

Research Article

## Tryptophan and Protein Deviation in Relation to Wellbeing: An Exploratory Study on University Students

Maria-Monica Popescu-Mitroi<sup>1</sup>, Ionel Popescu-Mitroi<sup>2\*</sup>

<sup>1</sup>Politehnica University of Timișoara, Department for Teaching Training, Timișoara 300006, Romania

<sup>2</sup>“Aurel Vlaicu” University of Arad, Faculty of Food Engineering, Tourism and Environmental Protection, Arad 310330, Romania



### Article History:

Received 15-08-2025

Revised 06-11-2025

Accepted 05-01-2026

Published 31-03-2026

### Keywords:

protein deviation,  
tryptophan, wellbeing

### \*Corresponding Author:

tel: +40721589689,

email: ionel.popescu-mitroi@uav.ro

### ABSTRACT

This study set out to investigate a possible link between wellbeing and a high-protein diet (measured by different levels of protein deviation), respectively a rich-tryptophan diet (measured by foods with different tryptophan content). This exploratory study used data collected from 20 students based on the 7-day food diary (to calculate: protein deviation, energy deviation, and additionally body mass index), a second instrument: food frequency questionnaire for foods A (rich in tryptophan) and foods B (low in tryptophan), and a third instrument: WHO-5 Wellbeing Index questionnaire. The study identified that there is an association that ignores the causality Goodman-Kruskal gamma ( $\gamma$ ) Test, a symmetrical relationship between protein deviation and wellbeing ( $p \leq 0.05$ ). Some significant differences are present: the students with low levels of wellbeing compared to those with high wellbeing have unbalanced eating habits and a greater protein deviation ( $p \leq 0.05$ ); the students in the low wellbeing category with a below-normal protein level have a negative energy deviation and a diet low in tryptophan ( $p \leq 0.05$ ) compared to those with an above-normal protein deviation. It was found some significant correlations that are worth exploring in the future in the case of over-normal protein deviation group like correlation between Body Mass Index (BMI) and Foods A (rich in tryptophan) and in the case of low wellbeing group correlation between protein deviation and Foods B (low in tryptophan), respectively energy deviation.

## INTRODUCTION

Health is a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity, in the view of World Health Organization, but not in the sense of perfection, rather in a holistic way, as claimed by Schramme (2023). Thus, wellbeing is an essential concept in defining health, with the two concepts appearing to be interchangeable. Wellbeing is difficult to define individually and at societal level. Simons and Baldwin (2021) argue that wellbeing is a combination (balance/equilibrium) between: (a) feeling good (hedonic perspective) and (b) functioning effectively in everyday life (eudaemonic perspective), i.e., having a harmonious development. Block *et al.* (2011) talk about a paradigm shift from food as health

to food as wellbeing, and introduce the concept of food wellbeing, as a positive psychological, physical, emotional, social relationship with food (both individually and at societal level), this also contributing to a better understanding of consumers' food choices (Ares *et al.* 2014).

Holder (2019) and Gardner *et al.* (2014) argue, however, that the relationship between nutrition and wellbeing remains unclear: wellbeing influences food choices, but food choices in turn influence wellbeing, meaning that there is a bidirectional relationship. For instance, when we make food choices, we should keep in mind the association between wellbeing=healthy, unbalance=unhealthy. Both animal and vegetable proteins are consumed in the current diet. Dietary proteins normally contain 20–22 amino acids, of which 12–14 can be synthesised by the human

organism and 9 that cannot: tryptophan, histidine, lysine, leucine, isoleucine, phenylalanine, methionine, threonine, and valine (Lopez & Mohiuddin 2024). Amino acids are the building blocks of proteins, and neurotransmitters are made up of amino acids (Dunne 2012).

Along with its nutritional importance as an essential amino acid, tryptophan appears to be paramount for mental health and wellbeing, being a basic precursor for tryptamine, serotonin, and melatonin (Xu *et al.* 2025): (a) Tryptamine is formed from tryptophan by decarboxylation under the action of tryptophan decarboxylase; (b) Serotonin (5-hydroxytryptamine\5-HTP) comes from the metabolism of tryptophan, but is also a tissue hormone (tissue product); (c) Melatonin (N-acetyl-5-methoxytryptamine) can be formed from the metabolism of tryptophan, but is also a hormone produced by the pineal gland. Tryptophan, as a precursor of serotonin, controls appetite, sleep, memory, learning, temperature, emotional state, perception (Toker *et al.* 2010).

According to the Recommended Dietary Allowance (RDA) value, teenagers need 4-5 mg, and the middle-aged adult needs 5 mg of tryptophan/kg bodyweight/day (Mosconi 2021). Studies show that the exhaustion of tryptophan in the body leads to the inhibition of REM sleep (Greenfield 2020). We refer to wellbeing as a more general concept that includes mental health. Many diseases and mental disorders are related to the dysfunctional metabolism of tryptophan: depression, anxiety (Friedman 2018; Musumeci *et al.* 2017), sleep disorders, anorexia and bulimia, Alzheimer's, Parkinson's, obesity, irritable bowel syndrome (Kałużna-Czaplińska *et al.* 2019). Some studies have shown that taking 0.14–3 g of tryptophan/day helps to decrease anxiety and increase positive mood even in healthy people (Colzato *et al.* 2015; Steenbergen *et al.* 2015).

Another discussion concerns the high-protein diet. In this sense, some studies directly link the high-protein diet, especially the one rich in essential amino acids of the tryptophan type, with wellbeing (Jenkins *et al.* 2016). Higher protein intake was prospectively associated with lower severity of depressive symptoms (Gerber 2023; Oh *et al.* 2020). Another aspect covered was related to protein quality, thus vegetable protein intake has been associated with a reduced risk of mortality and morbidity in many studies (Pedersen *et al.* 2013). Other results (studies on rodents) suggested that high-protein diets, like

high-fat diets, cause oxidative damage to the brain (Aranda *et al.* 2015).

Azman *et al.* (2024) inversely investigate the relationship between psychological factors, such as self-esteem, and the impact on eating behaviour and eating disorders. From this perspective, wellbeing and food consumption have a bidirectional relationship. As studies about the relationship between food and wellbeing are inconclusive, the role of protein as the main source of essential amino acids for good health and wellbeing management needs to be investigated. This study set out to investigate a possible link between wellbeing and a high-protein diet (measured by different levels of protein deviation), respectively a rich-tryptophan diet (measured by foods with different tryptophan content).

## METHODS

### Design, location, and time

This cross-sectional study has the advantage of including real-life consumer data based on self-reporting (food diary), data based on the use of a Frequency-based Food Questionnaire (FFQ), and the use of a globally applicable wellbeing questionnaire (WHO-5). The food diary was completed by second year students from Aurel Vlaicu University of Arad Romania as part of an assessment portfolio in the Human Nutrition discipline in the 2023/2024 academic year. Regarding ethics in research, the students' participation in the study was voluntary and anonymous.

### Sampling

Initially, 28 students completed a food diary for one week (self-reporting), as part of the Nutrition Portfolio, but we eliminated portfolios with incomplete data and students who did not want to voluntarily participate in the study in the following stages. The study ultimately included 20 students (average age: 23.8 years, 6 male, 14 female, 13 from the urban environment, 7 from the rural environment). This exploratory study aims to provide a preliminary understanding of the potential relationship between wellbeing, protein deviation, energy deviation, and the consumption of foods rich versus low in tryptophan. The applied methodology can be replicated in future large-scale research.

### Data collection

Based on the food diary, the students completed and calculated their real and recommended ration. Based on the formula: (Percentage deviation  $\% = (\text{Intake} - \text{Requirement}) / \text{Requirement} \times 100$ )

The students determined both Protein Deviation (PD) and Energy Deviation (ED). Additionally, the students calculated their Body Mass Index ( $\text{BMI} = \text{weight} / \text{height}^2$ ).

The calculation (Ianchici 2008) used the caloric value of proteins (1 g of protein provides 4.1 kcal) and recommendations regarding the energy structure of the diet (14% protein, 30% lipids, and 56% carbohydrates). We verified the accuracy of the calculations.

Based on studies on rich tryptophan foods (Mosconi 2021; Muscaritoli 2021; Healthy Food Near Me 2020), we created a Food Frequency Questionnaire (FFQ) with 10 rich tryptophan foods called Foods A (A1–A10), selected according to tryptophan content in milligrams/100 g: cheeses (510 mg), soft-boiled egg (200 mg), turkey (330 mg), fish (300 mg), dried legumes (250 mg), peanuts (280 mg), tomatoes (90 mg), potatoes (25 mg), halva (180 mg), bananas (23 mg). Conversely, we selected 10 similar foods low in tryptophan, called Foods B (B1–B10): lactic acid products (50 mg), omelette (100 mg), pork (85 mg), seafood (100 mg), rice (100 mg), hazelnuts (120 mg), cucumbers (5 mg), cabbage (10 mg), chocolate (100 mg), apples (6 mg). For these foods, we measured the frequency of consumption during a week (0-not at all; 1-once/week; 2-two times/week; 3-three times/week; 4-four times/week; 5-daily).

Regarding wellbeing, we used the World Health Organization Wellbeing Index (WHO-5 1998 version), which is a globally used scale that includes 5 items used by the subjects to rate how they felt in the past 2 weeks. The scale is validated on the Romanian population (Liță 2018); it is used both in screening to detect depression (a cut-off score of  $\leq 50$ ), and as a generic scale for measuring wellbeing in a wide variety of fields, in the assessment of progress in the case of some therapeutic interventions, or to make comparisons between groups, as well as a predictor for the evolution of mental disorders or certain professional behaviours. A steady decline in the score may indicate an increased risk of the onset or progression of a disorder (Liță 2018; Sisichka *et al.* 2020).

### Data analysis

Data for parameters investigated based on the food diary Protein Deviation (PD) and Energy Deviation (ED) were organised into 3 distinct categories (groups): below ( $< -20\%$ , inadequate protein intake like deficiency), normal (between  $-20\%$  and  $+20\%$ , adequate intake in relation to the reference value) and over ( $> +20\%$ , inadequate protein intake like excess). Protein and energy deviation were reported within the normal range ( $-20\%$  and  $+20\%$ ), and BMI was within the normal range (normal range for men: 20–24.9; normal range for women: 18.6–23.8, according to Ianchici (2008).

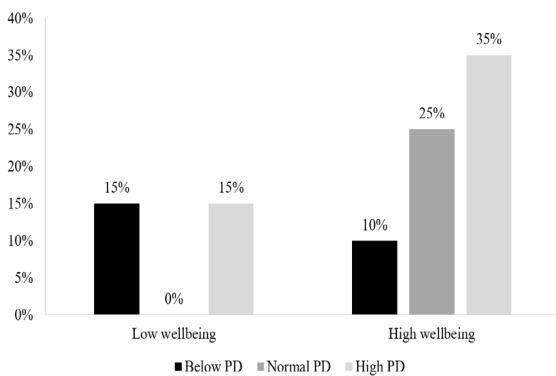
Tryptophan consumption, as identified by the FFQ, was classified into two categories: Foods A – rich in tryptophan, and Foods B – low in tryptophan. Wellbeing was divided into two categories based on a score  $\leq 50$  (low wellbeing and high wellbeing). Statistical processing was performed with SPSS.20. Non-parametric tests were applied for comparisons between samples, including the Mann-Whitney U Test, Kruskal-Wallis H Test, and Wilcoxon Test. Additionally, Kendall's Tau Test was used for correlations, and Goodman-Kruskal gamma ( $\gamma$ ) test and Somers' D test were used to assess measures of association.

## RESULTS AND DISCUSSION

Significant relationships between protein deviation and wellbeing. We identified a positive association between the analysed variables, specifically between changes in protein deviation and changes in wellbeing (Cross-tab statistical procedure). We also obtained a significant relationship in the Somers' D test  $d = 0.431$ ,  $p = 0.011$ , respectively Goodman-Kruskal gamma ( $\gamma$ ) test  $= 0.789$ ,  $p = 0.011$ . The symmetrical relationship between protein deviation and wellbeing implies that changes in protein status are associated equivalently with changes in wellbeing levels, regardless of the direction of the analysis.

The percentage distribution (Figure 1) showed that the high wellbeing group included a small percentage of respondents with a below normal protein deviation (10%), followed by respondents with a normal protein deviation (25%), with most respondents having an over normal protein deviation (35%).

In the low wellbeing group, only the extreme protein deviation registered the same



**Figure 1. Association between Protein Deviation (PD) and wellbeing**

percentage (15%), and there was no category listed with normal protein deviation. Therefore, the normal protein deviation was noted only in the high wellbeing group.

We noted (Table 1, Kendall  $\tau_b$  correlations) that the entire group registered a positive correlation between protein deviation and wellbeing, meaning that an increase in protein deviation was associated with an increase in wellbeing, and vice versa. The correlation between protein deviation and energy deviation for the entire group and in the case of the group with low wellbeing suggests that a greater protein deviation is associated with an increased disturbance of energy balance. In the case of the low wellbeing group, the correlation between protein deviation and Foods B (low in tryptophan), and energy deviation and Foods B should also be noted. In the case of the over protein deviation group, the correlation between BMI and Foods

A (rich in tryptophan) stood out, and should be investigated in future studies on obesity.

Differences in protein deviation between groups with different levels of wellbeing. Analysis of the difference between groups with different levels of wellbeing, performed using the non-parametric Mann-Whitney U Test, showed a significant difference in protein deviation ( $U=19.500, z=-2.018, p=0.044$ ) between groups with low wellbeing ( $n=6$ , Mean Rank 14.25,  $M=2.49$ ) and high wellbeing ( $n=14$ , Mean Rank 8.89,  $M=19.65$ ). Table 2 shows the statistical indicators for the two groups. The low wellbeing group presented a significantly greater protein deviation (extreme values contribute to this difference, although the median is within the normal range) compared to the high wellbeing group ( $p \leq 0.05$ ). These findings suggest a tendency towards greater protein deviation among respondents with lower levels of wellbeing. The median ( $M=19.65$ ) in the case of those with high wellbeing indicates a trend in this group towards protein deviations above normal and this fact needs to be explored in the future.

Differences between groups with different levels of protein deviation. Analysis of the difference between groups with different levels of protein deviation, performed using the Kruskal-Wallis H Test, revealed a significant difference in energy deviation, Chi-square 7.334,  $df(2), p=0.026$ . We then applied the Mann-Whitney U Test, and the Bonferroni correction by adjusting the significance threshold, this being  $p \leq 0.0166$  (i.e.  $p \leq 0.05/3$ , with 3 representing the number of comparisons). It followed that Energy Deviation (ED) differed significantly (Mann-Whitney

**Table 1. Significant correlations depending on wellbeing and protein imbalance**

Correlations	Kendall's Tau-b ( $\tau_b$ ) coefficient	<i>p</i>
All group (n=20)		
PD & Wellbeing	0.439*	0.044
PD & ED	0.454*	0.033
Low Wellbeing group (n=6)		
PD & Foods B	0.802*	0.046
ED & Foods B	0.802*	0.046
PD & ED	1.00**	0.000
Over Protein Deviation group (n=10)		
BMI & Foods A	0.586*	0.033

PD: Protein Deviation; ED: Energy Deviation; BMI: Body Mass Index; Foods A: Foods rich in tryptophan; Foods B: Foods low in tryptophan; Level of significant correlations: Corresponds to *p*: \*Corresponds to  $p < 0.05$  and \*\* Corresponds to  $p < 0.01$

**Table 2. Statistical indicators for the high wellbeing group versus the low wellbeing group**

Indicators	High wellbeing group (n=14)		Low wellbeing group (n=6)	
	mean±SD	Med	mean±SD	Med
Wellbeing	75.86±12.46	78.00	43.67±6.71	46.00
PD	19.94±37.00	19.65	14.19±74.75	2.49
ED	-8.66±26.74	-10.76	-19.62±27.50	-17.82
BMI	24.09±3.68	27.57	22.64±4.01	21.90
Foods A	1.89±0.61	1.80	1.93±0.36	1.75
Foods B	2.14±0.55	2.15	2.16±0.54	2.25

PI: Protein Deviation; EI: Energy Deviation; BMI: Body Mass Index; Foods A: Foods rich in tryptophan; Foods B: Foods low in tryptophan; Med: Median; SD: Standard Deviation

U=7.50, z=-2.475, p=0.013) between the below PD group (n=5, Mean Rank 11.50, M=-46.33) and over PD group (n=10, Mean Rank 6.25, M=2.73). Table 3 shows the statistical indicators for the three PD groups.

A significant difference in energy deviation (p≤0.05) was noted between the below protein deviation and over protein deviation groups, in the sense that the first group presented a negative energy deviation (suggesting a pronounced energy deficit), this implying that protein deficiency is strongly associated with disrupted energy balance. We also identified a correlation between these two variables, suggesting a consistent and proportional relationship between protein status and energy balance.

Analysis of the difference between groups with different levels of protein deviation in the case of low wellbeing group (Table 4), performed using the Kruskal Wallis H Test, including the Mann-Whitney U Test (the Bonferroni correction was not applied because we had only one comparison), revealed two significant differences: (a) the Energy Deviation (ED) differs significantly in those with below PD (n=3, Mean Rank 5, M=-47.30) compared to over PD (n=3, Mean Rank

2, M=8.19), Mann-Whitney U Test (z=-2.236, p=0.025); (b) Foods B were consumed differently by the same subgroups below PD (n=3, Mean Rank 5, M=2.40) and over PD (n=3, Mean Rank 2, M=1.90), Mann-Whitney U Test (z=-1.993, p=0.046).

It was found that, within the low wellbeing group, energy deviation and the consumption of Foods B differed significantly for respondents with a below normal PD compared to those with an over normal PD (p≤0.05). In the high wellbeing group, no statistically significant differences were found with respect to protein deviation. Zielińska *et al.* (2023) show the impact of nutrient deficiencies on the risk of depression by a comprehensive synthesis of existing data. Protein serves as a crucial source of amino acids that serve as precursors to neurotransmitters within the brain. Reuter *et al.* (2021) show that a diet rich in tryptophan has a positive effect on mood. The fact that protein deviation correlates with energy deviation and both correlate with Foods B (low in tryptophan) in the case of those with low wellbeing led us to infer that Foods B may be nutritionally inadequate, and contribute to metabolic and nutritional imbalances in this population.

**Table 3. Statistical indicators for the PD – protein deviation groups (below, normal and over)**

Indicators	Below PD (n=5)		Normal PD (n=5)		Over PD (n=10)	
	mean±SD	Med	mean±SD	Med	mean±SD	Med
Wellbeing	58.60±19.99	49.00	68.00±11.31	64.00	69.10±21.33	70.00
PD	-36.75±17.04	-36.75	-1.00±10.72	-3.50	55.32±38.78	40.30
ED	-41.30±10.04	-46.33	2.21±33.55	-10.47	-4.36±17.59	2.73
BMI	24.10±3.81	24.71	23.53±23.74	4.03	23.50±3.96	22.76
Foods A	1.56±0.56	1.60	2.06±0.51	1.90	2.00±0.52	1.85
Foods B	2.56±2.40	0.32	1.94±0.72	2.10	2.05±0.44	2.05

PD: Protein Deviation; ED: Energy Deviation; BMI: Body Mass Index; Foods A: Foods rich in tryptophan; Foods B: Foods low in tryptophan; Med; Median; SD: Standard Deviation

**Table 4. Statistical indicators for low-wellbeing group in terms of protein deviation**

Indicators	Below PD (n=5)		Over PD (n=3)	
	mean±SD	Med	mean±SD	Med
Wellbeing	44.33±4.50	44.00	43.00±9.53	48.00
PD	-43.53±19.58	-45.57	71.91±59.94	47.57
ED	-43.67±10.34	-47.30	4.42±6.99	8.19
BMI	24.52±4.96	24.71	20.77±2.26	20.76
Foods A	1.90±0.43	1.70	1.96±0.37	1.80
Foods B	2.56±0.28	2.40	1.76±0.41	1.90

PD: Protein Deviation; ED: Energy Deviation; BMI: Body Mass Index; Foods A: Foods rich in tryptophan; Foods B: Foods low in tryptophan; Med: Median; SD: Standard Deviation

Differences in the consumption of foods containing tryptophan among the groups investigated. Analysis of differences between paired foods (rich versus low in tryptophan) for the high wellbeing group, performed using the Wilcoxon Test, indicated which foods B (low in tryptophan) were preferred: lactic acid products more than cheeses (B1/A1,  $z=-3.002$ ,  $p=0.003$ ), potatoes more than cabbage (the only preference for a rich tryptophan foods A8/B8,  $z=-2.394$ ,  $p=0.017$ ), pork more than turkey (B3/A3,  $z=-2.509$ ,  $p=0.012$ ), chocolate more than halva (B9/A9,  $z=-2.821$ ,  $p=0.005$ ). For the low wellbeing group, the following foods were preferred: pork more than turkey (B3/A3,  $z=-2.121$ ,  $p=0.034$ ), chocolate more than halva (B9/A9,  $z=-2.041$ ,  $p=0.041$ ). Respondents with a low wellbeing registered two preferences shared with respondents with a high wellbeing, in the sense that they preferred pork over turkey (B3/A3), chocolate over halva (B9/A9), the difference being that respondents with a high wellbeing additionally selected lactic acid products over cheeses (B1/A1), and potatoes over cabbage (A8/B8).

Analysis of differences between paired foods (rich versus low in tryptophan) for the groups with normal PD and over normal PD, performed using the Wilcoxon Test, indicated which foods B were preferred: lactic acid products were consumed more than cheeses (B1/A1, normal PI:  $z=-2.236$ ,  $p=0.025$ ; over PI:  $z=-2.392$ ,  $p=0.017$ ), and chocolate more than halva (B9/A9, normal PI:  $z=-2.070$ ,  $p=0.038$ ; over PI:  $z=-2.234$ ,  $p=0.024$ ).

In terms of selecting a certain type of food, respondents with a normal and over normal protein deviation opted more for the following two Foods B: lactic acid products (B1/A1) and chocolate (B9/A9). Certain foods from group B

(low in tryptophan), such as pork and chocolate, are common preferences regardless of wellbeing. Certain foods from the Foods B category, such as lactic acid products and chocolate, were preferred by those with a high wellbeing and by those with over normal and normal protein deviation.

## CONCLUSION

Without ignoring the multitude of factors that can influence wellbeing, the study identified that there is symmetrical relationship and positive association between protein deviation and wellbeing, that is, if we reverse the variables, the Gamma value remains the same. We found some significant correlations that are worth exploring in the future (in the over-normal protein deviation group, low wellbeing group). Protein deviation differed significantly according to wellbeing, with greater protein deviation observed among respondents with lower levels of wellbeing. Also, for the low wellbeing group, we identified that the Energy Deviation (ED) and the consumption of Foods B (low in tryptophan) differed significantly between the below normal and over normal protein deviation groups.

Our study is exploratory. Therefore further studies are needed to shed light on whether the low wellbeing of students is related to the low protein, low energy diet and the consumption of low tryptophan-proteins. A simple nutritional assessment (protein and energy deviation, tryptophan level) can contribute to a better understanding of the level of wellbeing and vice versa. The findings of this study may further contribute; (1) by creating prevention programs (like screening for protein deviation could help identify wellbeing risks early); (2) by creating projects with a global and multidisciplinary approach to the topic of wellbeing and

mental health issues (like integrate nutrition into wellbeing programs health issues), and (3) therapeutic interventions and individual nutritional recommendations (such as correcting protein deviation in parallel with measurable improvements in wellbeing).

#### **ACKNOWLEDGMENT**

The authors declare that there has been no funding to carry out this study.

#### **DECLARATION OF CONFLICT OF INTEREST**

The authors declare no conflict of interest.

#### **DECLARATION OF GENERATIVE AI IN SCIENTIFIC WRITING**

The authors declare that they did not use generative AI in scientific writing.

#### **REFERENCES**

- Aranda P, Camiletti-Moirón D, Aparicio VA, Nebot E, Medina G, Martínez R, Kapravelou G, Andrade A, Porres JM, López-Jurado M. 2015. High-protein diet induces oxidative stress in rat brain: Protective action of high-intensity exercise against lipid peroxidation. *Nutr Hosp* 31(2):866–874. <https://doi.org/10.3305/nh.2015.31.2.8182>
- Ares G, De Saldamando L, Giménez A, Deliza R. 2014. Food and wellbeing: Towards a consumer-based approach. *Appetite* 74:61–69. <https://doi.org/10.1016/j.appet.2013.11.017>
- Azman ANM, Shamsudin J, Nor ZM. 2024. Self-Esteem, body mass index status and risk of eating disorders among health sciences students. *J Gizi Pangan* 19(3):137–146. <https://doi.org/10.25182/jgp.2024.19.3.137-146>
- Block LG, Grier SA, Childers TL, Davis B, Ebert JEI, Kumanyika S, Laczniak RN, Machin JE, Motley CM, Peracchio L *et al.* 2011. From nutrients to nurturance: A conceptual introduction to food wellbeing. *J Public Policy Mark* 30(1):5–13. <https://doi.org/10.1509/jppm.30.1.5>
- Colzato LS, de Haan AM, Hommel B. 2015. Food for creativity: Tyrosine promotes deep thinking. *Psychol Res* 79(5):709–714. <https://doi.org/10.1007/s00426-014-0610-4>
- Dunne A. 2012. Food and mood: Evidence for diet-related changes in Mental Health. *Br J Community Nurs* 17(Sup11):S20–S24. <https://doi.org/10.12968/bjcn.2012.17.Sup11.S20>
- Friedman M. 2018. Analysis, nutrition, and health benefits of tryptophan. *Int J Tryptophan Res* 11:1178646918802282. <https://doi.org/10.1177/1178646918802282>
- Gardner MP, Wansink B, Kim Y, Park S. 2014. Better moods for better eating? How mood influences food choice. *J Consum Psychol* 24(3):320–335. <https://doi.org/10.1016/j.jcps.2014.01.002>
- Gerber M, Jakowski S, Kellmann M, Cody R, Gygax B, Ludyga S, Müller C, Ramseyer S, Beckmann J. 2023. Macronutrient intake as a prospective predictor of depressive symptom severity: An exploratory study with adolescent elite athletes. *Psychol Sport Exerc* 67:102442. <https://doi.org/10.1016/j.psychsport.2023.102442>
- Greenfield S. 2020. *A Day in the Life of the Brain – The Neuroscience of Consciousness from Dawn Till Dusk*. Bucharest (RO): Niculescu Publishing House.
- Healthy Food Near Me. 2020. Tryptophan in Foods (Table). <https://healthy-food-near-me.com/the-tryptophan-in-food-table> [Accessed 10 November 2023]
- Holder MD. 2019. The contribution of food consumption to wellbeing. *Ann Nutr Metab* 74(Suppl.2):44–51. <https://doi.org/10.1159/000499147>
- Ianchici R. 2008. *Theoretical and Practical Notions of Human Nutrition*. Arad (RO): Aurel Vlaicu University Publishing House.
- Jenkins TA, Nguyen JCD, Polglaze KE, Bertrand PP. 2016. Influence of tryptophan and serotonin on mood and cognition with a possible role of the gut-brain axis. *Nutr* 8(1):1–15. <https://doi.org/10.3390/nu8010056>
- Kałużna-Czaplińska J, Gątarek P, Chirumbolo S, Chartrand MS. 2019. How important is tryptophan in human health? *Crit Rev Food Sci Nutr* 59(1):72–88. <https://doi.org/10.1080/10408398.2017.1357534>

- Liță S. 2018. Evaluating Change in Psychological Interventions – Using the WHO-5 Scale on Psychological Well-Being. National Symposium on Psychology of the Romanian Police, Bucharest.
- Lopez MJ, Mohiuddin SS. 2024. Biochemistry, Essential Amino Acids. Treasure Island (FL): StatPearls Publishing.
- Mosconi L. 2021. Brain Food: Unlock Your Cognitive Power Through Nutrition. Bucharest (RO): Curtea Veche Publishing.
- Muscaritoli M. 2021. The impact of nutrients on mental health and well-being: Insights from the literature. *Front Nutr* 8:656290 <https://doi.org/10.3389/fnut.2021.656290>
- Musumeci G, Castrogiovanni P, Szychlińska MA, Imbesi R, Loreto C, Castorina S, Giunta S. 2017. Protective effects of high tryptophan diet on aging-induced passive avoidance impairment and hippocampal apoptosis. *Brain Res Bull* 128:76–82. <https://doi.org/10.1016/j.brainresbull.2016.11.007>
- Oh J, Yun K, Chae JH, Kim TS. 2020. Association between macronutrients intake and depression in the United States and South Korea. *Front Psychiatry* 11:207. <https://doi.org/10.3389/fpsy.2020.00207>
- Pedersen AN, Kondrup J, Børsheim E. 2013. Health effects of protein intake in healthy adults: A systematic literature review. *Food Nutr Res* 57(1):212–245. <https://doi.org/10.3402/fnr.v57i0.21245>
- Reuter M, Zamoscik V, Plieger T, Bravo R, Ugartemendia L, Rodriguez A, Kirsch P. 2021. Tryptophan-rich diet is negatively associated with depression and positively linked to social cognition. *Nutr Res Rev* 85:14–20. <https://doi.org/10.1016/j.nutres.2020.10.005>
- Schramme T. 2023. Health as complete well-being: The WHO definition and beyond. *Public Health Ethics* 16(3):210–218. <https://doi.org/10.1093/phe/phad017>
- Sischka PE, Costa AP, Steffgen G, Schmidt AF. 2020. The WHO-5 well-being index – validation based on item response theory and the analysis of measurement invariance across 35 countries. *J Affect Disord Rep* 1:100020. <https://doi.org/10.1016/j.jadr.2020.100020>
- Simons G, Baldwin DS. 2021. A critical review of the definition of wellbeing for doctors and their patients in a post Covid-19 era. *Int J Soc Psychiatr* 67(8):984–991. <https://doi.org/10.1177/00207640211032259>
- Steenbergen L, Sellaro R, Hommel B, Colzato LS. 2015. Tyrosine promotes cognitive flexibility: evidence from proactive vs. reactive control during task switching performance. *Neuropsychologia* 69:50–55. <https://doi.org/10.1016/j.neuropsychologia.2015.01.022>
- Toker L, Amar S, Bersudsky Y, Benjamin J, Klein E. 2010. The biology of tryptophan depletion and mood disorders. *Isr J Psychiatry Relat Sci* 47(1):46–55.
- [WHO] World Health Organization. 2024. WHO-5 well-being index – background information. [https://cdn.who.int/media/docs/default-source/mental-health/who-5\\_english-original4da539d6ed4b49389e3afe47cda2326a.pdf?sfvrsn=ed43f352\\_11&download=true](https://cdn.who.int/media/docs/default-source/mental-health/who-5_english-original4da539d6ed4b49389e3afe47cda2326a.pdf?sfvrsn=ed43f352_11&download=true) [Accessed 9th May 2024].
- Xu M, Zhou EY, Shi H. 2025. Tryptophan and its metabolite serotonin impact metabolic and mental disorders via the brain–gut–microbiome axis: A Focus on sex differences *cells* 14(5):384. <https://doi.org/10.3390/cells14050384>
- Zielińska M, Łuszczki E, Dereń K. 2023. Dietary nutrient deficiencies and risk of depression (review article 2018–2023). *Nutr* 15(11):2433. <https://doi.org/10.3390/nu15112433>