IECN 2024 Conference
The 4th International Electronic Conference on Nutrients
16–18 October 2024 | Online
MDPI

# How plant-based diets influence mental health: mitigating depression and anxiety

P. Barciela [1], A. Perez-Vazquez [1], A.O.S. Jorge [1,2], P. Donn [1], S. Seyyedi-Mansour [1], J. Echave [1,3], M.A. Prieto [1,*].

[1] Universidade de Vigo, Nutrition and Bromatology Group, Department of Analytical Chemistry and Food Science, Instituto de Agroecoloxía e Alimentación (IAA) – CITEXVI, 36310 Vigo, España.
[2] LAQV@REQUIMTE, Department of Chemical Sciences, Faculdade de Farmácia, Universidade do Porto, R. Jorge Viterbo Ferreira 228, 4050-313, Porto, Portugal.
[3] Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, Campus de Santa Apolonia, 5300-253 Bragança, Portugal.

***Corresponding author:** M.A. Prieto (mprieto@uvigo.es).

**The 4th International Electronic Conference on Nutrients - Plant-Based Nutrition Focusing on Innovation, Health, and Sustainable Food Systems**

## 1. Introduction: Overview of mental disorders and health in relation to diet

**Neuropsychiatric disorders like depression and anxiety** are prevalent, often occurring together or in sequence, significantly impacting quality of life and complicating chronic disease management. Factors such as stress, genetics, hormonal imbalances, and environmental influences contribute to these conditions. **Recent research underscores the role of diet in mental health, particularly through the gut-brain axis.** This axis, which involves bidirectional communication between gut health and brain function, affects neurotransmitter production and inflammatory responses influenced by gut microbiota**. Disruptions in this system can lead to brain inflammation and neurotransmitter imbalances, exacerbating chronic pain and depression.**

**Figure 1** offers an overview of the gut-brain axis, illustrating how disturbances in this system can affect mental health. Key components such as the aryl hydrocarbon receptor (AhR) and bile acids are highlighted, providing insight into the connection between gut microbiota and mental health. Understanding these interactions emphasizes how dietary factors impacting gut health may help manage and alleviate symptoms of depression and anxiety.

**Recent evidence suggests that plant-based diets may positively influence mental health by modulating the gut-brain axis**. These diets are rich in antioxidants, phytochemicals, and dietary fiber, which help maintain a healthy gut microbiota For instance, **quercetin** from plants boosts serotonin (5-HT), dopamine (DA), and norepinephrine (INN) levels. Additionally, plant-based diets improve tryptophan utilization, essential for 5-TH production. **Thus, dietary changes, particularly adopting a plant-based diet, can significantly improve mental well-being.**

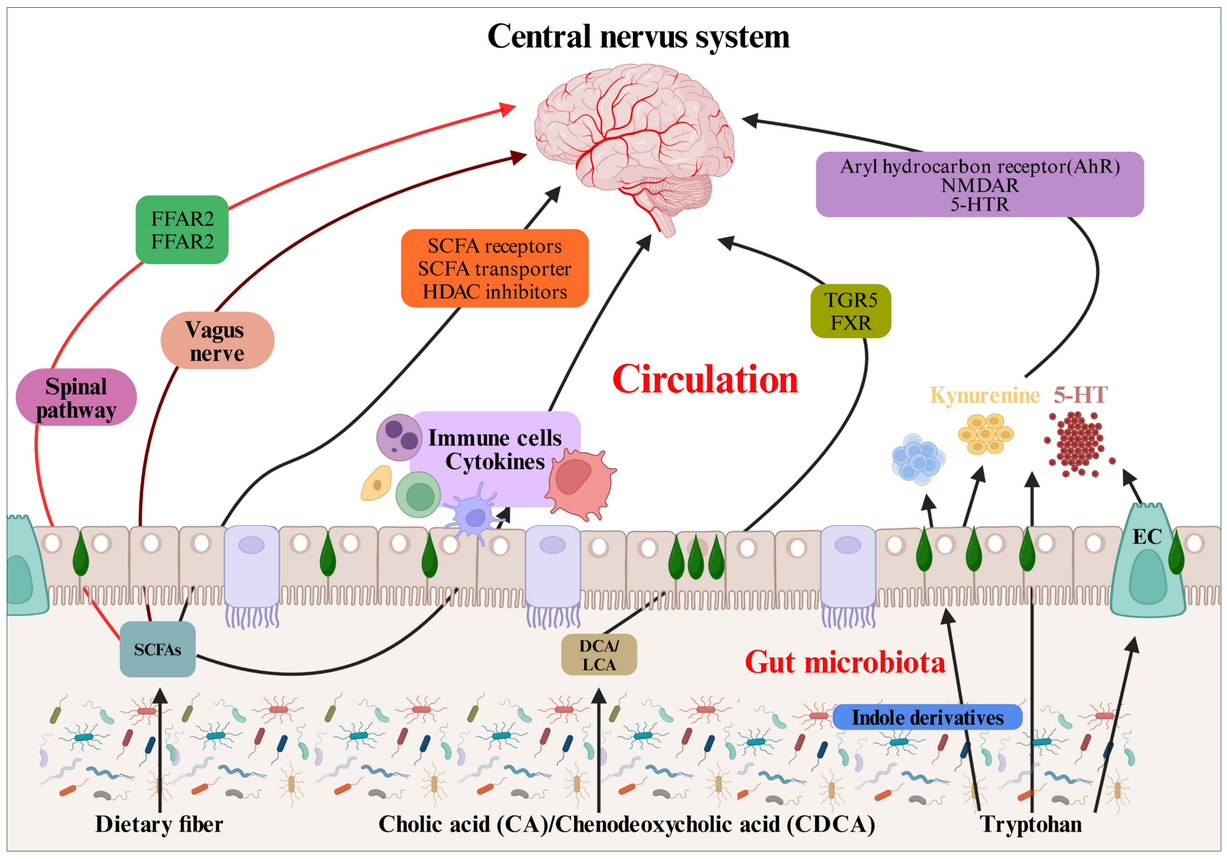


**Figure 1.** Overview of the "microbiota-gut-brain" axis in chronic pain and depression. DCA (deoxycholic acid), LCA (lithocholic acid), EC (enterochromaffin cell), FFAR 2/3 (free fatty acid receptor 2 or 3), HDAC (histone deacetylase), 5-HT (5-hydroxytryptamine), NMDAR (N-Methyl-D-aspartate receptor), SCFA (short-chain fatty acids), FXR (farnesoid X receptor), TGR 5 (Takeda G-protein-coupled receptor 5).

## 2. Serotonergic system — Key mood-regulating neurotransmitter serotonin (5-HT)

| | |
|---|---|
| Depression → | **Altered 5-HT Function**: Contributing to heightened stress response. **Mechanisms:** Dysregulated 5-HT signaling; Increased 5-HT receptor sensitivity; Imbalance in 5-HT reuptake. |
| Anxiety → | **Low 5-HT Levels**: Contributing to mood disturbances. **Mechanisms**: Reduced 5-HT synthesis; Altered 5-HT receptor function; Impaired 5-HT reuptake. |

## 3. Protective effects of natural plant foods against depression and anxiety — *In vivo* studies

Numerous plant-based dietary natural products and their nutrients offer protective effects against both depression and anxiety, although the **underlying mechanisms differ**. For **depression**, compounds such as *Geum japonicum* and royal jelly improve symptoms by enhancing neuroprotection and regulating neurotransmitters like Brain-Derived Neurotrophic Factor (BDNF) and cortisol (CORT). In contrast, for **anxiety**, saffron and bergamot essential oil exhibit **anxiolytic effects** by lowering CORT levels, reducing inflammatory markers, and boosting antioxidant activity in the brain. These mechanisms and effects are summarized in **Table 1.**

**Table 1. Impact and mechanisms of dietary natural products and nutrients on depression and anxiety based on experimental research.** Abbreviations: BDNF (Brain-Derived Neurotrophic Factor); CORT (Corticosterone); MAO (Monoamine Oxidase); TrkB (Tropomyosin Receptor Kinase B); IL (Interleukin); TNF-α (Tumor Necrosis Factor-alpha); GPx (Glutathione Peroxidase); CAT (Catalase); SOD (Superoxide Dismutase); 5-HT (Serotonin); NF-κB (Nuclear Factor kappa B); IFN-γ (Interferon-gamma); MDA (Malondialdehyde); NOS (Nitric Oxide Synthase).

| Plant foods | Study Type | Model | Dose | Effects and mechanisms |
|---|---|---|---|---|
| | | | | *Depression* |
| *Geum japonicum* | *In Vivo* | ICR mice | 30, 100, 300 mg/kg | Exerted neuroprotective effects; Upregulated expression of BDNF in hippocampus |
| Royal jelly | *In Vivo* | CUMS mice | 4.5 g/kg | Attenuated CUMS-induced depression; Inhibited the biosynthesis of CORT |
| Purple cauliflower | *In Vivo* | CUMS mice | 50, 100, 200 mg/kg | Improved depressive symptoms; Increased content of monoamine neurotransmitter; Suppressed activity of MAO; Upregulated BDNF, TrkB |
| Navel orange essential oil | *In Vivo* | Kunming mice | 0.5, 1, 2% | Exerted anti-depressive effects; Increased serotonin and dopamine levels in brain |
| | | | | *Anxiety* |
| Saffron | *In Vivo* | Rats | 30, 60 mg/kg | Exerted anxiolytic effect; Downregulated serum CORT level; Upregulated BDNF in hippocampa |
| Bergamot essential oil | *In Vivo* | SD rats | 200 mg/kg | Improved anxiety; Decreased IL-1β, IL-6, TNF-α; Enhanced the activity of GPx, CAT, SOD |
| Red pomegranate fruit extract-based formula | *In Vivo* | C57BL/6J mice | 2.0, 1.5, 1.0 mg/g | Exerted anxiolytic effect; Increased 5-HT in hippocampus; Suppressed indoleamine-2,3-dioxygenase; Improved tryptophan hydroxylase; Reduced NF-κB, TNF-α, IL-6, IL-1β, IFN-γ, MDA; Promoted the activities of NOS, SOD, and CAT |

## 4. Role of antioxidants in brain health — Influence on neurotransmitter balance

### 4.1. Quercetin as a Monoamine Oxidase (MAO) inhibitor

**Quercetin**, (**Figure 2**) a dietary flavonoid found in plant-based foods, enhances brain health by inhibiting MAO-A. This enzyme breaks down key neurotransmitters such as 5-HT, DA, and NE. By inhibiting MAO-A, quercetin helps maintain higher levels of these neurotransmitters, which can alleviate symptoms of depression and anxiety. **An *in vivo* recent study proved that quercetin inhibits MAO-A in the brain without affecting gut monoamine metabolism, suggesting its safety.**

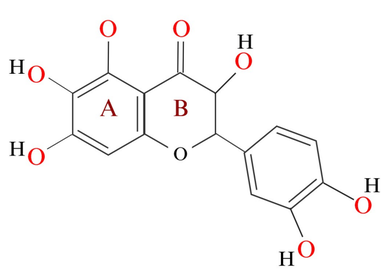


**Figure 2.** Quercetin chemical structure.

## 5. Plant-based versus animal — based food consumption

Plant-based and animal-based diets show **notable differences** in nutrient composition and effects on mood and satiety (**Table 2**). Plant-based meals typically have higher carbohydrates and sugar, but lower fat and protein compared to animal-based meals. Although protein content was about one-third lower in plant-based meals, this had only a marginal effect on post-meal satiety.

A large-scale study involving 16,379 adults revealed that while meal intake improved satiety and mood overall, plant-based meal choices led to slightly higher mood before the meal and smaller mood increases after the meal compared to animal-based meals. **This suggests that plant-based diets can positively influence mood, providing a modest mental health benefit.**

**Table 2. Detailed comparison of major macronutrient and micronutrient differences between plant and animal-based diets.** Abbreviations: ALA: Alpha-Linolenic Acid; EPA: Eicosapentaenoic Acid; DHA: Docosahexaenoic Acid.

| Nutrient | Plant-Based Diet | Animal-Based Diet |
|---|---|---|
| | *Macronutrients* | |
| Carbohydrates | ↑ (e.g., grains, legumes, fruits, vegetables) | ↓ (e.g., meat, fish, dairy) |
| Sugar | ↑ (e.g., fruits, some vegetables) | ↓ (e.g., meat, fish) |
| Fat | ↓ (e.g., nuts, seeds, avocados, olive oil) | ↑ (e.g., meat, fish, dairy) |
| Protein | ↓ (e.g., beans, lentils, tofu, nuts) | ↑ (e.g., meat, fish, eggs, dairy) |
| | *Micronutrients* | |
| Fiber | ↑ (e.g., whole grains, fruits, vegetables, legumes) | ↓ (minimal fiber content) |
| Vitamin B12 | ↓ (fortified foods, supplements, nutritional yeast) | ↑ (meat, fish, dairy, eggs) |
| Iron | Non-heme iron (less absorbable, found in legumes, tofu) | Heme iron (more absorbable, poultry, fish) |
| Omega-3 Fatty Acids | ALA (from flaxseeds, chia seeds, walnuts, canola oil) | EPA and DHA (from fatty fish like salmon, sardines) |
| Calcium | ↓ (fortified plant milks, tofu, leafy greens) | ↑ (dairy products, fish with bones) |
| Zinc | ↓ (grains, legumes, nuts, seeds) | ↑ (meat, shellfish) |
| Vitamin D | ↓ (fortified foods, supplements) | ↑ (fatty fish, egg yolks, fortified dairy products) |
| Magnesium | ↑ (nuts, seeds, leafy green vegetables, whole grains) | ↓ (meat, dairy products) |
| Potassium | ↑ (fruits like bananas, oranges; vegetables like potatoes) | ↓ (meat, fish) |
| Vitamin C | ↑ (citrus fruits, strawberries, bell peppers, broccoli) | ↓ (minimal in animal products) |
| Saturated fat | ↓ (coconut oil, palm oil, some processed foods) | ↑ (meat, dairy, processed meats) |
| Cholesterol | None (only found in animal products) | Present (meat, dairy, eggs) |
| Antioxidants | ↑ (variety of fruits and vegetables, nuts, seeds) | ↓ (minimal in animal products) |

## 6. Differences in food preferences between sexes

**The appeal of plant-based diets varies between men and women due to differences in preferences, attitudes, and motivations.** Women are generally more inclined toward vegetarian or vegan diets for health and ethical reasons, while men face societal pressures linking meat consumption with masculinity. This leads to more prejudice against vegetarian men, impacting their mental well-being through social isolation and stress. Studies show that men adopting plant-based diets may experience these negative effects more acutely, while women face less bias. Additionally, although the diet-depression link seems stronger in women, it is also significant for men.

**Understanding these gender-specific dynamics is crucial for creating supportive environments and tailored interventions that promote mental health and effective dietary changes. Further research is necessary to have a full understanding of these effects.**

## Conclusion

Plant-based diets can improve mood and reduce depression and anxiety.

Mood-boosting foods are plant foods that are rich in omega-3 fatty acids and tryptophan.

More research is needed to fully understand how a plant-based diet has an impact on mental health.

**Acknowledgments.** The research leading to these results was supported by MICINN supporting the Ramón y Cajal grant for.A. Prieto (RYC-2017-22891), by Xunta de Galicia for supporting the the pre-doctoral grant of P. Barciela (ED481A-2024-230). Moreover, the authors are grateful to the National funding by FCT, Foundation for Science and Technology, through the individual research grants of J. Echave (2023.04987.BD) and A.O.S. Jorge (2023.00981.BD).