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ORIGINAL PAPERS

DIETARY INFLUENCES ON INFLAMMATORY PATHWAYS IN ENDOMETRIOSIS: BIOLOGICAL AND CLINICAL PERSPECTIVES

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Abstract: Endometriosis is a chronic estrogen-dependent inflammatory disorder characterized by the presence of endometrial-like tissue outside the uterine cavity, significantly affecting women's reproductive health and quality of life. Increasing evidence suggests that dietary factors may play a critical role in modulating inflammatory pathways involved in the pathophysiology and progression of the disease. Nutrition influences immune responses, oxidative stress, estrogen metabolism, and gut microbiota composition, all of which are closely associated with inflammatory activity in endometriosis.

This article explores the biological and clinical relationships between dietary patterns and inflammatory mechanisms in endometriosis. Particular attention is given to the impact of pro-inflammatory dietary components, including saturated fats, refined sugars, and ultra-processed foods, which may exacerbate systemic inflammation and hormonal imbalance. Conversely, anti-inflammatory nutrients such as omega-3 fatty acids, antioxidants, polyphenols, fiber, and vitamin D demonstrate potential protective and therapeutic effects through the modulation of cytokine production, oxidative stress, and immune regulation.

Clinical evidence supporting nutritional interventions in endometriosis management is also discussed, highlighting the potential benefits of personalized dietary strategies in reducing pain, improving metabolic and hormonal balance, and enhancing overall quality of life. An integrative bio-nutritional approach may represent a valuable complementary strategy in the multidisciplinary management of endometriosis and related inflammatory conditions.

Keywords: endometriosis, inflammation, nutrition, oxidative stress, dietary patterns, chronic disease

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1. Introduction

1.1. Overview of Endometriosis

Endometriosis is a chronic, estrogen-dependent inflammatory disorder characterized by the presence of endometrial-like tissue outside the uterine cavity, most commonly affecting the ovaries, pelvic peritoneum, and deep pelvic structures. It affects approximately 10% of women of reproductive age worldwide and is frequently associated with infertility and chronic pelvic pain[1]. Clinical manifestations vary widely and include dysmenorrhea, dyspareunia, non-cyclic pelvic pain, heavy menstrual bleeding, fatigue, and gastrointestinal or urinary symptoms [1,2]. The disease often remains underdiagnosed for years because of heterogeneous presentations and normalization of menstrual pain [1-3]. Beyond physical symptoms, endometriosis imposes a substantial psychological, social, and economic burden [4]. Chronic pain, reduced fertility, impaired sexual functioning, and recurrent medical interventions significantly diminish quality of life, contributing to anxiety, depression, reduced work productivity, and increased healthcare utilization [1-3].

1.2. Inflammation as a Central Mechanism in Endometriosis

Inflammation is considered a central mechanism in the initiation and progression of endometriosis [1,2,5]. The disease is characterized by a persistent inflammatory microenvironment within the pelvic cavity, where ectopic endometrial lesions stimulate continuous immune activation and tissue remodeling[1,5]. Immune dysregulation plays a major role, involving altered macrophage activity, impaired natural killer cell function, and abnormal T-cell responses that reduce the clearance of ectopic cells and promote lesion survival. Inflammatory mediators are markedly elevated in the peritoneal fluid and affected tissues of patients with endometriosis[6]. Key cytokines, including tumor necrosis factor-α (TNF-α), interleukin-1β (IL-1β), and interleukin-6 (IL-6), contribute to angiogenesis, cellular proliferation, and pain sensitization[7]. Additionally, increased cyclooxygenase-2 (COX-2) activity enhances prostaglandin production, particularly prostaglandin E2 (PGE2), further amplifying inflammation, estrogen synthesis, and chronic pelvic pain[8].

1.3. Rationale for Investigating Dietary Influences

Growing evidence suggests that lifestyle factors, particularly diet, may influence the development and progression of endometriosis through modulation of inflammatory and hormonal pathways [9]. As interest in non-pharmacological and patient-centered approaches increases, nutrition has emerged as a potentially important modifiable factor in disease management [9,10]. Dietary components can affect oxidative stress, immune responses, estrogen metabolism, and the production of pro-inflammatory mediators, thereby potentially influencing symptom severity and lesion activity [11]. Anti-inflammatory dietary patterns rich in omega-3 fatty acids, antioxidants, and fiber have shown promising effects on pain reduction and overall well-being [12]. However, despite increasing public and scientific interest, current evidence remains inconsistent and limited by methodological heterogeneity, small sample sizes, and a lack of long-term randomized clinical trials. Consequently, further research is needed to clarify the biological mechanisms and clinical efficacy of dietary interventions in endometriosis management [9-12].

1.4. Aim and Scope of the Article

This article aims to examine the relationship between dietary factors and inflammatory pathways involved in the pathophysiology of endometriosis, with emphasis on both biological and clinical perspectives. It explores the molecular mechanisms through which nutrients and dietary patterns may influence immune regulation, oxidative stress, cytokine production, prostaglandin synthesis, and estrogen-mediated inflammatory signaling. In addition, the article reviews current clinical evidence regarding the effects of dietary interventions, including anti-inflammatory diets, micronutrient supplementation, and functional foods, on symptom control, pain reduction, and quality of life in individuals with endometriosis.

2. Pathophysiology of Inflammatory Processes in Endometriosis

2.1. Immune Dysfunction and Peritoneal Inflammation

Immune dysfunction is a hallmark of endometriosis and contributes significantly to the establishment and persistence of ectopic endometrial lesions [13]. The peritoneal environment in affected individuals is characterized by chronic inflammation and increased recruitment of immune cells, particularly activated macrophages. These macrophages produce pro-inflammatory cytokines, growth factors, and angiogenic mediators that promote lesion survival, vascularization, and tissue remodeling [13,14]. In parallel, altered natural killer (NK) cell activity reduces the immune system's ability to recognize and eliminate ectopic endometrial cells, facilitating their implantation within the pelvic cavity. T-cell dysregulation further contributes to immune imbalance, with altered proportions of regulatory T cells and pro-inflammatory T-helper subsets enhancing chronic inflammatory responses[15]. Together, these immune alterations create a permissive microenvironment that sustains inflammation, promotes disease progression, and contributes to pain generation and infertility associated with endometriosis [13-15].

2.2. Cytokines and Chemokines

Cytokines and chemokines play a critical role in the inflammatory cascade associated with endometriosis and contribute to lesion development, angiogenesis, and pain generation [16]. Elevated levels of tumor necrosis factor-α (TNF-α) stimulate inflammatory signaling, cellular proliferation, and adhesion of ectopic endometrial cells. Interleukin-1β (IL-1β) promotes the expression of cyclooxygenase-2 and enhances prostaglandin synthesis, thereby intensifying pelvic inflammation and pain [17]. Increased concentrations of interleukin-6 (IL-6) are associated with immune dysregulation, chronic inflammation, and infertility. Interleukin-8 (IL-8), a potent chemokine, facilitates neutrophil recruitment and angiogenesis, supporting lesion vascularization and growth [18]. Monocyte chemoattractant protein-1 (MCP-1) contributes to macrophage accumulation within the peritoneal cavity, further amplifying inflammatory responses [19]. Together, these mediators establish a self-sustaining inflammatory

microenvironment that promotes disease progression and symptom persistence in endometriosis [17-19].

2.3. Oxidative Stress and Reactive Oxygen Species

Oxidative stress is increasingly recognized as a major contributor to the pathophysiology of endometriosis [20,21]. Excessive production of reactive oxygen species (ROS) within the peritoneal cavity promotes chronic inflammation, cellular damage, and lesion progression [20,22]. Elevated ROS levels induce lipid peroxidation, leading to membrane instability and the generation of toxic byproducts that further amplify inflammatory responses [22]. Mitochondrial dysfunction also plays a significant role by impairing cellular energy metabolism and increasing oxidative damage, thereby supporting the survival and proliferation of ectopic endometrial cells [20,23]. In addition, individuals with endometriosis often exhibit reduced antioxidant defenses, including decreased levels of enzymes such as superoxide dismutase and glutathione peroxidase, resulting in antioxidant depletion [20,24]. The imbalance between oxidative stress and antioxidant capacity contributes to tissue injury, angiogenesis, pain sensitization, and infertility, reinforcing the chronic inflammatory environment characteristic of endometriosis [20-25].

2.4. Estrogen-Inflammation Crosstalk

Endometriosis is an estrogen-dependent disorder in which estrogen and inflammation interact through complex bidirectional mechanisms that promote lesion persistence and progression [26,27]. Ectopic endometrial lesions exhibit increased sensitivity to estrogen, which stimulates cellular proliferation, angiogenesis, and resistance to apoptosis [26. A key feature of this process is the aberrant expression of aromatase, the enzyme responsible for estrogen biosynthesis, within endometriotic tissues. Elevated aromatase activity leads to local estrogen overproduction, creating a self-sustaining hormonal microenvironment that enhances inflammatory responses [27,28]. Estrogen further activates pro-inflammatory signaling pathways, including nuclear factor kappa B (NF-κB) and cyclooxygenase-2 (COX-2), resulting in increased production of cytokines and prostaglandin E2 (PGE2). In turn, inflammatory mediators stimulate additional aromatase expression, establishing a positive

feedback loop between estrogen synthesis and inflammation [28,29]. This crosstalk contributes significantly to chronic pain, lesion growth, and disease recurrence in endometriosis [26-29].

2.5. NF-κB and Other Molecular Signaling Pathways

Multiple molecular signaling pathways contribute to the inflammatory and proliferative processes underlying endometriosis, with nuclear factor kappa B (NF-κB) serving as a central regulator[30]. Persistent NF-κB activation in endometriotic lesions promotes the transcription of pro-inflammatory cytokines, adhesion molecules, and anti-apoptotic factors, thereby supporting lesion survival and chronic inflammation [26,30]. One major downstream mechanism involves the cyclooxygenase-2/prostaglandin E2 (COX-2/PGE2) axis, which enhances prostaglandin production, pain sensitization, angiogenesis, and local estrogen synthesis through aromatase stimulation. In addition, mitogen-activated protein kinase (MAPK) pathways regulate cellular proliferation, migration, and inflammatory responses in ectopic tissues [26,31]. Signal transducer and activator of transcription (STAT) proteins, particularly STAT3, also contribute to immune dysregulation and resistance to apoptosis[31]. The interaction among these pathways creates a complex molecular network that sustains inflammation, promotes disease progression, and represents a potential target for novel therapeutic interventions in endometriosis [26, 30,31].

3. Dietary Components and Their Effects on Inflammatory Pathways

3.1. Dietary Fats

3.1.1. Omega-3 Polyunsaturated Fatty Acids

Omega-3 polyunsaturated fatty acids (PUFAs), primarily derived from fatty fish, flaxseed, and walnuts, have attracted considerable attention for their anti-inflammatory properties in endometriosis [32]. These fatty acids modulate inflammatory responses by reducing the production of pro-inflammatory cytokines and inhibiting activation of nuclear factor kappa B (NF-κB)[33]. Omega-3 PUFAs also influence prostaglandin synthesis by competing with arachidonic acid for cyclooxygenase enzymes, resulting in decreased formation of

pro-inflammatory prostaglandin E2 (PGE2) and increased production of less inflammatory lipid mediators [34]. Additionally, they contribute to the generation of specialized pro-resolving mediators, including resolvins and protectins, which promote resolution of inflammation[32-35]. Clinical studies suggest that higher dietary intake of omega-3 fatty acids may be associated with reduced risk of endometriosis and improvement in pelvic pain symptoms. Nevertheless, further randomized controlled trials are needed to establish optimal dosage, duration, and long-term therapeutic efficacy [32-35].

3.1.2. Saturated and Trans Fats

High intake of saturated and trans fats has been associated with enhanced inflammatory activity and may contribute to the progression of endometriosis [36]. These dietary fats promote the activation of pro-inflammatory signaling pathways, including nuclear factor kappa B (NF-κB), leading to increased production of cytokines such as tumor necrosis factor-α (TNF-α) and interleukin-6 (IL-6)[36]. Saturated fats may also stimulate oxidative stress and macrophage activation within the peritoneal environment, thereby supporting lesion growth and chronic inflammation. Trans fats, commonly found in ultra-processed and fried foods, have been linked to endothelial dysfunction and elevated systemic inflammatory markers [37]. Epidemiological studies suggest that diets rich in saturated and trans fats may correlate with increased risk and severity of endometriosis, including greater pelvic pain and inflammatory burden [36,38,39]. Although causal relationships remain under investigation, reducing consumption of these fats may represent a beneficial dietary strategy in the management of endometriosis-associated inflammation [36-39].

3.1.3. Omega-6/Omega-3 Ratio

The balance between omega-6 and omega-3 polyunsaturated fatty acids plays an important role in regulating inflammatory responses in endometriosis [32,40]. Modern Western diets are often characterized by an excessive omega-6/omega-3 ratio, which favors the production of pro-inflammatory eicosanoids derived from arachidonic acid [32,40]. Elevated omega-6 intake can enhance the synthesis of prostaglandin E2 (PGE2), leukotrienes, and inflammatory cytokines, thereby contributing to chronic pelvic inflammation and pain[41]. In contrast, omega-3

fatty acids generate anti-inflammatory mediators that help resolve inflammation and reduce oxidative stress[41,42]. An imbalance favoring omega-6 fatty acids may therefore intensify inflammatory signaling pathways and support lesion progression in endometriosis [32, 40-42]. Adjusting this ratio through dietary modification may have therapeutic potential.

3.2. Vitamins A, C, D, and E

Vitamins A, C, D, and E play important roles in immune regulation and protection against oxidative stress in endometriosis [43. Vitamin A contributes to cellular differentiation and modulation of inflammatory immune responses, while vitamin D exerts immunomodulatory effects by suppressing pro-inflammatory cytokine production and regulating T-cell activity [43,44]. Vitamins C and E are potent antioxidants that neutralize reactive oxygen species and reduce lipid peroxidation within the peritoneal environment [45,46]. These micronutrients help preserve cellular integrity, limit oxidative tissue damage, and potentially reduce inflammatory lesion progression [43,46]. Deficiencies in antioxidant vitamins have been associated with increased oxidative stress and symptom severity, suggesting that adequate intake may support inflammatory control in endometriosis [43-46].

4. Future Directions and Research Priorities

Future research on diet and endometriosis should focus on clarifying the molecular mechanisms through which nutritional factors influence inflammatory and hormonal pathways. Mechanistic studies identifying specific molecular targets may improve understanding of disease progression and support the development of personalized nutritional interventions. Emerging fields such as nutrigenomics and metabolomics offer promising opportunities to explore interactions between diet, gene expression, metabolism, and immune regulation in endometriosis. In addition, greater standardization of dietary intervention trials is needed, including consistent outcome measures, validated dietary assessment tools, and well-designed longitudinal studies to evaluate long-term efficacy and safety. Future investigations should also examine novel therapeutic approaches, particularly microbiome modulation through probiotics, prebiotics, and dietary strategies that restore intestinal homeostasis. Furthermore, anti-inflammatory

bioactive compounds, including polyphenols and specialized lipid mediators, represent promising candidates for complementary therapies targeting chronic inflammation and symptom burden in endometriosis.

5. Conclusions

Current evidence suggests that dietary factors can significantly influence inflammatory, oxidative, hormonal, and immune pathways involved in endometriosis. Nutrients such as omega-3 fatty acids, antioxidants, fiber, and bioactive plant compounds may help reduce inflammation and oxidative stress, whereas saturated fats and ultra-processed foods may exacerbate disease activity. Consequently, nutrition has emerged as a promising complementary strategy for symptom management and improvement of quality of life in individuals with endometriosis. Integrating personalized dietary approaches into multidisciplinary care may enhance conventional medical and surgical treatments. However, despite growing interest, existing evidence remains limited by methodological heterogeneity and insufficient long-term clinical trials. High-quality, standardized research is essential to clarify therapeutic efficacy and establish evidence-based nutritional recommendations for endometriosis management.

R E F E R E N C E S

[1] As-Sanie S, Mackenzie SC, Morrison L, Schrepf A, Zondervan KT, Horne AW, Missmer SA. Endometriosis: A Review. JAMA. 2025 Jul 1;334(1):64-78. doi: 10.1001/jama.2025.2975.

[2] Ortega-Gutiérrez, M.; Muñoz-Gamez, A.; Girón-Prieto, M.d.l.S. Primary Care Approach to Endometriosis: Diagnostic Challenges and Management Strategies—A Narrative Review. *J. Clin. Med.* **2025**, *14*, 4757. https://doi.org/10.3390/jcm14134757

[3] Zondervan, K.T.; Becker, C.M.; Missmer, S.A. Endometriosis. *N. Engl. J. Med.* **2020**, *382*, 1244–1256.

[4] Rempert AN, Rempert TH, Liu A, Hernández A, Blanck J, Segars J, Singh B. A Systematic Review of the Psychosocial Impact of Endometriosis before and after Treatment. Reprod Sci. 2024 Jul;31(7):1828-1860. doi: 10.1007/s43032-024-01515-w.

[5] Mariadas H, Chen JH, Chen KH. The Molecular and Cellular Mechanisms of Endometriosis: From Basic Pathophysiology to Clinical Implications. Int J Mol Sci. 2025 Mar 10;26(6):2458. doi: 10.3390/ijms26062458.

[6] Sisnett DJ, Zutautas KB, Vo DHN, Ravishanker K, Holmes JP, Wodz A, Tayade C. Immune dysregulation in endometriosis: the T cell perspective. Front Immunol. 2026 Apr 1;17:1712360. doi: 10.3389/fimmu.2026.1712360.

[7] Zhou WJ, Yang HL, Shao J, Mei J, Chang KK, Zhu R, Li MQ. Anti-inflammatory cytokines in endometriosis. Cell Mol Life Sci. 2019 Jun;76(11):2111-2132. doi: 10.1007/s00018-019-03056-x. Epub 2019 Mar 2.

[8] Lai ZZ, Yang HL, Ha SY, Chang KK, Mei J, Zhou WJ, Qiu XM, Wang XQ, Zhu R, Li DJ, Li MQ. Cyclooxygenase-2 in Endometriosis. Int J Biol Sci. 2019 Oct 23;15(13):2783-2797. doi: 10.7150/ijbs.35128.

[9] Osińska, D.; Woźniak, A.; Woźniak, S. The Role of Nutrition on the Pathogenesis of Endometriosis. *Nutrients* **2026**, *18*, 646. https://doi.org/10.3390/nu18040646

[10] Muharam R, Christopher Yo E, Nurdya Irzanti A, Mutia K, Sumapraja K, Kemal Harzif A, Pratama G, Maidarti M, Wiweko B, Hestiantoro A. The Role of Nutrition in Endometriosis Prevention and Management: A Comprehensive Review. Int J Fertil Steril. 2025 Sep 30;19(4):344-352. doi: 10.22074/ijfs.2025.2029021.1683.

[11] Jiang S, Liu H, Li C. Dietary Regulation of Oxidative Stress in Chronic Metabolic Diseases. Foods. 2021 Aug 11;10(8):1854. doi: 10.3390/foods10081854.

[12] Yu X, Pu H, Voss M. Overview of anti-inflammatory diets and their promising effects on non-communicable diseases. Br J Nutr. 2024 Oct 14;132(7):898-918. doi: 10.1017/S0007114524001405.

[13] Rathod S, Shanoo A, Acharya N. Endometriosis: A Comprehensive Exploration of Inflammatory Mechanisms and Fertility Implications. Cureus. 2024 Aug 4;16(8):e66128. doi: 10.7759/cureus.66128.

[14] Wang X, Wu N, Xue Q. Macrophages in endometriosis: key roles and emerging therapeutic opportunities-a narrative review. Reprod Biol Endocrinol. 2025 Oct 21;23(1):134. doi: 10.1186/s12958-025-01471-3.

[15] Reis JL, Rosa NN, Ângelo-Dias M, Martins C, Borrego LM, Lima J. Natural Killer Cell Receptors and Endometriosis: A Systematic Review. Int J Mol Sci. 2022 Dec 25;24(1):331. doi: 10.3390/ijms24010331.

[16] Oală IE, Mitranovici MI, Chiorean DM, Irimia T, Crișan AI, Melinte IM, Cotruș T, Tudorache V, Moraru L, Moraru R, Caravia L, Morariu M, Puşcaşiu L. Endometriosis and the Role of Pro-Inflammatory and Anti-Inflammatory Cytokines in Pathophysiology: A Narrative Review of the Literature. Diagnostics (Basel). 2024 Jan 31;14(3):312. doi: 10.3390/diagnostics14030312.

[17] Yang B, Li F, Cao G, Nuo M, Shi Y, Wang Z, Jia J, Shi W, Liu Z. Mechanistic insights into inflammatory cytokines in adenomyosis-induced infertility (Review). Int J Mol Med. 2026 May;57(5):107. doi: 10.3892/ijmm.2026.5778.

[18] Abramiuk M, Grywalska E, Małkowska P, Sierawska O, Hrynkiewicz R, Niedźwiedzka-Rystwej P. The Role of the Immune System in the Development of Endometriosis. Cells. 2022 Jun 25;11(13):2028. doi: 10.3390/cells11132028.

[19] Soni UK, Tripathi R, Jha RK. MCP-1 exerts the inflammatory response via ILK activation during endometriosis pathogenesis. Life Sci. 2024 Sep 15; 353:122902. doi: 10.1016/j.lfs.2024.122902.

[20] Scutiero G, Iannone P, Bernardi G, Bonaccorsi G, Spadaro S, Volta CA, Greco P, Nappi L. Oxidative Stress and Endometriosis: A Systematic Review of the Literature. Oxid Med Cell Longev. 2017; 2017:7265238. doi: 10.1155/2017/7265238.

[21] Didziokaite G, Biliute G, Gudaite J, Kvedariene V. Oxidative Stress as a Potential Underlying Cause of Minimal and Mild Endometriosis-Related Infertility. Int J Mol Sci. 2023 Feb 14;24(4):3809. doi: 10.3390/ijms24043809.

[22] Clower, L.; Fleshman, T.; Geldenhuys, W.J.; Santanam, N. Targeting Oxidative Stress Involved in Endometriosis and Its Pain. *Biomolecules* **2022**, *12*, 1055. https://doi.org/10.3390/biom12081055

[23] Kim BS, Kim B, Yoon S, Park W, Bae SJ, Joo J, Kim W, Ha KT. Warburg-like Metabolic Reprogramming in Endometriosis: From Molecular Mechanisms to Therapeutic Approaches. Pharmaceuticals (Basel). 2025 May 28;18(6):813. doi: 10.3390/ph18060813.

[24] Ekarattanawong S, Tanprasertkul C, Somprasit C, Chamod P, Tiengtip R, Bhamarapravatana K, Suwannarurk K. Possibility of using superoxide dismutase and glutathione peroxidase as endometriosis biomarkers. Int J Womens Health. 2017 Sep 27; 9:711-716. doi: 10.2147/IJWH.S141021.

[25] Santanam N, Kavtaradze N, Murphy A, Dominguez C, Parthasarathy S. Antioxidant supplementation reduces endometriosis-related pelvic pain in humans. Transl Res. 2013 Mar;161(3):189-95. doi: 10.1016/j.trsl.2012.05.001.

[26] Simancas-Racines D, Jiménez-Flores E, Montalvan M, Horowitz R, Araujo V, Reytor-González C. Endometriosis as a Systemic and Complex Disease: Toward Phenotype-Based Classification and Personalized Therapy. Int J Mol Sci. 2026 Jan 16;27(2):908. doi: 10.3390/ijms27020908.

[27] Mori T, Ito F, Koshiba A, Kataoka H, Takaoka O, Okimura H, Khan KN, Kitawaki J. Local estrogen formation and its regulation in endometriosis. Reprod Med Biol. 2019 Jun 18;18(4):305-311. doi: 10.1002/rmb2.12285.

[28] Moustakli, E.; Potiris, A.; Grigoriadis, T.; Zikopoulos, A.; Drakaki, E.; Zouganeli, I.; Theofanakis, C.; Gerede, A.; Zachariou, A.; Domali, E.; et al. Unraveling the Core of Endometriosis: The Impact of Endocrine Disruptors. *Int. J. Mol. Sci.* **2025**, *26*, 7600. https://doi.org/10.3390/ijms26157600

[29] Frasor J, Weaver AE, Pradhan M, Mehta K. Synergistic up-regulation of prostaglandin E synthase expression in breast cancer cells by 17beta-estradiol and proinflammatory cytokines. Endocrinology. 2008 Dec;149(12):6272-9. doi: 10.1210/en.2008-0352.

[30] Liu Y, Wang J, Zhang X. An Update on the Multifaceted Role of NF-kappaB in Endometriosis. Int J Biol Sci. 2022 Jul 4;18(11):4400-4413. doi: 10.7150/ijbs.72707.

[31] McKinnon BD, Kocbek V, Nirgianakis K, Bersinger NA, Mueller MD. Kinase signalling pathways in endometriosis: potential targets for non-hormonal therapeutics. Hum Reprod Update. 2016 Apr;22(3):382-403. doi: 10.1093/humupd/dmv060.

[32] Liu E, Wang Q, Bai Y, Zhang X, Wang J. Effect of omega-3 polyunsaturated fatty acid on endometriosis. Clinics (Sao Paulo). 2025 Apr 23; 80:100654. doi: 10.1016/j.clinsp.2025.100654.

[33] Bodur M, Yilmaz B, Ağagündüz D, Ozogul Y. Immunomodulatory Effects of Omega-3 Fatty Acids: Mechanistic Insights and Health Implications. Mol Nutr Food Res. 2025 May;69(10):e202400752. doi: 10.1002/mnfr.202400752.

[34] Jerab D, Blangero F, da Costa PCT, de Brito Alves JL, Kefi R, Jamoussi H, Morio B, Eljaafari A. Beneficial Effects of Omega-3 Fatty Acids on Obesity and Related Metabolic and Chronic Inflammatory Diseases. Nutrients. 2025 Apr 3;17(7):1253. doi: 10.3390/nu17071253.

[35] Serhan CN, Petasis NA. Resolvins and protectins in inflammation resolution. Chem Rev. 2011 Oct 12;111(10):5922-43. doi: 10.1021/cr100396c.

[36] Marcinkowska A, Górnicka M. The Role of Dietary Fats in the Development and Treatment of Endometriosis. Life (Basel). 2023 Feb 27;13(3):654. doi: 10.3390/life13030654.

[37] Quetglas-Llabrés MM, Monserrat-Mesquida M, Bouzas C, Mateos D, Ugarriza L, Gómez C, Tur JA, Sureda A. Oxidative Stress and Inflammatory Biomarkers Are Related to High Intake of Ultra-Processed Food in Old Adults with Metabolic Syndrome. Antioxidants (Basel). 2023 Jul 31;12(8):1532. doi: 10.3390/antiox12081532.

[38] Helbig M, Vesper AS, Beyer I, Fehm T. Does Nutrition Affect Endometriosis? Geburtshilfe Frauenheilkd. 2021 Feb;81(2):191-199. doi: 10.1055/a-1207-0557.

[39] Martire, F.G.; Costantini, E.; d'Abate, C.; Capria, G.; Piccione, E.; Andreoli, A. Endometriosis and Nutrition: Therapeutic Perspectives. *J. Clin. Med.* **2025**, *14*, 3987. https://doi.org/10.3390/jcm14113987

[40] Khanaki K, Nouri M, Ardekani AM, Ghassemzadeh A, Shahnazi V, Sadeghi MR, Darabi M, Mehdizadeh A, Dolatkhah H, Saremi A, Imani AR, Rahimipour A. Evaluation of the relationship between endometriosis and omega-3 and omega-6 polyunsaturated fatty acids. Iran Biomed J. 2012;16(1):38-43. doi: 10.6091/ibj.1025.2012.

[41] Pereira FEXG, Medeiros FDC, Rocha HAL, Silva KSD. Effects of omega-6/3 and omega-9/6 nutraceuticals on pain and fertility in peritoneal endometriosis in rats. Acta Cir Bras. 2019 May 6;34(4):e201900405. doi: 10.1590/s0102-865020190040000005.

[42] Huang Y, Zhou WJ, Zhu L, Ni DD. Omega-3 polyunsaturated fatty acid intake and pain, inflammatory cytokines, and quality of life in endometriosis. Front Nutr. 2026 Mar 4;13:1768244. doi: 10.3389/fnut.2026.1768244.

[43] Anderson G. Endometriosis Pathoetiology and Pathophysiology: Roles of Vitamin A, Estrogen, Immunity, Adipocytes, Gut Microbiome and Melatonergic Pathway on Mitochondria Regulation. Biomol Concepts. 2019 Jul 19;10(1):133-149. doi: 10.1515/bmc-2019-0017.

[44] Xie B, Liao M, Huang Y, Hang F, Ma N, Hu Q, Wang J, Jin Y, Qin A. Association between vitamin D and endometriosis among American women: National Health and Nutrition Examination Survey. PLoS One. 2024 Jan 12;19(1): e0296190. doi: 10.1371/journal.pone.0296190.

[45] Bayu P, Wibisono JJ. Vitamin C and E antioxidant supplementation may significantly reduce pain symptoms in endometriosis: A systematic review and meta-analysis of randomized controlled trials. PLoS One. 2024 May 31;19(5): e0301867. doi: 10.1371/journal.pone.0301867.

[46] Tsokkou, S.; Matsas, A.; Konstantinidis, I.; Karopoulou, E.; Papamitsou, T.; Stamoula, E. Therapeutic Effects of Vitamins in Endometriosis Patients: A Systematic Review of Randomized Controlled Trials. *Int. J. Mol. Sci.* **2026**, *27*, 1476. https://doi.org/10.3390/ijms27031476