnostic categories can be obtained from this algorithm: (1) generalized anxiety disorder, (2) mixed anxiety and depressive disorder, (3) phobias, (4) obsessive-compulsive disorder, (5) panic disorder, and (6) common mental disorder, when the score is ≥12 points. (Moreno et al., 2019). Five types of depressive episodes are evaluated: mild depressive episode, with and without somatic symptoms; moderate depressive episode, with and without somatic symptoms; and severe depressive episode without psychotic symptoms (Moreno et al., 2019). Individuals who had any of the aforementioned types of depressive episodes in the 7 days preceding the interview were considered as having a depressive episode.

2.5. Statistical analysis

Statistical analyses were conducted in IBM SPSS Version 22. Significance was accepted at $p < 0.05$. Results are described as mean and standard deviation or median and interquartile range as appropriate for continuous numeric variables, or as absolute and relative (percent) frequency for categorical variables; Student's *t*-test, the Mann–Whitney *U* test, or the chi-square test were used for comparisons, according to data distribution.

The association between meatless diet and presence of depressive episodes (dependent variable) was expressed as a prevalence ratio (PR) with 95 % confidence interval (CI), calculated by Poisson regression with robust variance, progressively adjusting for (1) sociodemographic characteristics: age, sex, skin color, education, income, health insurance; (2) lifestyle: smoking, alcohol intake, physical activity; (3) clinical variables: presence of chronic disease, abnormal blood count, supplement use; (4) self-rated health status; (5) BMI; (6) micronutrient intake, protein intake, level of food processing, and energy intake; and (7) switch to vegetarian diet/reduced meat intake during the preceding 6 months.

3. Results

Of the 14,216 participants, 54.7 % were women, 52.6 % declared themselves white, and 53.2 % had an undergraduate or higher education. Mean age was 52.1 ± 9.1 years, median per capita income was 3.0 (IQR: 1.6–4.9) times the minimum wage, and 4.2 % of participants had some type of depressive episode.

The sociodemographic and clinical characteristics of the participants according to their meat intake status are presented in Table 1. Overall, 82 participants (0.57 %) did not consume meat. We found differences ($p < 0.05$) between these groups, with meat abstainers being more likely to declare themselves white, having a higher education, and a higher per capita income. Regarding lifestyle, when compared to meat eaters, most meat abstainers had never smoked (74.4 % vs. 57 %), did not consume alcohol regularly (70.7 % vs. 51.8 %), and had a higher median physical

Table 1
Sociodemographic and clinical profile of the participants according to their meat intake status. Brazilian Longitudinal Study of Adult Health (ELSA-Brasil) (n = 14,216).

	Total	Do not consume meat	Consume meat	*p*-value
	n = 14,216	n = 82	n = 14,134	
Depressive episodes	595 (4.2)	7 (8.5)	588 (4.2)	0.085[B]
Age (years)	52.1 ± 9.1	50.8 ± 9.6	52.1 ± 9.1	0.190[C]
Sex				0.353[A]
Male	6445 (45.3)	33 (40.2)	6412 (45.4)	
Female	7771 (54.7)	49 (59.8)	7722 (54.6)	
Skin color				0.023[A]
Black	2264 (15.9)	2 (2.4)	2262 (16)	
Brown	3976 (28.0)	28 (34.1)	3948 (27.9)	
White	7473 (52.6)	49 (59.8)	7424 (52.5)	
Yellow	353 (2.5)	2 (2.4)	351 (2.5)	
Native Brazilian	150 (1.1)	1 (1.2)	149 (1.1)	
Marital status				0.845[A]
Married/ cohabitating	9401 (66.1)	53 (64.6)	9348 (66.1)	
Separated/divorced/ single	2304 (16.2)	11 (13.4)	2293 (16.2)	
	1450 (10.2)	11 (13.4)	1439 (10.2)	
Widowed	593 (4.2)	4 (4.9)	589 (4.2)	
Other (previously married)	468 (3.3)	3 (3.7)	465 (3.3)	
Educational attainment				<0.001[A]
Some primary	824 (5.8)	2 (2.4)	822 (5.8)	
Primary	957 (6.7)	0 (0.0)	957 (6.8)	
Secondary	4870 (34.3)	18 (22.0)	4852 (34.3)	
Higher	7565 (53.2)	62 (75.6)	7503 (53.1)	
Per capita income (× minimum wage[E])	3.0 (1.6–4.9)	3.8 (2.2–5.9)	3.0 (1.6–4.9)	0.001[D].
Has health insurance	9785 (68.8)	62 (75.6)	9723 (68.8)	0.184[A]
Smoking				0.003[A]
Never smoked	8122 (57.1)	61 (74.3)	8061 (57.0)	
Former smoker	4272 (30.1)	18 (22.0)	4254 (30.1)	
Smoker	1822 (12.8)	3 (3.7)	1819 (12.9)	
Alcohol intake				0.001[A]
No	7383 (51.9)	58 (70.7)	7325 (51.8)	
Yes	6833 (48.1)	24 (29.3)	6809 (48.2)	
Leisure-time physical activity (MET)	240 (0; 960)	594 (0; 1137)	240 (0; 960)	0.020[D].
Chronic disease	2187 (15.4)	6 (7.3)	2181 (15.4)	0.042[A]
Abnormal blood count	1440 (10.1)	8 (9.8)	1432 (10.1)	0.911[A]
Vitamin/mineral supplements (12 m)	3168 (22.3)	34 (41.5)	3134 (22.2)	<0.001[A]
Health status				0.035[A]
Excellent	3998 (28.1)	36 (43.9)	3962 (28.0)	
Good	7429 (52.3)	34 (41.5)	7395 (52.3)	
Fair	2518 (17.7)	11 (13.4)	2507 (17.7)	
Poor	220 (1.5)	1 (1.2)	219 (1.5)	
Very poor	51 (0.4)	0 (0)	51 (0.4)	
BMI				<0.001[A]
Underweight	133 (0.9)	1 (1.2)	132 (0.9)	

(continued on next page)

Table 1 (*continued*)

	Total	Do not consume meat	Consume meat	*p*-value
	n = 14,216	n = 82	n = 14,134	
Normal weight	5130 (36.1)	47 (57.3)	5083 (36)	
Overweight	5742 (40.4)	25 (30.5)	5717 (40.4)	
Obesity	3211 (22.6)	9 (11)	3202 (22.7)	
BMI	27.0 ± 4.7	25.2 ± 4.2	27.0 ± 4.7	0.001[C]
Central obesity	5086 (35.8)	19 (23.2)	5067 (35.8)	0.017[A]
Waist circumference	91.2 ± 12.7	85.6 ± 11.6	91.2 ± 12.7	<0.001[C]

Data expressed as mean ± standard deviation, median (interquartile range), or n (%).
MET: metabolic equivalents per minute per week. Chronic disease: diabetes, heart failure, stroke, cancer (except skin), myocardial infarction, kidney disease; abnormal blood count: hemoglobin <14 g/dL (men) or <12 g/dL (women), red cells $<4.5 \times 10^{12}$/L (men) or $<4 \times 10^{12}$/L (women), hematocrit <42 % (men) or <36 % (women); BMI: body mass index; central obesity: waist circumference > 102 cm (men) or >88 cm (women).
[A] Pearson's chi-square test.
[B] Fisher's exact test.
[C] *t*-test.
[D] Mann–Whitney *U* test.
[E] Minimum wage as of 2009 = R$465.00.

activity in MET minutes (594 vs. 240). Meat abstainers also had a lower prevalence of overall obesity (11.0 % vs. 22.7 %) and central obesity (23.2 % vs. 35.8 %) and a lower prevalence of chronic diseases (7.3 % vs. 15.4 %), were more likely to take vitamin and mineral supplements (41.5 % vs. 22.2 %), and more often reported having an excellent health status (43.9 % vs. 28 %).

Table 2 describes food intake patterns among meat consumers and abstainers. Participants who consumed a meatless diet exhibited lower daily intake of energy, proteins, lipids, omega-3 fatty acids, vitamins B6, B12, and D, iron, and zinc. Meat abstainers also had a lower intake of unprocessed or minimally processed foods as a percentage of daily energy intake when compared to meat consumers (median: 59.0, IQR: 49.7–66.7, vs. median: 64.5, IQR: 56.4–72.1), and a higher intake of ultra-processed foods (median: 26.45, IQR: 20.8–35.8, vs. median: 23.6, IQR: 17.5–30.6).

Of the 82 individuals who excluded meat from their diet, 7 reported switching to a vegetarian/low-meat diet in the previous 6 months, and 2 of them had a depressive episode. Among meat-eaters, 210 also reported switching to a vegetarian/low-meat diet, and 13 of them had a depressive episode.

Table 3 describes the frequency of symptoms according to the CIS-R results. Participants who consumed a meatless diet exhibited a higher prevalence of difficulty concentrating and forgetfulness when compared to the group that consumed meat (24,4 % vs. 15,5 %). Regarding depressive episodes, it was possible to observe that meat non-consumers had a higher frequency of mild depressive episodes without somatic symptoms when compared to the other group (6,1 % vs. 1,8 %).

The association between meatless diet and the presence of a depressive episode in the previous 7 days, evaluated with progressive models adjusted for possible confounding/mediating factors, is shown in Table 4. Positive associations between the prevalence of depressive episodes and a meatless diet were found in all models ($p < 0.05$). Those not consuming meat experienced approximately twice as many depressive episodes as those consuming, with a PR ranging from 2.05 (95%CI 1.00–4.18) in the crude model to 2.37 (95%CI 1.24–4.51) in the widely adjusted model.

The variables female gender (PR = 2.56, 95%CI 2.08–3.14), age (PR = 0.98, 95%CI 0.97–0.99 for each 1-year increase in age), income (PR = 0.93, 95%CI 0.89–0.97 for each 1 increase in minimum wage), physical

Table 2
Dietary habits of the participants according to their meat intake status. Brazilian Longitudinal Study of Adult Health (ELSA-Brasil) (n = 14,219).

	Total	Do not consume meat	Consume meat	p-value
	n = 14,216	n = 82	n = 14,134	
Total energy intake (kcal/day)	2613.3 ± 934.3	2069.0 ± 812.6	2616.4 ± 934.1	<0.001[A]
Unprocessed/minimally processed foods (g)	1737.9 (1352.9–2230.4)	1564.1 (1322.1–2249.3)	1739.3 (1353.2–2230.3)	0.169[B]
Unprocessed/minimally processed foods (kcal/day)	1554.3 (1192.9–2018.9)	1098.2 (869.6; −1539.8)	1557.3 (1196.5–2021.4)	<0.001[B]
Unprocessed/minimally processed foods (% TEI)	64.49 (56.42–72.13)	59.04 (49.72–66.74)	64.52 (56.45–72.15)	<0.001[B]
Processed foods (g)	122.7 (66.2–225.7)	88.8 (47.3–161.2)	122.9 (66.4–226.4)	0.001[B]
Processed foods (kcal/day)	256.9 (147.9–406.5)	247.4 (110.4–406.9)	256.9 (147.9–406.4)	0.246[B]
Processed foods (% TEI)	10.46 (5.57–15.39)	11.87 (6.61–17.61)	10.45 (6.57–15.36)	0.096
Ultra-processed foods (g)	364.8 (226.4–564.1)	298.5 (171.2–460.4)	365.2 (226.6–565.0)	0.009[B]
Ultra-processed foods (kcal/day)	571.7 (386.9–816.1)	525.6 (339.4–761.8)	572.0 (387.3–816.2)	0.172[B]
Ultra-processed foods (% TEI)	23.63 (17.52–30.61)	26.45 (20.88–35.88)	23.60 (17.51–30.60)	0.002[B]
Carbohydrates (g)	303.8 (236.5–393.4)	306.9 (232.8–397.8)	303.8 (236.6–393.4)	0.823[B]
Protein (g)	118.6 (92.0–154.5)	65.9 (48.9–89.1)	119.0 (92.2–154.7)	<0.001[B]
Fat (g)	80.2 (60.8–105.6)	54.9 (37.6–78.8)	80.3 (61.0–105.8)	<0.001[B]
Saturated fat (g/day)	27.4 (20.1–36.8)	21.8 (12.4–29.4)	27.4 (20.1–36.8)	<0.001[B]
Trans fat (g/day)	2.64 (1.88–3.64)	1.81 (1.23–2.83)	2.65 (1.88–3.65)	<0.001[B]
Omega-3 fatty acids (g/day)	3.14 (2.30–4.30)	1.71 (1.30–2.35)	3.15 (2.31–4.31)	<0.001[B]
Total fiber (g/day)	28.6 (21.4–38.2)	36.0 (26.4–46.1)	28.6 (21.4–38.1)	<0.001[B]
Vitamin B6 (mg/day)	2.77 (2.14–3.61)	1.63 (1.26–2.18)	2.77 (2.14–3.61)	<0.001[B]
Vitamin B12 (mcg/day)	6.22 (4.37–8.9)	2.37 (1.21–3.68)	6.24 (4.40–8.92)	<0.001[B]
Vitamin D (mcg/day)	13.26 (8.19–21.08)	2.65 (0.68–4.48)	13.32 (8.29–21.14)	<0.001[B]
Magnesium (mg/day)	401.1 (314.7–513.7)	419.4 (322.1–542.5)	401.0 (314.6–513.5)	0.565[B]
Iron (mg/day)	16.0 (12.51–20.63)	13.23 (10.43–18.33)	16.03 (12.52–20.65)	<0.001[B]
Zinc (mg/day)	14.54 (11.24–19.07)	10.34 (7.03–14.82)	14.56 (11.26–19.09)	<0.001[B]
Changed habits/diet in the last 6 months	4372 (30.8)	22 (26.8)	4350 (30.8)	0.438[C]
Vegetarian diet/reduced meat intake	217 (1.5)	7 (8.5)	210 (1.5)	<0.001[C]

Data expressed as mean ± standard deviation, median (interquartile range), or n (%).
TEI, total energy intake.
[A] *t*-test.
[B] Mann–Whitney *U* test.
[C] Pearson's chi-square test.

Table 3
Frequency of symptoms of the CIS-R results (n = 14,219).

	Total	Do not consume meat	Consume meat	p-value
	n = 14,216	n = 82	n = 14,134	
Overall score in the CIS-R	8.15 (2–12)	8.73 (1–14)	8.14 (2–12)	0.968[A]
Depressive episode				
Mild with somatic symptoms	111 (0.8)	1 (1.2)	110 (0.8)	0.651
Mild without somatic symptoms	265 (1.9)	5 (6.1)	260 (1.8)	0.004
Moderate with somatic symptoms	29 (0.2)	0 (0.0)	29 (0.2)	0.681
Moderate without somatic symptoms	101 (0.7)	0 (0.0)	101 (0.7)	0.442
Severe	89 (0.6)	1 (1.2)	88 (0.6)	0.494
Symptoms				
Somatic symptoms	1471 (10.3)	12 (14.6)	1459 (10.3)	0.201
Fatigue	4799 (33.8)	31 (37.8)	4768 (33.7)	0.438
Concentration and forgetfulness	2213 (15.6)	20 (24.4)	2193 (15.5)	0.027
Sleep problems	4754 (33.4)	25 (30.5)	4729 (33.5)	0.569
Irritability	3348 (23.6)	13 (16.0)	3335 (23.6)	0.110
Worry about physical health	1922 (13.5)	10 (12.2)	1912 (13.5)	0.725
Depression	1855 (13.1)	14 (17.1)	1841 (13.0)	0.278
Depressive ideas	1682 (11.8)	13 (15.9)	1669 (11.8)	0.260
Worry	5814 (40.9)	37 (45.1)	5777 (40.9)	0.439
Anxiety	3516 (25.0)	25 (30.9)	3491 (24.9)	0.219
Phobias	1069 (7.5)	9 (11.0)	1060 (7.5)	0.238
Panic	481 (3.4)	5 (6.1)	476 (3.4)	0.179
Compulsions	1367 (9.6)	5 (6.1)	1362 (9.6)	0.278
Obsessions	1897 (13.4)	8 (9.8)	1889 (13.4)	0.337

Data expressed as median (interquartile range), or n (%). Pearson's chi-square test.
[A] Mann–Whitney *U* test.

activity (PR = 0.95, 95%CI 0.91–0.98, for each additional 250 METs), smoking (PR = 1.80, 95%CI 1.46–2.23, for smokers vs. never smokers; PR = 1.31, 95%CI 1.09–1.57, for former smokers vs. never smokers), self-rated health (PR = 3.85, 95%CI 2.93–5.05, for fair/very poor vs. excellent health; PR = 1.56, 95%CI 1.21–2.03, for good vs. excellent health) and the presence of chronic diseases (PR = 1.26, 95%CI 1.03–1.54) were also statistically associated with the presence of a depressive episode.

4. Discussion

In this study, participants who excluded meat from their diet had a higher prevalence of depressive episodes as compared to participants who consumed meat. Those who abstained from meat intake presented some characteristics which were associated with a lower frequency of depression, such as higher income, lower prevalence of smoking and chronic illness, higher level of physical activity, better self-rated health, and lower rates of obesity. Thus, after adjusting for these covariates, the increased prevalence of depressive episodes was estimated to be 165 % higher in non-meat consumers compared to consumers. Considering that the composition of a more restrictive diet can be unfavorable in terms of depression, when analyses were further adjusted for intake of micronutrients, proteins, energy, and level of food processing, we again found a higher prevalence (149 %), still only partially explaining the association between meatless diet and depressive episodes. Seeking to limit the possibility of reverse causality, when the model was additionally adjusted for changes in diet in the last 6 months, a 137 % higher prevalence in meat abstainers was still observed.

Table 4
Association between meatless diet and the presence of depressive episodes in the previous 7 days, adjusted for possible confounders/mediators. Brazilian Longitudinal Study of Adult Health (ELSA-Brasil) (n = 14,216).

Models	Covariates	PR (95%CI)
Crude	–	2.05 (1.00; 4.18)
Model 1	Age, sex, white color, education, income, health insurance	2.32 (1.16; 4.66)
Model 2	+ Smoking, alcohol, physical activity	2.46 (1.23; 4.94)
Model 3	+ Chronic diseases, abnormal blood count, supplement use.	2.52 (1.26; 5.04)
Model 4	+ Self-rated health status	2.61 (1.37; 4.95)
Model 5	+ body mass index	2.65 (1.40; 5.01)
Model 6	+ Micronutrient intake[a]	2.49 (1.30; 4.75)
Model 7	+ Switched to vegetarian diet/reduced meat intake in preceding 6 months.	2.37 (1.24; 4.51)

PR, prevalence ratio.
[a] Vitamin D, B6, B12, magnesium, iron, zinc, omega 3, unprocessed/minimally processed foods as % total energy intake, ultra-processed foods as % total energy intake, protein intake (g/day), and daily calories.

The higher prevalence of depressive episodes observed in meat non-consumers is consistent with most previous studies (Dobersek et al., 2021).

In Brazil, few studies provide data on the prevalence of vegetarians. However, the percentage of participants who did not consume meat was very low compared to the prevalence found in a survey (IBOPE, 2018) conducted in 2018 (14 %) and in the article by Barros, Bierhals and Assunção (2020) (5.4 %). Possible explanations for the low prevalence rely on three aspects: 1) data were collected when vegetarianism was less common, 2) this population was less susceptible to fad diets (on average around 50 years old), and 3) this population has easy access to meat. World estimates indicate that the vast majority of individuals who do not consume meat do so due to financial difficulties (Nezlek and Forestell, 2020; Leahya et al., 2010). This does not seem to correspond to the reality of the population included in the ELSA-Brasil, a population of public servants, most likely financially stable.

The most common symptom in this population was worry. Other symptoms were also common, such as fatigue, sleep difficulty, and anxiety (NUNES et al., 2016). Participants who consumed a meatless diet exhibited a higher difficulty in concentrating and forgetfulness, and had a higher frequency of mild depressive episodes without somatic symptoms. This seems to be the first study in the literature to describe common mental disorders symptoms derived in CIS-R separately, by meat intake.

Our findings indicate that exclusion of meat from one's diet is not accompanied by better food quality as measured by intake of ultra-processed vs. unprocessed or minimally processed foods, since the general quality of one's diet is influenced by the totality of one's food choices. Vegetarian diets can commonly include a high intake of empty calories and refined foods (Conrad et al., 2017), although some authors have suggested that a vegetarian diet (including one characterized solely by the exclusion of meat) is healthier than omnivorous ones (Hargreaves et al., 2020; Parker and Vadiveloo, 2019). In the present study, we found a lower intake of unprocessed/minimally processed foods and a higher intake of ultra-processed foods among those individuals who did not consume meat. The understanding of what characterizes "healthy

eating" is changing and the extent to which food is processed has received recent attention. Yet, few studies have evaluated the quality of vegetarian diets in this regard. Food processing was not considered at all in previously published research on vegetarianism and depression. However, a high intake of vegetables, fruit, and fish has been associated with a reduced risk of depression, while a diet rich in sugar, sugar-sweetened beverages, refined products, and fast food is associated with an increased risk of depression (Ljungberg et al., 2020; Moreno et al., 2019).

Many positive health outcomes have been found using data from the Adventist Health Study II (ASH-2), the largest prospective cohort study that includes substantial numbers of vegetarians (approximately 25 % of the cohort). The generalizability of these findings to the general population may be limited due to cultural attributes of Seventh-day Adventists, who generally avoid eating refined foods and demonstrate a greater concern with health. A recent debate concerns whether better health outcomes in vegetarians reflect (and should be attributed to) less overweight and greater adherence to dietary recommendations than to a vegetarian diet per se. Omnivores who eat a healthy or high-quality diet can apparently enjoy the same benefits often attributed to a vegetarian diet (Mayra et al., 2019; Azevedo, 2013).

In the present study, meat non-consumers had a lower intake of several nutrients important for mental health, such as omega-3 fatty acids, vitamins B12, B6, and D, iron, and zinc. The literature has suggested that omega-3 deficiency due to exclusion of fish from the diet is a potential mediator linking vegetarianism to depression, as these fatty acids play an important role in modulating the metabolism of neurotransmitters and cell signal transduction (Liao et al., 2019; Wolfe et al., 2009). Likewise, a relationship to other nutrients has been observed. Vitamin B12 plays an important role in DNA synthesis and neurological function. Its deficiency is associated with hematological, neurological, and psychiatric manifestations, the latter including irritability, personality changes, depression, and, ultimately, dementia (Syed et al., 2013). In addition, vitamin B12, iron, and zinc deficiencies can result in anemia, which is associated with a higher incidence of depressive symptoms (Vulser et al., 2016). The role of vitamin D in depression has also been the object of research. Vitamin D is believed to upregulate receptors in specific areas of the brain (such as the prefrontal and cingulate cortex) known to play a key role in mood regulation, in addition to having neuroprotective properties due to its anti-inflammatory effects (Menon et al., 2020). However, the present analyses indicate that these nutrients only partially explained the association between meatless diet and depressive episodes (approximately 10 % of the increased prevalence).

One hypothesis to explain the association found between meat avoidance and a higher frequency of depressive episodes is reverse causality, where mental disorders, including symptoms of depression, can lead to changes in eating habits due to limitations imposed by the disease. Most medications used to treat depression cause weight gain. This has been noted as a reason why individuals on antidepressant treatment should receive guidance on adopting a healthy diet (Markowitz et al., 2008). Although healthier eating is provided for in treatment strategies for depression, the manifestations of depression itself are characterized by poor diet, either due to lack of appetite or to difficulty in performing activities of daily living such as running errands (including grocery shopping) and preparing food (Ljungberg et al., 2020; Kazes et al., 1993). Meats are perishable and require a longer preparation time than ultra-processed foods, which are available for immediate consumption and are characteristically hyper-palatable, which may justify their intake to the detriment of meat.

One study found that psychological disorders (depression, anxiety, and somatoform disorder) usually precede the adoption of a vegetarian diet (Michalak et al., 2012).

A possible explanation for this finding is that a mental disorder may increase the likelihood that the individual will choose a vegetarian diet (ie, the mental disorder causes the vegetarian diet). Individuals with a history of mental disorders may exhibit more health-oriented behavior trying to positively influence the course of their illness, as a meat-free diet is perceived as healthier. They also may be more sensitive to the suffering of other living beings, including animals. However, further studies are needed to better understand the temporal relationship between the onset of depression and the adoption of this eating behavior.

Likewise, research has demonstrated a relationship between dysfunctional eating behavior and vegetarianism, as well as a higher prevalence of eating disorders in vegetarian women (Bardone-Cone et al., 2012). Regarding eating disorders, it is believed that adoption of a vegetarian diet can be a way of legitimizing food avoidance, often related to weight concerns (Bardone-Cone et al., 2012). Vegetarians also seem to have greater orthorexic tendencies than omnivores (Matta et al., 2018). This excessive concern with healthy eating can be triggered by eating disorders, which often present with depressive symptoms (Singleton et al., 2019; Thornton et al., 2016). Vegetarians more often reported being told by a physician that they had an eating disorder (Michalak et al., 2012). Vegetarian adolescents were more likely to attempt suicide than nonvegetarians (PERRY et al., 2002).

Another hypothesis is that vegetarians may experience greater prejudice due to their dietary choices and because they are a minority in Western countries, which can lead to reduced well-being. In surveys conducted in Asian countries with a high prevalence of vegetarianism, or among individuals who follow religions where vegetarianism is common, there was no relationship between the adoption of a vegetarian diet and depression; so that the favorable vs. unfavorable environment may be a possible explanation for heterogeneity of results (Jin et al., 2021; Gonyea et al., 2018; Beezhold et al., 2010).

There may be multiple motivations and reasons for excluding meat from one's diet, which can interact with one another and may relate to personal, social, and moral aspects. Future research should focus on this issue and seek to clarify whether certain motivations may be more strongly associated with the presence of depressive episodes. Likewise, the duration of specific food habits and the onset of depressive symptoms should be investigated to better establish inferences regarding the temporality of the association. Close observation of the individual's and family's psychiatric history, as well as the possible presence of eating disorders, can also help to elucidate the causality of the association between diet and a depressive episode.

Overall, our results corroborate previous findings suggesting that meatless diets are associated with the presence of symptoms of depression. However, it bears stressing that we do not provide evidence of a causal role of meat avoidance in the etiology of depressive episodes. Nevertheless, nutrition and mental health in vegetarians should be viewed as interrelated. The direction of the association remains unknown, and additional longitudinal data are needed to better understand this relationship.

4.1. Strengths and limitations

Some limitations of this study must be considered. Although our results suggest a link between meat avoidance and a higher prevalence of depressive episodes, we cannot assert from these cross-sectional data whether any specific dietary deficiency is the cause of these differences in mental health, nor can we elucidate the direction of any relationship between these variables. Retrospective assessment of depressive episodes in a 7-day period without a clinical assessment of the history of depression or information about previous depressive episodes can be a limitation for the understanding of depression throughout the life course (Moreno et al., 2019). The CIS-R assesses depressive episodes in the preceding 7 days (very recent episodes), while eating habits can be considered as longer-term habits or lifestyles. Thus, the possibility that the exclusion of meat from one's diet precedes the depressive episode can be seen as potentially more plausible than the opposite (a depressive episode preceding the exclusion of meat). Dietary assessment was performed by the FFQ, and recall or information bias may have led to differential under- or overestimation of food intake among individuals with

and without a depressive episode. In addition, the FFQ applied was not developed for vegetarian eating practices, and may lack food items that are commonly consumed by these individuals, whose diet may be even more varied than that of omnivores. Individuals who abstain from meat may consume other foods to replace it, such as textured vegetable protein, which is not included in our FFQ. Thus, nutrient analysis may have been impacted by the limitation of the list of foods included in the questionnaire. On the other hand, it is noteworthy that the FFQ used herein was validated in comparison to food records in the ELSA-Brasil survey, and that many studies on this topic have adopted the same methodology. Furthermore, we cannot rule out the possibility of residual confounding, e.g., by lifestyle variables that may not have been fully captured.

Strengths of our study include the large sample and the fact that we explored the influence of different potentially confounding or mediating characteristics in the association between meatless diet and depressive episodes, in progressively adjusted models. Our study analyzed aspects related to the presence of symptoms of other common mental disorders, self-assessment of health status, and nutrition which have not been widely investigated to date, and found that these only partially explained the higher prevalence of depressive episodes in meat non-eaters.

All data were collected in standardized interviews by a trained team. The definition of a meatless diet for this study was based on the individual's eating habits in the preceding 12 months, adjusting for those who reported changing their habits in the preceding 6 months, thus avoiding possible fad dieters or temporary adherents, also in an attempt to limit reverse causality.

CRediT authorship contribution statement

I.S.K. performed the statistical analysis, wrote the manuscript and had primary responsibility for the final content; V.C.L. reviewed the data analysis, reviewed the manuscript and had primary responsibility for the final content; M.I.S. designed the research, reviewed the manuscript; A. L.P., M.C.M. and M.A.A.N reviewed the manuscript.

Funding sources

This work was supported by the Brazilian Ministry of *Health* (Department of Science and Technology) and Ministry of Science, Technology and Innovation (Financiadora de Estudos e Projetos (FINEP); grant numbers 01 06 0010.00, 01 06 0212.00, 01 06 0300.00, 01 06 0278.00, 01 06 0115.00 and 01 06 0071.00) and the National Council for Scientific and Technological Development (CNPq).

Conflicts of Interest

All authors declare they have no conflicts of interest.

Acknowledgements

The authors thank the staff and participants of ELSA-Brasil for their important contributions.

References

Aprelini, C.M.O., et al., 2019. Consumption of red and processed meat, insulin resistance, and diabetes in the brazilian longitudinal study of adult health (ELSA-Brasil). Rev. Panam. Salud Publica 43, 40. https://doi.org/10.26633/RPSP.2019.40.

Aquino, E.M.L., et al., 2012. Brazilian longitudinal study of adult health (ELSA-Brasil): objectives and design. Am. J. Epidemiol. 175, 315–324. https://doi.org/10.1093/aje/kwr294.

Aquino, E.M.L., et al., 2013. Participants recruitment in ELSA-brasil (Brazilian longitudinal study for adult Health). Rev. Saúde Pública 47, 10–18. https://doi.org/10.1590/S0034-8910.2013047003953.

Askari, M., et al., 2022. Vegetarian diet and the risk of depression, anxiety, and stress symptoms: a systematic review and meta-analysis of observational studies. Crit. Rev. Food Sci. Nutr. 62, 261–271. https://doi.org/10.1080/10408398.2020.1814991.

Azevedo, E., 2013. Vegetarianismo. Demetra 8, 275–288. https://doi.org/10.12957/demetra.2013.6609.

Bardone-Cone, A.M., et al., 2012. The inter-relationships between vegetarianism and eating disorders among females. J. Acad. Nutr. Diet. 112, 1247–1252. https://doi.org/10.1016/j.jand.2012.05.007.

Barros, M.B.A., et al., 2017. Depression and health behaviors in Brazilian adults - PNS 2013. Rev. Saúde Pública 51. https://doi.org/10.1590/S1518-8787.2017051000084.

Barros, K.S, Bierhals, I.O., Assunção, M.C.F., 2020. Vegetarianismo entre ingressantes de uma universidade pública no sul do Brasil. Epidemiol. Serv. Saúde 29. http://scielo.iec.gov.br/scielo.php?script=sci_arttext&pid=S1679-49742020000400017&nrm=iso.

Beezhold, B.L., Johnston, C.S., Daigle, D.R., 2010. Vegetarian diets are associated with healthy mood states: a cross-sectional study in seventh day adventist adults. Nutr. J. 9, 26. https://doi.org/10.1186/1475-2891-9-26.

Bensenor, I.M., et al., 2013. Routines of organization of clinical tests and interviews in the ELSA-brasil investigation center. Rev. Saúde Pública 47, 37–47. https://doi.org/10.1590/S0034-8910.2013047003780.

Bucciarelli, V., et al., 2020. Depression and cardiovascular disease: the deep blue sea of women's heart. Trends Cardiovasc. Med. 30, 170–176. https://doi.org/10.1016/j.tcm.2019.05.001.

Conrad, Z., et al., 2017. Diet quality on meatless days: National Health and nutrition examination survey (NHANES), 2007–2012. Public Health Nutr. 20, 1564–1573. https://doi.org/10.1017/S136898001700026X.

Dobersek, U., et al., 2021. Meat and mental health: a systematic review of meat abstention and depression, anxiety, and related phenomena. Crit. Rev. Food Sci. Nutr. 61, 622–635. https://doi.org/10.1080/10408398.2020.1741505.

Forestell, C.A., Nezlek, J.B., 2018. Vegetarianism, depression, and the five factor model of personality. Ecol. Food Nutr. 57, 246–259. https://doi.org/10.1080/03670244.2018.1455675.

Gonyea, J.G., et al., 2018. Perceptions of neighborhood safety and depressive symptoms among older minority urban subsidized housing residents: the mediating effect of sense of community belonging. Aging Ment. Health 22, 1564–1569. https://doi.org/10.1080/13607863.2017.1383970.

Hargreaves, S.M., et al., 2020. Brazilian vegetarians diet quality markers and comparison with the general population: a nationwide cross-sectional study. PloS One 15, e0235991. https://doi.org/10.1371/journal.pone.0232954.

Hibbeln, J.R., et al., 2018. Vegetarian diets and depressive symptoms among men. J. Affect. Disord. 225, 13–17. https://doi.org/10.1016/j.jad.2017.07.051.

IBOPE, 2018. Pesquisa de opinião pública sobre vegetarianismo. https://www.svb.org.br/images/Documentos/JOB_0416_VEGETARIANISMO.pdf. (Accessed 4 August 2019).

Iguacel, I., et al., 2020. Vegetarianism and veganism compared with mental health and cognitive outcomes: a systematic review and meta-analysis. Nutr. Rev. 79, 361–381. https://doi.org/10.1093/nutrit/nuaa030.

Jin, Y., et al., 2021. Vegetarian diet is inversely associated with prevalence of depression in middle-older aged south asians in the United States. Ethn Health. 26, 504–511. https://doi.org/10.1080/13557858.2019.1606166.

Kazes, M., et al., 1993. The loss of appetite during depression with melancholia: a qualitative and quantitative analysis. Int. Clin. Psychopharmacol. 8, 55–59. https://doi.org/10.1097/00004850-199300810-00009.

Lavallee, K., et al., 2019. Vegetarian diet and mental health: cross-sectional and longitudinal analyses in culturally diverse samples. J. Affect. Disord. 248, 147–154. https://doi.org/10.1016/j.jad.2019.01.035.

Leahya, E., Lyonsa, S., Tola, R.S.J., 2010. An estimate of the number of vegetarians in the world. https://www.econstor.eu/handle/10419/50160#:~:text=We%20estimate%20that%20there%20are,million%20are%20vegetarians%20of%20necessity. (Accessed 18 March 2019).

Lee, M.F., Eather, R., Best, T., 2021. Plant-based dietary quality and depressive symptoms in Australian vegans and vegetarians: a cross-sectional study. BMJ Nutr. Prev. Health 4, 479–486. https://doi.org/10.1136/bmjnph-2021-000332.

Lewis, G., et al., 1992. Measuring psychiatric disorder in the community: a standardized assessment for use by lay interviewers. Psychol. Med. 22, 465–486. https://doi.org/10.1017/s0033291700030415.

Li, H., et al., 2018. Depression in the context of chronic diseases in the United States and China. Int. J. Nurs. Sci. 6, 117–122. https://doi.org/10.1016/j.ijnss.2018.11.007.

Liao, Y., et al., 2019. Efficacy of omega-3 PUFAs in depression: a meta-analysis. Transl. Psychiatry 9, 190. https://doi.org/10.1038/s41398-019-0515-5.

Liu, Q., et al., 2020. Changes in the global burden of depression from 1990 to 2017: findings from the global burden of disease study. J. Psychiatr. Res. 126, 134–140. https://doi.org/10.1016/j.jpsychires.2019.08.002.

Ljungberg, T., Bondza, E., Lethin, C., 2020. Evidence of the importance of dietary habits regarding depressive symptoms and depression. Int. J. Environ. Res. Public Health 17. https://doi.org/10.3390/ijerph17051616.

Lohman, T.J., Roache, A.F., Martorell, R., 1988. Anthropometric Standardization Reference Manual. Human Kinetics Books, Champaign, IL.

Markowitz, S., Friedman, M.A., Arent, S.M., 2008. Understanding the relation between obesity and depression: causal mechanisms and implications for treatment. Clin. Psychol. Sci. Pract. 15, 1–20. https://doi.org/10.1111/j.1468-2850.2008.00106.x.

Matta, J., et al., 2018. Depressive symptoms and vegetarian diets: results from the constances cohort. Nutrients 10, 1695. https://doi.org/10.3390/nu10111695.

Mayra, S., Ugarte, N., Johnston, C.S., 2019. Health biomarkers in adults are more closely linked to diet quality attributes than to plant-based diet categorization. Nutrients 11, 1427. https://doi.org/10.3390/nu11061427.

Menon, V., et al., 2020. Vitamin D and depression: a critical appraisal of the evidence and future directions. Indian J. Psychol. Med. 42, 11–21. https://doi.org/10.4103/IJPSYM.IJPSYM_160_19.

Michalak, J., Zhang, X.C., Jacobi, F., 2012. Vegetarian diet and mental disorders: results from a representative community survey. Int. J. Behav. Nutr. Phys. Act. 9, 67. https://doi.org/10.1186/1479-5868-9-67.

Molina, M.C.B., et al., 2013. Reprodutibilidade e validade relativa do Questionário de Frequência alimentar do ELSA-brasil. Cad. Saúde Pública 29, 379–389. https://doi.org/10.1590/S0102-311X2013000200024.

Monteiro, C.A., 2016. Food classification. Public health NOVA. The star shines bright. World Nutr. 7, 28–38. https://worldnutritionjournal.org/index.php/wn/article/view/5.

Moreno, A., et al., 2019. Dietary patterns and depression: first results in a cross-sectional study from the Brazilian longitudinal study of adult health (ELSA-Brasil). Psych. 2, 11–24. https://doi.org/10.3390/psych2010002.

Nezlek, J.B., Forestell, C.A., 2020. Vegetarianism as a social identity. Curr. Opin. Food Sci. 33, 45–51. https://doi.org/10.1016/j.cofs.2019.12.005.

Nunes, M.A., et al., 2011. Adaptação transcultural do CIS-R (Clinical interview schedule-revised Version) Para o português no estudo longitudinal De Saúde do adulto (ELSA). Clin. Biomed. Res. 31, 487–490.

Nunes, M.A., et al., 2016. Common mental disorders and sociodemographic characteristics: baseline findings of the Brazilian longitudinal study of adult health (ELSA-Brasil). Braz. J. Psychiatry 38, 91–97. http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1516-44462016000200091&nrm=iso.

Ocklenburg, S., Borawski, J., 2021. Vegetarian diet and depression scores: a meta-analysis. J. Affect. Disord. 294, 813–815. https://doi.org/10.1016/j.jad.2021.07.098.

Parker, H.W., Vadiveloo, M.K., 2019. Diet quality of vegetarian diets compared with nonvegetarian diets: a systematic review. Nutr. Rev. 77, 144–160. https://doi.org/10.1093/nutrit/nuy067.

Perry, C.L., et al., 2002. Adolescent vegetarians. How well do their dietary patterns meet the healthy people 2010 objectives? Arch. Pediatr. Adolesc. Med. 156, 431–437. https://doi.org/10.1001/archpedi.156.5.431.

Rosenfeld, L.G., 2019. Reference values for blood count laboratory tests in the Brazilian adult population, National Health Survey. Rev. Bras. Epidemiol. 22 (SUPL.2), E190003 https://doi.org/10.1590/1980-549720190003.supl.2.

Ruby, M.B., 2012. Vegetarianism. A blossoming field of study. Appetite 58, 141–150. https://doi.org/10.1016/j.appet.2011.09.019.

Schmidt, M.I., et al., 2015. Cohort profile: longitudinal study of adult health (ELSA-Brasil). Int. J. Epidemiol. 44, 68–75. https://doi.org/10.1093/ije/dyu027.

Secretti, T., et al., 2019. Characteristics of neighborhood environment (social cohesion and safety) and common mental disorders in ELSA-Brasil study: a multilevel analysis. Cad. Saúde Pública 35, 1–15. https://doi.org/10.1590/0102-311X00197017.

Shen, Y.C., et al., 2021. Vegetarian diet is associated with lower risk of depression in Taiwan. Nutrients 13. https://doi.org/10.3390/nu13041059.

Singleton, C., et al., 2019. Depression partially mediates the association between binge eating disorder and health-related quality of life. Front. Psychol. 10 https://doi.org/10.3389/fpsyg.2019.00209.

Syed, E.U., Wasay, M., Awan, S., 2013. Vitamin B12 supplementation in treating major depressive disorder: a randomized controlled trial. Open Neurol. J. 7, 44–48. https://doi.org/10.2174/1874205X01307010044.

Thornton, L.M., et al., 2016. Anorexia nervosa, major depression, and suicide attempts: shared genetic factors. Suicide Life Threat Behav. 46, 525–534. https://doi.org/10.1111/sltb.12235.

Timko, C.A., Hormes, J.M., Chubski, J., 2012. Will the real vegetarian please stand up? An investigation of dietary restraint and eating disorder symptoms in vegetarians versus non-vegetarians. Appetite 58, 982–990. https://doi.org/10.1016/j.appet.2012.02.005.

Vulser, H., et al., 2016. Association between depression and anemia in otherwise healthy adults. Acta Psychiatr. Scand. 134, 150–160. https://doi.org/10.1111/acps.12595.

Wang, J., et al., 2017. Prevalence of depression and depressive symptoms among outpatients: a systematic review and meta-analysis. BMJ Open 7, e017173. https://doi.org/10.1136/bmjopen-2017-017173.

Wang, X., Li, Y., Fan, H., 2019. The associations between screen time-based sedentary behavior and depression: a systematic review and meta-analysis. BMC Public Health 19, 1524. https://doi.org/10.1186/s12889-019-7904-9.

WHO, 2017. In: Depression and Other Common Mental Disorders Global Health Estimates, 48, pp. 56–60. https://apps.who.int/iris/handle/10665/254610.

Wolfe, A.R., et al., 2009. Dietary linoleic and oleic fatty acids in relation to severe depressed mood: 10 years follow-up of a national cohort. Prog. Neuro-Psychopharmacol. Biol. Psychiatry 33, 972–977. https://doi.org/10.1016/j.pnpbp.2009.05.002.