

SERUM VITAMIN B12, FOLATE, AND HEMATOLOGICAL INDICES IN VEGETARIANS AND NON-VEGETARIANS IN ERBIL, IRAQ: A COMPARATIVE CROSS-SECTIONAL STUDY

Zahraakhan Maarooftaher^{1,*}, Zheyen Tahir Younis², Dunya Abdulqader Asaad³, Bakhtawar Ziad Omer¹, Hero Ismael Mohammed¹, Kanyaw Ezzalddin Abdulrahman⁴, Atallah Ahmed Atallah¹, Sara Hachim Sultan¹, Ayah Mouawiah Kassem¹, Noor Muafaq Hasoon¹, and Safaa Khalil Hussien¹

¹ Department of Biomedical Sciences, College of Applied Sciences, Cihan University-Erbil, Erbil, Kurdistan Region, Iraq

² Department of Basic Science, College of Dentistry, Hawler Medical University, Erbil, Kurdistan Region, Iraq

³ Department of Medical Biochemical Analysis, College of Health Technology, Cihan University-Erbil, Erbil, Kurdistan Region, Iraq

⁴ Department of Clinical Biochemistry, College of Health Science, Hawler Medical University, Erbil, Kurdistan Region, Iraq

*Correspondence Email: zahraakhan.maarooft@cihanuniversity.edu.iq

ABSTRACT

Introduction: Vegetarian diets have many health disadvantages; avoiding animal-derived foods may increase the risk of vitamin B12 deficiency, especially vitamin B12 and folate deficiency. This study compared serum vitamin B12 and folate levels between vegetarians and non-vegetarians. **Methods:** This comparative cross-sectional study included 50 healthy participants in Erbil, Iraq: 25 vegetarians and 25 non-vegetarians. Blood samples were collected and analyzed blood samples to determine complete blood count and serum vitamin B12 and folate levels. **Results:** Vegetarians had lower vitamin B12 concentrations with a borderline significant difference ($p=0.050$), while serum folate levels did not differ significantly between groups. Compared with non-vegetarians, vegetarians had significantly lower hemoglobin concentration and red blood cell count ($p < 0.05$), while RDW-SD and RDW-CV were significantly higher ($p < 0.05$). **Conclusion:** This study concluded that vitamin B12 levels decreased and several complete blood count parameters were altered in the vegetarian group. In comparison between the two groups, serum folate levels were not altered.

Keywords: Vegetarian; Non-Vegetarians; Vitamin B12; Folate

INTRODUCTION

A non-vegetarian diet includes both animal-based foods like eggs, dairy products, fish, meat, and chicken, and plant-based foods like green leafy vegetables, rice, and potatoes (Eveleigh et al., 2023). Vegetarian or vegan diets, which either completely or partially forgo these foods, contrast with this eating pattern (Raj et al., 2025). The vegetarian diet plans include plant-based foods such as vegetables, fruits, seeds, and nuts, while excluding fish, meat, and poultry (Tseng et al., 2020). A non-vegetarian diet enables a wider intake of vital nutrients, including accessible iron, vitamin B12, and complete proteins, which are more prevalent in foods of animal origin, because it includes a range of foods from both plant and animal sources (Bruns et al., 2024). In contrast, veganism is a lifestyle that is characterized by excluding animal-based foods and consuming non-animal-origin foods like fruits, vegetables, nuts, and seeds (Bali and Naik, 2023).

Vitamin B12 (Cobalamin) is a water-soluble vitamin that has many important functions in the human body, such as supporting the healthy growth and development of the brain and nervous system, as well as red blood cells, and also functioning as a coenzyme in many metabolic processes, such as the production of DNA, methylation processes, and fatty acid metabolism (Al Amin & Gupta, 2020; Halczuk et al., 2023).

The vitamin B12 deficiency then progresses to megaloblastic anemia and cognitive impairment, which are the most common nutritional defects among vegetarian diets due to animal-derived foods, such as fish, meat, poultry, eggs, and dairy products, being the primary source of vitamin B12, which causes vitamin B12 deficiency (Dhande et al., 2024). Vitamin B9 (Folate) is a water-soluble B-complex vitamin that acts as a cofactor in DNA synthesis and repair, amino acid homeostasis, RBC production, antioxidant generation, and methylation (Lyon et al., 2020). Green leafy vegetables, legumes, fruits, eggs, and liver are the primary natural food sources of folate (Li et al., 2025). Deficiency of vitamin B9 can impair DNA production processes that lead to neuropsychiatric symptoms, megaloblastic anemia, and elevated homocysteine levels, which increase the risk of developing cardiovascular diseases (Baddam et al., 2025). During pregnancy, folate plays an important role in healthy cell division and embryonic growth and development; deficiency can cause neural defects and other congenital abnormalities in the fetus (Buchanan, 2024). The first-line hematological test and one of the most common blood tests requested by clinicians is complete blood count (CBC), which estimates the total number of cell components in the blood, such as red blood cells (RBC), white blood cells (WBC), and platelets, and also evaluates the characteristics of blood cells such as hemoglobin count (Hb), RBC count, hematocrit (HCT) indicates the percentage of total blood volume, mean corpuscular volume (MCV) indicate the average size of red blood cells, mean corpuscular hemoglobin (MCH) evaluate the average amount of Hb per RBC, and mean corpuscular hemoglobin concentration (MCHC) reflects the average concentration of Hb with RBC, red cell distribution width (RDW) Indicates variation in red blood cells size, WBC total and differential count, and platelet count and mean platelet volume (MPV) (Seo and Lee, 2022). Both vitamins must be sufficiently available in the bone marrow for proper erythropoiesis and the development and maturation of adult red blood cells, as they are involved in DNA synthesis and one-carbon metabolism processes; these processes play an essential role in normal DNA production and bone

marrow cell division, leading to normal RBC count, hemoglobin concentration, MCV, and RDW (O'Leary and Samman, 2010; Baddam et al., 2025). Several studies have concluded that the vegetarian diet plan is associated with reduced risks of obesity, type two diabetes mellitus, hypertension, cardiovascular diseases, and cancer, while increasing the risk of some micronutrient deficiencies such as vitamin B12, calcium, vitamin D, zinc, iron, and omega-3 (Melina et al., 2016; Craig et al., 2021). Compared to omnivorous diets, vegetarian diets, especially strict vegan diets, are linked to lower circulating vitamin B12 concentrations and a higher prevalence of B12 deficiency (Rizzo et al., 2016). Due in major part to their consumption of more folate-rich fruits, vegetables, legumes, and whole grains, vegetarians and vegans typically have greater dietary folate and, on average, higher serum folate concentrations than non-vegetarians (Dawczynski et al., 2022). However, folate status varies across populations: some vegetarian communities may still have deficient folate levels without deliberate intake or fortification because of differences in supplement and fortified-food use, regional food patterns, and research methodologies. Studies from other populations have shown variations in vitamin B12, folates, and hematological indices according to dietary patterns. For instance, the study found that Spanish vegetarians had generally high folate status but showed evidence of vitamin B12 insufficiency (Gallego-Narbón et al., 2019). Because dietary patterns may affect vitamin intake and concentration, they may also alter hematological profiles. This study aims to compare serum vitamin B1 and folate levels and hematological parameters between individuals following vegetarian and non-vegetarian diets, and to find the effects of these vitamins on hematological parameters in the human body.

METHODS

A comparative cross-sectional study was designed to estimate and compare the serum levels of vitamin B12 and folate in vegetarians and non-vegetarians. Fifty healthy Participants were chosen from the eligible study population using random sampling. Every eligible participant was assigned a unique identification number, and a list of all participants who met the inclusion criteria was created from September 25 to November 2, 2025. Every participant ranged in age from 18 to 40, and the frequency of female participants in the sample was higher than that of male participants. This sample size was suitable for accomplishing the study's goals within the specified time frame and research environment. Participants were divided into vegetarian (n=25) and non-vegetarian (n=25) groups based on their eating patterns. The vegetarian group had followed a vegetarian diet for at least a year before the study; their diet plans included plant-based foods such as vegetables, fruits, nuts, and legumes, whereas the non-vegetarian group ate animal-based foods such as fish, meat, and poultry at least 3 times per week.

People who did not fit the dietary classification requirements, were beyond the specified age range, or refused to participate were all omitted from the study. Participants with hematological disorders, established

chronic diseases, taking vitamin B12 supplements, any supplements that affect the CBC results, or conditions that might affect the metabolism of folate or vitamin B12 were not allowed to participate. A systematic questionnaire was used to collect demographic information such as age, gender, dietary pattern, duration of vegetarian diet, and medical history. By using a standard operating procedure for phlebotomy, 5 mL of venous blood was drawn from each individual and collected in an EDTA tube for CBC testing and in serum separator tubes (SST), allowed to clot at room temperature for 30 minutes, and then centrifuged at 3,000 rpm for 10 minutes to obtain serum to evaluate serum vitamin B12 and folate. All parameters, complete blood count (CBC), serum vitamin B12, and Folate concentration, were analyzed at the Dina Diagnostic Laboratory in Erbil, Iraq. The Beckman Colter Access Immunoassay System (Beckman Colter, USA) was used to evaluate the amount of serum vitamin B12 and folate using competitive immunoassay methods. Statistical Package for the Social Sciences (SPSS) was used for statistical data analysis. For finding the normality of continuous data in SPSS, the Shapiro-Wilk test was used. Numerical data were expressed as mean $\pm$ standard error, estimated using an independent t-test. To assess associations between categorical (qualitative) variables, Fisher's exact test was used. Pearson correlation coefficient was used to evaluate the statistical correlation (relationship) between two quantitative variables. A statistically non-significant difference is shown by a P-value greater than 0.05, whereas a significant difference is indicated by a probability value (P-value) less than 0.05. A highly significant difference was indicated when the P-value was less than 0.001.

RESULTS

Demographic and lifestyle characteristics of vegetarian and non- vegetarian participants

We used Fisher's exact test to compare demographic and lifestyle features of participants between vegetarians (n = 25) and non-vegetarians (n = 25), as shown in Table 1. With five males and twenty females in each group, the sex distribution was the same in both groups, with no statistically significant difference ($p > 0.999$). Similarly, there was no discernible difference in the participants' smoking status between the two groups. Among vegetarians, there were four smokers and twenty-one non-smokers, whereas the non-vegetarian group had six smokers and nineteen non-smokers ($p = 0.725$). Exercise habits, however, differed notably. Twenty-four vegetarians and sixteen non-vegetarians reported not exercising, while only one vegetarian participant reported exercising, compared to nine in the non-vegetarian group. In this study sample, non-vegetarians were more likely to exercise than vegetarians, as evidenced by the statistically significant difference ($p = 0.011$). The two groups' ages did not differ significantly ($p = 0.703$).

Table 1: Demographic and lifestyle characteristics

Variable	Category	Vegetarian (n=25)	Non-Vegetarian (n=25)	p-value
Gender No. (%)	Male	5	5	0.999
	Female	20	20	
Smoking status No. (%)	Smoker	4	6	0.725
	Non-smoker	21	19	
Duration of Vegetarian Diet No. (%)	< 1 year	7 (28.0%)	-----	0.140
	1–5 years	5 (20.0%)	-----	
	> 5 years	13 (52.0%)	-----	
Exercise No. (%)	Yes	1	9	0.011*
	No	24	16	
Age (years) Mean ± SE		26.40 ± 1.29	25.44 ± 1.17	0.703

Fisher's Exact Test, Independent t-test

Comparison of hematological parameters between vegetarian and non- vegetarian participants

Table 2 presents the comparison of hematological characteristics between vegetarian and non-vegetarian participants. We used an independent t-test to analyze the data, which are displayed as Mean ± Standard Error (SE). Vitamin B12 levels were lower in vegetarians than in non-vegetarians and showed borderline significance ($p = 0.050$). A few blood values varied notably. Vegetarians had lower hemoglobin and red blood cell counts than non-vegetarians ($p = 0.027$ and $p = 0.004$). Vegetarians had reduced MCHC ($p < 0.001$) and higher MCV ($p < 0.001$). Additionally, vegetarians had lower WBC counts and greater RDW-SD and RDW-CV, with statistically significant differences. However, vegans and non-vegetarians did not differ of folate, MCH, or platelet count. Overall, these findings show that while some blood parameters

Table 2: Comparison of hematological parameters between vegetarian and non- vegetarian participants

Parameter	Vegetarian (n=25) (Mean $\pm$ SE)	Non-Vegetarian (n=25) (Mean $\pm$ SE)	Mean Diff	95% CI	<i>p-value</i>
Vitamin B12 pg/mL	170.40 $\pm$ 11.10	194.00 $\pm$ 11.03	-23.29	(-55.41, 8.83)	0.050
Folate ng/mL	7.82 $\pm$ 0.87	8.14 $\pm$ 0.59	-0.32	(-2.34, 2.06)	0.342
Hemoglobin g/dL	11.80 $\pm$ 0.27	12.65 $\pm$ 0.26	-0.85	(-1.54, -0.10)	0.027*
RBC $\times 10^6/\mu\text{L}$	4.15 $\pm$ 0.12	4.59 $\pm$ 0.09	-0.44	(-0.76, -0.05)	0.004*
MCV fL	93.02 $\pm$ 2.13	83.67 $\pm$ 0.88	9.35	(4.37, 13.95)	< 0.001*
MCH pg	28.70 $\pm$ 0.67	27.62 $\pm$ 0.37	1.08	(-0.70, 2.60)	0.165
MCHC g/dL	30.98 $\pm$ 0.58	32.98 $\pm$ 0.13	-2.00	(-3.52, -0.60)	< 0.001*
RDW-SD fL	69.66 $\pm$ 8.37	44.25 $\pm$ 0.26	25.41	(8.08, 45.02)	0.038
WBC $\times 10^3/\mu\text{L}$	6.38 $\pm$ 0.39	7.62 $\pm$ 0.26	-1.24	(-2.37, -0.24)	0.010*
Platelet $\times 10^3/\mu\text{L}$	257.60 $\pm$ 13.38	277.30 $\pm$ 9.82	-19.07	(-52.9, 20.8)	0.242
RDW-CV %	20.71 $\pm$ 1.82	14.24 $\pm$ 0.17	-0.0089	(2.70 to 10.24)	0.001*

Values are expressed as Mean $\pm$ Standard Error (SE), and an independent *t* test was used. Significant values are bolded ($p < 0.05$)

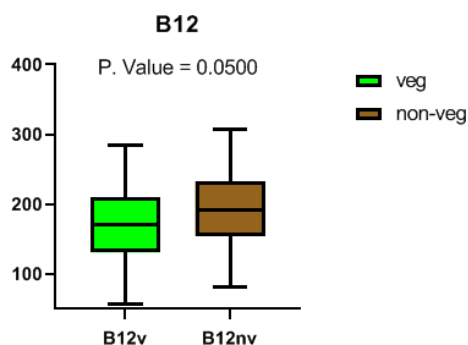


Figure 1: A box plot comparing vitamin B12 levels between vegetarians (veg) and non-vegetarians (non-veg). The verge of statistical significance, as indicated by the *p-value* of 0.05.

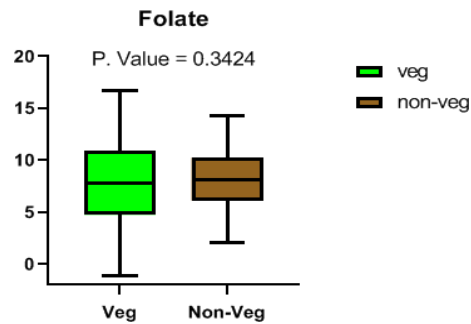


Figure 2: A box plot comparing folate levels between the vegetarian (veg) and non-vegetarian (non-veg) groups. The ($p = 0.3424$) shows that the difference is not statistically significant.

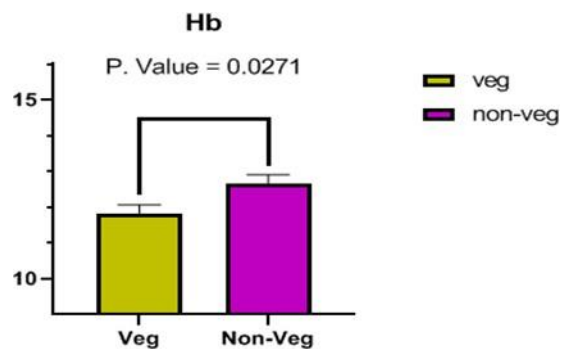


Figure 3: Hemoglobin (Hb) levels are higher in non-vegetarians than in vegetarians, according to the graph. This difference is statistically significant because the *P-value* is 0.0271.

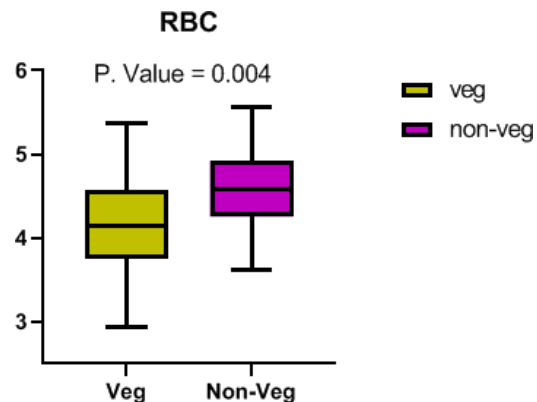


Figure 4: The Red Blood Cell (RBC) counts of vegetarians and non-vegetarians are contrasted in this graph

Correlation between Vitamin B12, Folate, and hematological parameters

A statistically significant result is shown by a p-value of less than 0.05. Hemoglobin and vitamin B12 had a very modest correlation ($r = 0.099$) that was not statistically significant ($p = 0.637$). This indicates no correlation between vitamin B12 levels and hemoglobin levels in this investigation. Hemoglobin and folate had a weakly positive correlation ($r = 0.178$), but the p-value (0.395) was higher than 0.05. This suggests no meaningful connection between folate and hemoglobin. For folate and MCH, there was no link between MCH and folate, as shown by the near-zero correlation ($r = -0.011$) and p-value of 0.960. Vitamin B12 and MCH. Overall, because all p-values were higher than 0.05, no discernible relationship was found between vitamin B12, folate, hemoglobin, and MCH.

Table 3: Correlation between Vitamin B12, Folate, and hematological parameters

Variables	r (Correlation coefficient)	p-value
Hemoglobin vs Vitamin B12	0.099	0.637
Hemoglobin vs Folate	0.178	0.395
MCH vs Folate	-0.011	0.960
MCH vs Vitamin B12	0.206	0.323

Pearson correlation coefficients.

DISCUSSION

The present study discussed significant differences in vitamin B12 levels and some hematological parameters between non-vegetarian and vegetarian participants. This study compared serum vitamin B12 and folate levels in vegetarians with non-vegetarians, revealing significant differences in micronutrient status, particularly in vitamin B12. This finding is consistent with the results of a study by Naji (2025). Because vitamin B12 is found almost exclusively in animal-based foods, vegetarians have low levels of this vitamin. In contrast to the majority of vitamins, cobalamin is produced by bacteria and builds up in animal tissue. As a result, people who limit or abstain from animal products consume less vitamin B12 (Rizzo et al., 2016). Because of the extensive use of fortified foods and supplements, a 2024 systematic review and meta-analysis of Seventh-day Adventists concluded that vegan or vegetarian diets did not increase the risk of vitamin B12 deficiency (Janko et al., 2025).

The present study showed a non-significantly lower folate level in a vegetarian diet than a non-vegetarian diet; this finding disagrees with a previous study, which demonstrated significantly increased folate levels among vegetarian diets, which may be related to sample size and also to the fact that vegetarian individuals consume folate-rich foods such as legumes and leafy green vegetables (Pawlak et al., 2021).

Compared with non-vegetarians, hematological parameters such as red blood cell (RBC) count, hemoglobin, mean corpuscular hemoglobin concentration (MCHC), and white blood cell (WBC) were significantly lower in the vegetarian group. In contrast, mean corpuscular volume (MCV), red cell distribution width-standard deviation (RDW-SD), and red cell width-coefficient of variation (RDW-CV) were significantly higher. This finding indicated early hematological alteration associated with lower vitamin B12 concentration. A recent study concluded that hemoglobin and RBC count were significantly lower in vegetarians since Vitamin B12 plays an important role in the DNA synthesis pathway that affects the production of red blood cells and hemoglobin, and also showed no significant difference in MCV, MCHC, RDW, and WBC (Storz et al., 2025). These variations in erythropoietic and nutritional status, such as insufficient consumption or bioavailability of vitamin B12 or other hematopoietic nutrients like iron, may be reflected in this pattern. When evaluating these findings, consider potential confounders such as physical activity and supplement use, especially folate and vitamin B12 supplements, since they may affect hematological parameters, particularly vitamin B12, folate status, hemoglobin, and RBC count. Socioeconomic class may influence access to fortified foods, the use of nutritional supplements, and eating choices.

In this study, there was no statistically significant correlation between vitamin B12 levels and hemoglobin concentration ($r = 0.099$, $p = 0.637$); this is consistent with another study (Kwok et al., 2002). In the current study, we found no significant correlation between folate and hemoglobin ($r = 0.1780$, $p = 0.395$). This result may suggest that variations in hemoglobin levels among vegetarian participants are not explained by serum folate concentration alone, as other nutritional factors, such as iron and vitamin B12 status, may also affect

hematological status (Selinger et al., 2019). Regarding mean corpuscular hemoglobin (MCH), the study found no significant correlation with vitamin B12 and folate ($r = 0.206$, $p = 0.323$) and ($r = -0.011$, $p = 0.960$), respectively.

The main strengths of this study are the direct comparison of serum folate and vitamin B12 levels between vegetarian and non-vegetarian individuals and the evaluation of hematological parameters.

The limitations of this study are a small sample size, a short study duration, and the fact that most people in the study environment do not follow a vegetarian diet. The present study shows that serum levels of vitamin B12 are low among vegetarian participants and recommends that vegetarians consume adequate levels of vitamin B12 through fortified foods or supplements to protect themselves against vitamin deficiency and alterations in hematological parameters. In addition, periodic assessment of complete blood count and vitamin B12 concentration may help prevent micronutrient deficiency and hematological disorders.

CONCLUSION

In the present study, variation in vitamin B12 levels and several hematological markers was observed in vegetarian and non-vegetarian individuals. Vegetarians showed lower serum vitamin B12, along with low red blood cell count, hemoglobin concentration, and MCHC, while MCV, RDW-SD, and RDW-CV were higher. These data suggest that poor vitamin B12 intake may be linked to early hematological changes in those on a vegetarian diet. However, the lack of a strong association between vitamin B12 or folate levels and hemoglobin or MCH suggests that hematological variability may not be explained solely by these micronutrients and may involve other dietary and lifestyle factors. To further assess the noted variations in vitamin B12, folate status, and hematological markers between vegetarian and non-vegetarian populations. Larger prospective studies are needed.

Conflicts of Interest

The authors declare no conflicts of interest.

Ethics Approval

Ethical approval was obtained from the relevant Ethics Committee of Cihan University-Erbil (Ethics Approval No. CUE-REC/2026/07). All procedures involving human participants were conducted in accordance with the approved ethical guidelines.

AI Usage Statement

Artificial intelligence (AI)-based tools were used solely to support the language refinement of the manuscript, including improvements in grammar, clarity, and readability.

Data Availability Statement

The data generated and analyzed during the current study are not publicly available due to participant privacy and confidentiality considerations but are available from the corresponding author upon reasonable request.

REFERENCES

- Al Amin, A. S. M., & Gupta, V. (2020). Vitamin B12 (cobalamin). In StatPearls. StatPearls Publishing.
<https://www.ncbi.nlm.nih.gov/books/NBK559132/>
- Baddam, S., Khan, K. M., & Jialal, I. (2025). Folic acid deficiency. In *StatPearls*. StatPearls Publishing.
<https://www.ncbi.nlm.nih.gov/books/NBK535377/>
- Bali, A., & Naik, R. (2023). The impact of a vegan diet on many aspects of health: The overlooked side of veganism. *Cureus*, 15(2), e35148.
<https://doi.org/10.7759/cureus.35148>
- Bruns, A., Greupner, T., Nebl, J., & Hahn, A. (2024). Plant-based diets and cardiovascular risk factors: A comparison of flexitarians, vegans and omnivores in a cross-sectional study. *BMC Nutrition*, 10, 29.
<https://doi.org/10.1186/s40795-024-00839-9>
- Buchanan, K. L. (2024). *Increasing folic acid self-efficacy in college-age women of childbearing age* [Master's thesis, Abilene Christian University]. Digital Commons @ ACU.
<https://digitalcommons.acu.edu/etd/743/>
- Craig, W. J., Mangels, A. R., Fresán, U., Marsh, K., Miles, F. L., Saunders, A. V., Haddad, E. H., Heskey, C. E., Johnston, P., Larson-Meyer, E., & Orlich, M. (2021). The safe and effective use of plant-based diets with guidelines for health professionals. *Nutrients*, 13(11), 4144.
<https://doi.org/10.3390/nu13114144>
- Dawczynski, C., Weidauer, T., Richert, C., Schlattmann, P., Dawczynski, K., & Kiehntopf, M. (2022). Nutrient intake and nutrition status in vegetarians and vegans in comparison to omnivores—The Nutritional Evaluation (NuEva) Study. *Frontiers in Nutrition*, 9, 819106.
<https://doi.org/10.3389/fnut.2022.819106>
- Dhande, D., Dhok, A., Anjankar, A., Nagpure, S., & Dhande, D., Jr. (2024). A case report and literature review on dietary practices and megaloblastic anemia in a young female: Unraveling the impact of nutrition on hematological health. *Cureus*, 16(6), e61550.
<https://doi.org/10.7759/cureus.61550>
- Eveleigh, E. R., Coneyworth, L., & Welham, S. J. (2023). Systematic review and meta-analysis of iodine nutrition in modern vegan and vegetarian diets. *British Journal of Nutrition*, 130(9), 1580–1594.
<https://doi.org/10.1017/S000711452300051X>

- Gallego-Narbón, A., Zapatera, B., Barrios, L., & Vaquero, M. P. (2019). Vitamin B12 and folate status in Spanish lacto-ovo vegetarians and vegans. *Journal of Nutritional Science*, 8, e7
<https://doi.org/10.1017/jns.2019.2>
- Halczuk, K., Kaźmierczak-Barańska, J., Karwowski, B. T., Karmańska, A., & Cieślak, M. (2023). Vitamin B12—Multifaceted in vivo functions and in vitro applications. *Nutrients*, 15(12), 2734.
<https://doi.org/10.3390/nu15122734>
- Janko, R. K., Haussmann, I., & Patel, A. (2025). Vitamin B12 status in vegan and vegetarian Seventh-day Adventists: A systematic review and meta-analysis of serum levels and dietary intake. *American Journal of Health Promotion*, 39(1), 162–171.
<https://doi.org/10.1177/08901171241273330>
- Kwok, T., Cheng, G., Woo, J., Lai, W. K., & Pang, C. P. (2002). Independent effect of vitamin B12 deficiency on hematological status in older Chinese vegetarian women. *American Journal of Hematology*, 70(3), 186–190.
<https://doi.org/10.1002/ajh.10134>
- Li, J., Duan, H., Ramaswamy, H., & Wang, C. (2025). A comprehensive review of fortification, bioavailability, and health benefits of folate. *International Journal of Molecular Sciences*, 26(16), 7703
<https://doi.org/10.3390/ijms26167703>
- Lyon, P., Strippoli, V., Fang, B., & Cimmino, L. (2020). B vitamins and one-carbon metabolism: Implications in human health and disease. *Nutrients*, 12(9), 2867.
<https://doi.org/10.3390/nu12092867>
- Melina, V., Craig, W., & Levin, S. (2016). Position of the Academy of Nutrition and Dietetics: Vegetarian diets. *Journal of the Academy of Nutrition and Dietetics*, 116(12), 1970–1980.
<https://doi.org/10.1016/j.jand.2016.09.025>
- Naji, Z. A. (2025). A comparative study of vitamin B12 levels and nutritional status in vegetarian and non-vegetarian adults. *South Florida Journal of Health*, 6(3), e5610.
<https://doi.org/10.46981/sfjvhv6n3-002>
- O’Leary, F., & Samman, S. (2010). Vitamin B12 in health and disease. *Nutrients*, 2(3), 299–316.
<https://doi.org/10.3390/nu2030299>
- Pawlak, R., Grant, R., Vos, P., Bilgin, A. A., Berg, J., Pearce, R., & Morris, M. J. (2021). The status of folate, vitamin B-12 and homocysteine among Australian vegetarian and non-vegetarian teenagers. *Annals of Pediatrics and Child Health*, 9(1), 1–6.
<https://researchers.mq.edu.au/en/publications/the-status-of-folate-vitamin-b-12-and-homocysteine-among-australi/>
- Raj, S., Guest, N. S., Landry, M. J., Mangels, A. R., Pawlak, R., & Rozga, M. (2025). Vegetarian dietary patterns for adults: A position paper of the Academy of Nutrition and Dietetics. *Journal of the Academy of Nutrition and Dietetics*. Advance online publication.
<https://doi.org/10.1016/j.jand.2025.02.002>

- Rizzo, G., Laganà, A. S., Rapisarda, A. M. C., La Ferrera, G. M. G., Buscema, M., Rossetti, P., Nigro, A., & Vitale, S. G. (2016). Vitamin B12 among vegetarians: Status, assessment and supplementation. *Nutrients*, 8(12), 767.
<https://doi.org/10.3390/nu8120767>
- Selinger, E., Kühn, T., Procházková, M., Anděl, M., & Gojda, J. (2019). Vitamin B12 deficiency is prevalent among Czech vegans who do not use vitamin B12 supplements. *Nutrients*, 11(12), 3019.
<https://doi.org/10.3390/nu11123019>
- Seo, I. H., & Lee, Y. J. (2022). Usefulness of complete blood count (CBC) to assess cardiovascular and metabolic diseases in clinical settings: A comprehensive literature review. *Biomedicines*, 10(11), 2697
<https://doi.org/10.3390/biomedicines10112697>
- Storz, M. A., Kowarschik, S., Herter, J., & Huber, R. (2025). Whole blood count data and hematological parameters in US vegetarians: A cross-sectional study. *European Journal of Nutrition*, 64(6), 280.
<https://doi.org/10.1007/s00394-025-03778-8>
- Tseng, P. M., Mastrantonio, C., Glanz, P. H., Volpe, P. R. J., Neill, P. D. B., & Nazmi, P. A. (2020). Fruit and vegetable purchasing patterns and Supplemental Nutrition Assistance Program participation: Findings from a nationally representative survey. *Journal of the Academy of Nutrition and Dietetics*, 120(10), 1633–1642.
<https://doi.org/10.1016/j.jand.2020.05.016>