

Krasowska Dominika, Jastrzębska-Mierzyńska Marta, Kwiatkowski Michał, Hermanowicz Adam. The effect of consumption of selected nutrients on the occurrence and course of depression. Journal of Education, Health and Sport. 2021;11(9):351-361. eISSN 2391-8306. DOI <http://dx.doi.org/10.12775/JEHS.2021.11.09.044>
<https://apcz.umk.pl/JEHS/article/view/JEHS.2021.11.09.044>
<https://zenodo.org/record/5518232>

The journal has had 5 points in Ministry of Science and Higher Education parametric evaluation. § 8. 2) and § 12. 1. 2) 22.02.2019.

© The Authors 2021;

This article is published with open access at Licensee Open Journal Systems of Nicolaus Copernicus University in Torun, Poland

Open Access. This article is distributed under the terms of the Creative Commons Attribution Noncommercial License which permits any noncommercial use, distribution, and reproduction in any medium, provided the original author (s) and source are credited. This is an open access article licensed under the terms of the Creative Commons Attribution Non commercial license Share alike.

(<http://creativecommons.org/licenses/by-nc-sa/4.0/>) which permits unrestricted, non commercial use, distribution and reproduction in any medium, provided the work is properly cited.

The authors declare that there is no conflict of interests regarding the publication of this paper.

Received: 13.09.2021. Revised: 20.09.2021. Accepted: 21.09.2021.

The effect of consumption of selected nutrients on the occurrence and course of depression

Wpływ spożycia wybranych składników pokarmowych na występowanie i przebieg depresji

Dominika Krasowska¹, Marta Jastrzębska-Mierzyńska², Michał Kwiatkowski³, Adam Hermanowicz⁴

¹ul. Włociańska 7/1, 15-199 Białystok

e-mail: dkrasowska@vp.pl

ORCID: 0000-0003-3265-6349

²Zakład Dietetyki i Żywienia Klinicznego, Uniwersytet Medyczny w Białymstoku, ul. Mieszka I-go 4B, 15-054 Białystok (Department of Dietetics and Clinical Nutrition, Medical University of Białystok)

e-mail: marta.jastrzebska@umb.edu.pl

ORCID: 0000-0002-1914-9783

³Klinika Ortopedii i Traumatologii Dziecięcej, Uniwersytet Medyczny w Białymstoku, ul. Waszyngtona 17, 15-274 Białystok (Department of Pediatric Orthopedics and Traumatology, Medical University of Białystok)

e-mail: michalkwiatkowski@bialan.pl

ORCID: 0000-0003-0891-2402

⁴Klinika Chirurgii Dziecięcej i Urologii w UDSK w Białymstoku, ul. Waszyngtona 17, 15-274 Białystok (Department of Pediatric Surgery and Urology at UDSK in Białystok)

e-mail: ahermanowicz@wp.pl

ORCID: 0000-0002-5723-6941

The article is based on a bachelor's thesis, written as a part of the first cycle of studies at the Medical University of Białystok

Artykuł na podstawie pracy licencjackiej, napisanej w ramach zakończenia studiów I stopnia na Uniwersytecie Medycznym w Białymstoku

SUMMARY

Depression is a disease characterized by both mental and somatic disorders. The 21st century turned out to be the time when depression became a real health threat not only to individuals but also to entire societies. There are many theories pointing to the causes of depression, but these immediate causes are still not definitively clear. Equivalent importance of neuroanatomical and psycho-social factors is indicated. Among the theories considered so far, there are biological, hormonal, neurotransmitter-related, describing the malfunctions of the limbic system and hypothalamus, psychological theories. The studies conducted so far show that psychosocial factors play an extremely important role in the etiology of depression. Symptoms of depression are very complex and multifaceted, and may vary in severity. As a result of studies on the risk factors for depression, a relationship between the deficiency of individual nutrients and the manifestation of depressive disorders has been shown. The aim of the study is to present the influence of particular nutrients on the occurrence and course of depression. A properly balanced diet, both quantitatively and qualitatively, has a positive effect on reducing the risk of depression, as well as improving the condition of people who already suffer from it. Among the nutrients of particular importance are vitamin D, magnesium, folic acid, tryptophan, zinc, omega-3 fatty acids, cobalamin, and some probiotic microorganisms.

STRESZCZENIE

Depresja jest chorobą, którą charakteryzują zarówno zaburzenia psychiczne, jak i somatyczne. XXI wiek okazał się być czasem, w którym depresja stała się realnym zagrożeniem dla zdrowia nie tylko poszczególnych jednostek, ale także całych społeczeństw. Istnieje wiele teorii wskazujących na przyczyny występowania depresji, jednak te bezpośrednie podłoża nadal nie są ostatecznie uznane jako całkowicie klarowne. Wskazuje się na równoznaczną istotność czynników neuroanatomicznych oraz psychologiczno-społecznych. Wśród rozpatrywanych dotychczasowo teorii można wyróżnić biologiczną, hormonalną, związaną z neuroprzekaźnikami, opisującą wadliwe funkcjonowanie układu limbicznego i podwzgórza, teorie psychologiczne. Z przeprowadzonych dotychczas badań wynika, iż niezwykle istotną rolę w etiologii depresji odgrywają czynniki psychospołeczne. Objawy depresji są bardzo złożone i wielopłaszczyznowe, mogące posiadać różny stopień nasilenia. W wyniku badań dotyczących czynników ryzyka występowania depresji wykazano zależność pomiędzy niedoborem poszczególnych składników pokarmowych a ujawnianiem się zaburzeń depresyjnych. Celem pracy jest przedstawienie wpływu poszczególnych składników pokarmowych na występowanie i przebieg depresji. Właściwie zbilansowana dieta, zarówno pod kątem ilościowym, jak i jakościowym, wywiera pozytywny wpływ na zmniejszenie ryzyka wystąpienia depresji, a także poprawienie stanu osób, które już na nią cierpią. Wśród składników odżywczych, które mają tu szczególne znaczenie, znajdują się witamina D, magnez, kwas foliowy, tryptofan, cynk, kwasy tłuszczowe omega-3, kobalamina, niektóre drobnoustroje probiotyczne.

KEYWORDS: Depression; nutrients; vitamin D; tryptophan; depressive disorder; dietetics

SŁOWA KLUCZOWE: Depresja; składniki odżywcze; witamina D; tryptofan; zaburzenia depresyjne; dietetyka

INTRODUCTION

Depression is a disease characterized by both mental and somatic disorders. It manifests itself, inter alia, in a long-term depression of mood and life activity, a sense of helplessness, anxiety and ineffectiveness in action. It leads to significant mental, somatic and behavioral changes that impair the patient's ability to function properly in everyday life (1,3,4,5).

According to a 2011 survey by the Central Statistical Office, more than 11% of adult European Union citizens suffered from depression, while in the case of Poland - 2%. About 450 million people worldwide struggled with this disease in 2015 (7). In Polish society, women are more likely to suffer from major depression than men. This particularly applies to Polish women over 50. In turn, both women and men of all ages suffer from minor depression, i.e. the one with a low severity of symptoms, with the same frequency (8). The 21st century turned out to be the time when depression became a real threat to the health of not only individuals but also entire societies (1).

There are many theories pointing to the causes of depression, but these immediate causes are still not definitively clear. Equivalent importance of neuroanatomical and psycho-social factors is indicated (1). Among the theories considered so far, there can be distinguished biological, indicating, inter alia, genetic predisposition and neurodegenerative changes in the brain, as well as the hormonal theory related to hypercortisolemia, thyroxine and testosterone deficiency in men and estrogen in women (1,9,10). Another theory points to disturbances in the functioning of neurotransmitters and concerns serotonergic, cholinergic, dopaminergic, noradrenergic and GABA-ergic neurons (1,11). The theory describing the malfunction of the limbic system and the hypothalamus distinguishes a number of factors that can lead to these disorders. There are side effects of certain medications, alcohol and drug abuse, exposure to stress, changes in the endocrine system, and diseases such as AIDS, influenza, anemia, malignancies, Addison's disease, asthma, diabetes, enteritis and liver and thyroid disease (1). Psychological theories include: psychoanalytical, humanistic and cognitive-behavioral theory. The first one, related to psychoanalysis, concerns the lack of satisfaction of a person's emotional needs, which go back to the earliest years of his life. The humanistic theory is based on the Abraham Maslow's needs pyramid, while the cognitive-behavioral theory is based on dysfunctional beliefs or learned helplessness (1,13).

The research conducted so far shows that psychosocial factors play an extremely important role in the etiology of depression, including stress or the experience of difficult events related to the immediate environment. However, it is important that some people are more susceptible to this disease, which depends, for example, on childhood trauma, genetic predisposition, and having a neurotic personality (1,2,14).

Symptoms of depression are very complex and multifaceted, and may vary in severity. Weakened concentration, slowdown in action, anhedonia, difficulties in making decisions - these are just some of the symptoms that persist for more than 2 weeks and cause the inability to function properly in everyday life, indicate the development of depression. (1,15,16). As a result of studies conducted at the Department of Adult Psychiatry, Medical University of Lodz, significant cognitive and executive dysfunction in patients with depression was demonstrated (6).

The criteria for the diagnosis of depression according to ICD-10 and DSM-IV are presented in Table 1.

Table 1. Criteria for the diagnosis of depression according to ICD-10 and DSM-IV (1, 17).

ICD-10	DSM-IV
<p>Basic symptoms: - depressed mood -loss of interests and / or joy -lowering energy or increased fatigue</p> <p>Additional symptoms: 1. Loss of self-worth 2. Feeling of guilt 3. Suicidal thoughts 4. Disturbance of will, attention 5. Inhibition, anxiety 6. Sleep disturbances 7. Suppression of appetite</p> <p>Mild depressive episode: • at least 2 basic and 2 additional symptoms • The patient may feel discomfort but is functioning properly</p> <p>Moderate depressive episode: • At least 2 primary and 4 additional symptoms • At least 2 weeks and restricts proper functioning</p> <p>Severe depressive episode: • 3 basic symptoms and at least 4 additional symptoms • Considerably severe symptoms completely disrupt functioning</p>	<p>Occurrence of at least 5 of the following symptoms for at least 2 weeks. There must be a depressed mood or loss of interest.</p> <ul style="list-style-type: none"> - depressed mood for most of the day - a significant reduction in the interests or enjoyments associated with normal activities - significant weight loss or weight gain - insomnia or an excessive need for sleep - psychomotor agitation or slowness - tiredness or loss of energy - feeling of lower value or guilt - disturbance of concentration - recurring thoughts about death - suicidal thoughts or attempts <p>There must be clinically significant discomfort and dysfunction.</p> <p>Symptoms can't be the result of a physical condition or the effects of a substance (for example, drugs or medications).</p>

The symptoms of depression divided by Kwame McKenzie into psychopathological and somatic are shown in Table 2.

Table 2. Psychopathological and somatic symptoms of depression according to McKenzie (1, 12)

Psychopathological symptoms	Somatic symptoms
-depressed mood -loss of interests -anxiety -emotional indifference -depressive thinking -disorders of concentration, attention and memory -delusions - suicidal tendencies	- sleep disturbances - trouble falling asleep - waking up early or sleeping too long - mental and physical slowdown - a decrease or increase in appetite - a decrease or increase in weight -loss of interest in intercourse -fatigue

As a result of studies on the risk factors for depression, a relationship between the deficiency of individual nutrients and the manifestation of depressive disorders has been shown. An unbalanced, improper diet can aggravate nutritional deficiencies, which in turn contributes to the aggravation of the symptoms of the disease. Food low in vitamins and microelements and high in sugars, processed meat, saturated fatty acids, and trans unsaturated fatty acids make depression more likely. At the same time, a properly balanced diet, both quantitatively and qualitatively, has a positive effect on reducing the risk of this disease, as well as improving the condition of people who already suffer from it (18, 19, 20, 21).

OBJECTIVE OF THE WORK

The aim of the study is to present the influence of particular nutrients on the occurrence and course of depression.

STATE OF THE KNOWLEDGE DESCRIPTION

The influence of particular nutrients on the occurrence and course of depression.

VITAMIN D

The studies conducted so far have proved that vitamin D plays an important role in the functioning of the building structures of the central nervous system. Additionally, microglial cells, oligodendrocytes, astrocytes and Schwann cells are able to respond to its active metabolites. As a result, vitamin D exhibits neuroprotective effects in these areas (24, 25). Maintaining neurons and their functioning in optimal condition is also possible due to the fact that nuclear vitamin D receptors are present, among others, in the brain. This allows the regulation of calcium homeostasis as well as the synthesis of neurotrophins. It has also been shown that the correct concentration of this vitamin in the body contributes to the improvement of cognitive functions (24, 25, 26). It has been proven that there is a relationship between too low vitamin D levels and the frequency and severity of depression (27, 28). Norwegian scientists conducted a study on 441 overweight or obese patients with depression. The first group received vitamin D once a week for a year in the amount of 20,000 IU, while the second group - 40,000 IU. The third group was supplemented with a placebo. It turned out that in patients from the first two groups there was a reduction in symptoms of depression, which was not observed in the placebo group (24). A systematic review and meta-analysis of observational and randomized controlled trials, conducted by Anglin and co-authors, involving a total of 31,424 people, proved that a reduced level of vitamin D is noticeable in people who suffer from depression (30). Another study by Shaffer and co-authors, involving 3,191 people with depressive disorders or clinically significant symptoms of depression, showed that supplementation with vitamin D contributed to the improvement of patients' health, and statistical significance was demonstrated (31). In the case of breastfed infants, it turned out that those receiving milk from a mother with vitamin D deficiency were more likely to suffer from depression in their adulthood, compared to children who received an adequate amount of vitamin with food (32, 33). It is worth paying attention to the fact that people suffering from depression often avoid leaving the house, which results in reduced exposure to sunlight, and therefore insufficient endogenous synthesis of vitamin D. Latitude also plays an important role, as people living in areas with little sunshine all year round show a greater risk of depressive disorders compared to those living in areas with better sunshine (32, 33).

MAGNESIUM

Magnesium has antidepressant and anxiolytic properties. It takes part in the neurotransmission pathways associated with depressive symptoms. It affects glutamatergic transmission, which is assigned a significant role in the etiology and pathogenesis of depression. It regulates the activity of P-glycoprotein, which allows for the maintenance of the proper permeability of the blood-brain barrier, e.g. for glucocorticoids and mineralocorticoids. Disturbances in the functioning of this transport can lead to excessive penetration of corticosteroids to the brain, which may damage the hippocampus and defective activity of the pituitary-hypothalamus-adrenal axis (34,35,36). Magnesium also affects the activity of calcium channels coupled with N-methyl-d-aspartate, and in its deficiency, their tendency to open is observed, which results in damage to nerve cells (37). Insufficient amount of magnesium in the body contributes to the occurrence of depressive symptoms, which is especially noticeable in young adults. One can distinguish here, among others, the feeling of anxiety, apathy, and disorientation (35, 38). The studies conducted so far have shown a relationship between the low level of magnesium in the blood serum of patients with depression and the course of their disease. Patients with chronic unipolar depression had a reduced concentration of magnesium, but this was not noticed in patients with acute episodes of depression. Additionally, the correlation between the phase of the disease and the level of magnesium has been proven. It was manifested in the fact that patients with developed depression had the level of this element in the blood too low, and when their health improved - the concentration of magnesium returned to normal (39,40).

FOLIC ACID

Folic acid is involved in regulating the metabolism of methionine and homocysteine. Too low concentration of folate in the body is associated with excess concentration of homocysteine. This can result in more severe depressive episodes. It is also important that folic acid is responsible for the synthesis of S-adenosylmethionine, which is involved in the metabolism of catecholamines in the brain. The appropriate level of folates determines the proper neurotransmission, and thus - the optimal functioning of cognitive functions and emotional stability (18, 41, 42, 43). In the USA, a population study was conducted which found that people with low serum folate levels were more prone to anxiety and depressive disorders. Over 40% of people suffering from depression had a deficiency of folic acid in the body, while the lower this level was, the disease was more severe. Foliates turned out to have a significant impact on the improvement of the condition of patients in whom the form of the disease was drug-resistant. 800 micrograms is the suggested daily dose that could improve the patient's condition by increasing the response to antidepressant therapy (18,42,44,45). The study, conducted among 309 Japanese and 208 Japanese women, aged 21-67, aimed to assess the effect of too little folic acid consumption on increasing the risk of depression. It turned out that men who consumed more folate with their diet were characterized by a lower frequency of depression symptoms (34,42,46).

TRYPTOPHAN

Serotonin deficiency contributes to the occurrence of depression, while tryptophan is its precursor. Importantly, 95% of serotonin is produced in the gastrointestinal tract, and the remaining 5% in the nervous system. Providing the exogenous amino acid tryptophan along with the diet reduces the risk of depressive disorders (47). Tryptophan is degraded by indolamine 2,3-dioxygenase, transcriptionally induced by one of the pro-inflammatory interferons. The occurrence of a gene polymorphism related to these substances leads to an increased breakdown of tryptophan and subsequent serotonin deficiency, which in turn results in an increased susceptibility to the development of depression (48).

ZINC

The organ with the highest amount of zinc is the brain. Zinc is responsible, *inter alia*, for the modulation of synaptic plasticity, memory and learning processes, and the regulation of excitations and nerve signal conduction (23, 29). Zinc inhibits the functions of the N-methyl-D-aspartate receptor, thanks to which it exhibits antidepressant properties. It is manifested by the antagonistic effect of zinc on metabotropic glutamatergic receptors (1) and the enhancement of the function of ionotropic receptors (AMPA) and increased synthesis of brain-derived neurotrophic factor (BDNF) (49,50,51,52,53). In a study carried out on rats, it turned out that subjecting them to a three-week zinc-free diet led to the disclosure of a number of depressive symptoms (54). In turn, a study on mice showed that subjecting them to a zinc-poor diet, covering only 40% of the requirement for this ingredient, resulted in an increase in depressive behavior (55). Vashum and co-authors conducted a study showing that, regardless of gender, too low levels of zinc correlated with a greater likelihood of developing depression (56).

OMEGA-3 FATTY ACIDS

Omega-3 fatty acids, in addition to many beneficial functions, also fulfill neuroprotective functions, thanks to which they contribute to the reduction of the risk of depressive disorders (29, 57). The inhabitants of regions with low consumption of marine fish rich in omega-3 fatty acids have a higher incidence of depression (58,59,60). In people with depressive disorders, increased production of inflammatory cytokines from arachidonic acid is observed, and omega-3 fatty acids contribute to the reduction of this production (58, 61). Too low concentration of these acids in the body is related to the low concentration of 5-hydroxyindole acetic acid in the brain, which is the main metabolite of serotonin. This indicates a relationship between omega-3 fatty acids and the proper functioning of the serotonergic system (58, 62). A study on mice by Kang and Gleason demonstrated the neurogenesis of the hippocampus when administered with DHA. This is particularly important due to the fact that people suffering from depression are prone to atrophy of this brain structure (63).

VITAMIN B12

Vitamin B12 deficiency contributes to the drug-resistant form of depression and is observed in red blood cells and blood plasma of patients (64, 65, 66). A study by Natasha Kate and co-authors on two vegetarians with low levels of cobalamin in the blood serum and lack of response to three different antidepressants showed that supplementing vitamin B12 with folic acid resulted in a reduction of depression symptoms and a response to the use of antidepressants (67). Cobalamin is involved in the metabolism of homocysteine, the level of which is elevated in people suffering from depression (22). A 2012-2013 study among 100 vegetarians and 100 omnivores showed that vegetarians had a lower concentration of cobalamin than people in the group consuming animal products. Additionally, they struggled with neuropsychiatric and neurological problems, so it can be concluded that vegetarians are at a higher risk of depression due to vitamin B12 deficiency (68). A systematic review by Almeida and co-authors indicated that short-term cobalamin supplementation did not affect the health of people suffering from depression treated with antidepressants, while its long-term use, i.e. lasting from several weeks to several years, may reduce the risk of recurrence as well as alleviate disease symptoms (69).

PROBIOTIC MICROORGANISMS

Emotional lability and the occurrence of anxiety disorders are influenced by both the quantitative and qualitative composition of the microbiota. Patients suffering from depression show a disturbance in the proportion between bacteria of the Bacteroides because they have an excess of bacteria of the Alistipes (70,71). Huang and Wang conducted a meta-analysis, which showed that the use of probiotics contributed to the alleviation of depressive symptoms in people under 60 years of age (72). Another study using the probiotic bacteria Lactobacillus Plantarum 299v (LP299v) proved that microbiota can exert a great influence on modulating the cognitive functions of the central nervous system. One of the groups was taking drugs with LP299v, while the other was taking placebo. It turned out that the people taking LP299v achieved an improvement in cognitive functions, which could be associated with a decrease in the concentration of kynurenine, a metabolite of tryptophan (73).

CONCLUSIONS

Depression is a polyetiological disease, and one of the reasons for its occurrence is an unbalanced diet, containing an insufficient amount of nutrients such as vitamin D, magnesium, folic acid, tryptophan, zinc, omega-3 fatty acids, vitamin B12, and some probiotic microorganisms. Adequate dietary intake of these nutrients contributes to a reduced risk of this disease. It also helps to alleviate the symptoms of depression, and even respond to drugs in the case of drug-resistant form. Due to the fact that depression is a disease affecting a relatively large number of people around the world, it seems necessary to conduct research that would allow for drawing conclusions that would enable to explore the possibilities of improving the condition of patients suffering from this disease.

BIBLIOGRAPHY

1. Lelonek B, Wiraszka G, Puciłowska M, Ilendo-Milewska A, Zakrzewska K: Depresja – współczesny problem zdrowia psychicznego i zagrożenie cywilizacji; Problem depresji w środowisku młodzieży gimnazjalnej; Choroby o podłożu psychicznym – depresja. Postawy młodzieży wobec chorób psychicznych, na przykładzie badań uczniów gimnazjum. [w:] Wybrane choroby cywilizacyjne XXI wieku. Kowalczyk K., Krajewska-Kułak E., Cybulski M. (red.). Druk: „Duchno” Piotr Duchnowski, Białystok 2016, 2: 16-84
2. Hart AD, Hart-Weber C: Depresja nastolatka. Biblioteka Uniwersytecka w Warszawie, Warszawa 2007, 89: 98-100
3. Kalat JW: Biologiczne podstawy psychologii. Wydawnictwo Naukowe PWN, Warszawa 2006
4. Heitzman J: Zaburzenia depresyjne DSM-5 selections, Edra Urban&Partner, Wrocław 2017
5. Jaeschke R, Siwek M, Grabski B, Dudek D: Współwystępowanie zaburzeń depresyjnych i lękowych, Psychiatria 2010, 7: 189-197
6. Talarowska M, Florkowski A, Gałeczki P, Wysokiński A, Zboralski K: Funkcje poznawcze w depresji, Psychiatria Polska 2009, 43: 31–40
7. Kuźel A, Krajewska-Kułak E, Śmigielska-Kuzia J: Percepcja depresji w wybranych grupach społecznych, Medycyna Ogólna i Nauki o Zdrowiu 2015, 21: 295–302
8. Kiejna A, Piotrowski P, Adamowski T, Moskalewicz J, Wciórka J, Stokwiszewski J, Rabczyński D, Kessler RC: Rozpowszechnienie wybranych zaburzeń psychicznych w populacji dorosłych Polaków z odniesieniem do płci i struktury wieku – badanie EZOP Polska, Psychiatria Polska 2015, 49: 15–27
9. Clark, DM, Wells, A: A cognitive Model of Social Phobia [w:] Social Phobia. Diagnosis, Assessment and Treatment. R.G. Heimberg, M.R. Liebowitz, D. A. Hope, F. R. Schneier (red.). The Guilford Press, New York –London 1995

10. Flota-Parnowska I: Dynamika stanów depresyjnych w ujęciu A. Lowena [w:] Depresja, esencja i ciało. J. Santorski (red.) Agencja Wydawnicza Jacek Santorski & CO; Warszawa 1992
11. Markowicz-Narękiwicz A, Związek między wydzielaniem neuroprzekazników a powstawaniem chorób psychicznych – na szczegółowo omówionym przykładzie depresji. [w.]. Neurokognitywistyka w patologii i zdrowiu 2009-2011, I. Kojder (red.) Wydawnictwo Pomorskiego Uniwersytetu Medycznego w Szczecinie 2011, s. 55-59
12. Collados Zorraquino J: Depresja u dzieci i młodzieży. Wyd. eSPe, Kraków 2009
13. Diagnostic and statistical manual of mental disorders. Fourth edition (DSM-IV). Washington DC, American Psychiatric Association 1994
14. Klimasiński K: Cechy osobowości a postawy wobec inwalidów. Przegląd Psychologiczny 1976, 19: 71-83
15. Harkness KL, Luther J: Clinical Risk Factors for the Generation of Life Events in Major Depression. Journal of Abnormal Psychology 2001, 4: 110
16. Kostka T, Koziarska-Rościszewska M: Choroby wieku podeszłego, PZWL, Warszawa 2009
17. Pużyński S: Depresje, Wyd. Lekarskie PZWL, Warszawa 1988
18. Karakuła H, Opolska A, Kowal A, Domański M, Płotka A, Perzyński J: Czy dieta ma wpływ na nasz nastrój? Znaczenie kwasu foliowego i homocysteiny. Polski Merkuriusz Lekarski 2009, 26: 136-152
19. Majkutewicz P, Tyszko P, Okręglińska K, Leczenie żywieniowe depresji, Family Medicine & Primary Care Review 2014, 1: 48-50
20. Seppälä J, Kauppinen A, Kautiainen H, Vanhala M, Koponen H: Depression and diet, Duodecim 2014, 130: 902-909
21. Lang UE, Beglinger C, Schweinfurth N, Walter M, Borgwardt S: Nutritional aspects of depression, Cellular Physiology and Biochemistry 2015, 37: 1029-1043. doi: 10.1159/000430229.
22. Bańkowski E: Biochemia, Edra Urban & Partner, Wrocław 2016
23. Włodarek D, Lange E, Kozłowska J, Głąbska D: Dietoterapia, Wydawnictwo Lekarskie PZWL, Warszawa 2015
24. Józefowicz O, Rabe-Jabłońska J, Bogaczewicz J, Woźniacka A: Rola witaminy D3 w patogenezie zaburzeń psychicznych, Psychiatria i Psychologia Kliniczna 2009, 9: 200-206
25. McCann JC, Ames BN: Is there convincing biological or behavioral evidence linking vitamin D deficiency to brain dysfunction? The FASEB Journal 2008, 22: 982-1001
26. Przybelski RJ, Binkley NC: Is vitamin D important for pre-serving cognition? A positive correlation of serum 25-hydroxyvitamin D concentration with cognitive function. Archives of Biochemistry and Biophysics 2007, 460: 202-205
27. Dittfeld A, Gwizdek K, Koszowska A, Fizia K: Wielokierunkowe działanie witaminy D, Annales Academiae Medicae Silesiensis 2014, 68: 47-52
28. Grant WB, Holick MF. Benefits and requirements of vitamin D for optimal health: A review. Alternative Medicine Review 2005, 2: 94–11
29. Jarosz M: Normy żywienia dla populacji Polski, Instytut Żywności i Żywienia, Warszawa 2017
30. Anglin RE, Samaan Z, Walter SD, McDonald SD: Vitamin D deficiency and depression in adults: systematic review and meta-analysis, The British Journal of Psychiatry 2013, 202: 100-7
31. Shaffer JA, Edmondson D, Wasson LT, Falzon L, Homma K, Ezeokoli N, Li P, Davidson KW: Vitamin D supplementation for depressive symptoms: a systematic review and meta-analysis of randomized controlled trials, Psychosomatic Medicine 2014, 76: 190-6

32. Grygiel-Górniak B, Puszczewicz M: Witamina D – nowe spojrzenie w medycynie i reumatologii, *Postępy Higieny i Medycyny Doświadczalnej* 2014, 68: 359-368
33. Holick M: Vitamin D deficiency. *The New England Journal of Medicine* 2007, 357: 266-281
34. Stefańska E, Wendołowicz A, Kowzan U, Konarzewska B, Szulc A, Ostrowska L: Czy zwyczajowy sposób żywienia pacjentów z depresją wymaga suplementacji witaminami i składnikami mineralnymi?, *Psychiatria Polska* 2014, 48: 75–88
35. Serefko A, Szopa A, Poleszak E: Magnesium and depression, *Magnesium Research* 2016, 29: 112-119
36. Siwek M, Wróbel A, Dudek D, Nowak G, Zięba A: Udział miedzi i magnezu w patogenezie i terapii zaburzeń afektywnych. *Psychiatria Polska* 2005, 39: 911–920
37. Eby GA 3rd, Eby KL: Magnesium for treatment-resistant depression: a review and hypothesis, *Medical Hypotheses* 2010, 74: 649-60
38. Tarleton EK, Littenberg B.: Magnesium intake and depression in adults, *Journal of American Board of Family Medicine* 2015, 28: 249-56
39. Kirov GK, Birch NJ, Steadman P, Ramsey RG: Plasma magnesium levels in a population of psychiatric patients: Correlations with symptoms. *Neuropsychobiology* 1994, 30: 73-78
40. Eby GA, Eby KL: Rapid recovery from major depression using magnesium treatment. *Medical Hypotheses* 2006, 67: 362-370
41. Czeczot H, Kwas foliowy w fizjologii i patologii, *Postępy Higieny i Medycyny Doświadczalnej* 2008, 62: 405-419
42. Coppen A, Bolander-Gouaille C.: Treatment of depression: time to consider folic acid and vitamin B12, *Journal of Psychopharmacology* 2005, 19: 59-65
43. Kapka-Skrzypczak L, Niedźwiecka J, Skrzypczak M, Wojtyła A: Kwas foliowy – skutki niedoboru i zasadność suplementacji, *Medycyna Ogólna i Nauki o Zdrowiu*, 2012, 18: 65-69
44. Morris MS: Homocysteine and Alzheimer’s disease, *The Lancet Neurology* 2003, 2: 425-428
45. Morris MS, Fava M, Jacques PF i wsp.: Depression and folate status in the US Population, *Psychotherapy and Psychosomatics* 2003, 72: 80-8
46. Murakami K, Mizoue T, Sasaki S, Ohta M, Sato M, Matsushita Y, Mishima N.: Dietary intake of folate, other B vitamins, and omega-3 polyunsaturated fatty acids in relation to depressive symptoms in Japanese adults, *Nutrition* 2008, 24: 140-7
47. Stępień A, Walecka-Kapica E, Błońska A, Klupińska G: Rola tryptofanu i serotoniny w patogenezie leczenia zespołu jelita nadwrażliwego, *Folia Medica Lodziensia* 2014, 41:139-154
48. Myint AM, Bondy B, Baghai TC, Eser D, Nothdurfter C, Schüle C, Zill P, Müller N, Rupprecht R, Schwarz MJ.: Tryptophan metabolism and immunogenetics in major depression: a role for interferon- γ gene; *Brain, Behavior and Immunity*. 2013, 31: 128-33. doi: 10.1016/j.bbi.2013.04.003.
49. Smart TG, Xie X, Krishek BJ: Modulation of inhibitory and excitatory amino acid receptor ion channels by zinc. *Progress in Neurobiology* 1994, 42: 393-41
50. Duman RS, Heninger GR, Nestler EJ: A molecular and cellular theory of depression. *Archives of General Psychiatry* 1997, 54: 597-606
51. Zirpel L, Parks TN: Zinc inhibition of group I mGluR- mediated calcium homeostasis in auditory neurons. *Journal of The Association for Research in Otolaryngology* 2001, 2: 180-7
52. Rassendren FA, Lory P, Pin JP, Nargeot J: Zinc has opposite effects on NMDA and non-NMDA receptors expressed in *Xenopus* oocytes. *Neuron* 1990, 4: 733-40.
53. Gąsior M, Czuczwar S: Receptory GABA. [w:] Nowak ZJ, Zawilska JB (red.) *Receptory i mechanizmy przekazywania sygnału*. Warszawa 2004, 365-82.

54. Tassabehji NM, Corniola RS, Alshingiti A, Levenson CW: Zinc deficiency induces depression-like symptoms in adult rats. *Physiology & Behavior* 2008, 95: 365-69.
55. Whittle N, Lubec G, Singewald N: Zinc deficiency induces enhanced depression-like behaviour and altered limbic activation reversed by antidepressant treatment in mice. *Amino Acids* 2009, 36: 147-58
56. Vashum KP, McEvoy M, Milton AH, McElduff P, Hure A, Byles J, Attia J.: Dietary zinc is associated with a lower incidence of depression: findings from two Australian cohorts, *Journal of Affective Disorders*. 2014, 166: 249-57. doi: 10.1016/j.jad.2014.05.016
57. FAO, Fats and fatty acids in human nutrition. Report of an expert consultation, Rome, 2010
58. Krawczyk K, Rybakowski J: Zastosowanie kwasów tłuszczowych omega-3 w leczeniu depresji, *Farmakoterapia w psychiatrii i neurologii* 2007, 2: 101-10
59. Adams PB, Lawson S, Sanigorski A, Sinclair AJ. Arachidonic acid to eicosapentaenoic acid ratio in blood correlates positively with clinical symptoms of depression. *Lipids* 1996; 31: 157-16
60. Frangou S, Lewis M, McCrone P: Efficacy of ethyl-eicosapentaenoic acid in bipolar depression: randomized double-blind placebo-controlled study. *The British Journal of Psychiatry* 2006, 188: 46-50
61. Służewska A, Rybakowski J, Sobieska M. Aktywacja układu immunologicznego w depresji endogennej. *Psychiatria Polska* 1996, 30: 771-78
62. Hibbeln JR, Salem NJ.: Omega-3 fatty acids and psychiatric disorders. [w:] In: Mostofsky DJ, Yehuda S. Salem NJ. (Red.) *Fatty acids: Physiological and Behavioral Functions*. Humana Press Inc., Totowa, New Jersey 2001, 311-33
63. Kang JX, Gleason ED.: Omega-3 Fatty acids and hippocampal neurogenesis in depression, *CNS & Neurological Disorders Drug Targets*. 2013, 12: 460-5
64. Harbottle I, Schonfelder N. nutrition and depression: a review of the evidence. *Journal of Mental Health* 2008, 17: 576-587
65. Heitzman J. Postępy w diagnostyce i terapii zaburzeń psychicznych. *Przewodnik Lekarza* 2011, 1: 175-181
66. Majkutewicz P, Tyszko P, Okręglińska K: Leczenie żywieniowe depresji, *Family Medicine & Primary Care Review* 2014, 1: 48-50
67. Natasha Kate, Sandeep Grover, Munish Agarwal: Does B12 Deficiency Lead to Lack of Treatment Response to Conventional Antidepressants? *Psychiatry (Edgmont)*. 2010, 7: 42-44
68. Kapoor A, Baig M, Tunio SA, Memon AS, Karmani H.: Neuropsychiatric and neurological problems among Vitamin B12 deficient young vegetarians, *Neurosciences (Riyadh)*. 2017, 22: 228-232
69. Almeida OP, Ford AH, Flicker L: Systematic review and meta-analysis of randomized placebo-controlled trials of folate and vitamin B12 for depression, *International Psychogeriatrics*. 2015, 27: 727-37
70. Gulas E, Wysiadecki G, Strzelecki D, Gawlik-Kotelnicka O, Polgaj M: Jak mikrobiologia może wpływać na psychiatrię? Powiązania między florą bakteryjną jelita zaburzeniami psychicznymi, *Psychiatria Polska ONLINE FIRST* nr 91: 1-17
71. Dash S, Clarke G, Berk M, Jacka FN. The gut microbiome and diet in psychiatry: Focus on depression. *Current Opinion in Psychiatry* 2015, 28: 1-6
72. Huang R, Wang K, Hu J.: Effect of Probiotics on Depression: A Systematic Review and Meta-Analysis of Randomized Controlled Trials, *Nutrients* 2016, 6:8
73. Rudzki L, Ostrowska L, Pawlak D, Małus A, Pawlak K, Waszkiewicz N, Szulc A: Probiotic *Lactobacillus Plantarum* 299v decreases kynurenine concentration and improves cognitive functions in patients with major depression: A double-blind, randomized, placebo controlled study, *Psychoneuroendocrinology* 2019, 100: 213-222