***Minireview Article***

**Potential beneficial effects of *Ocimum gratissimum* on male fertility: implication of the gut-testicular axis**

**Abstract**

This review explores the potential of Ocimum gratissimum, a widely used medicinal plant, to positively influence male fertility, with a particular focus on the emerging role of the gut-testicular axis. Male infertility is a significant global health concern, often linked to oxidative stress, inflammation, and hormonal imbalances. Ocimum gratissimum possesses known antioxidant, anti-inflammatory, and antimicrobial properties, suggesting a potential therapeutic role. This review conducted a search using databases such as PubMed, Scopus, and Web of Science, focusing on studies investigating the effects of Ocimum gratissimum on male reproductive parameters, gut microbiota composition, and related biochemical pathways. Search terms included "Ocimum gratissimum," "male fertility," "sperm quality," "testosterone," "gut microbiota," "gut-testicular axis," and related terms. Studies were evaluated for relevance, rigor, and data quality. Available evidence suggests that Ocimum gratissimum may improve sperm quality, increase testosterone levels, and reduce oxidative stress in animal models. Furthermore, its antimicrobial properties could potentially modulate gut microbiota composition, influencing the production of metabolites that impact testicular function and hormone regulation via the gut-testicular axis. However, the exact mechanisms and specific bioactive compounds responsible for these effects remain to be fully elucidated, and human clinical trials are limited. In conclusion, Ocimum gratissimum holds promise as a potential natural agent for improving male fertility. Further research, particularly well-designed human studies, is warranted to validate these findings and to fully understand the role of the gut-testicular axis in mediating its effects. This could lead to the development of novel therapeutic strategies for male infertility.

**Keywords:** Ocimum gratissimum, male fertility, sperm quality, gut microbiota, gut-testicular axis.

Introduction

Male infertility is a widespread and distressing issue, impacting a significant portion of couples worldwide, and often representing a significant challenge to family building. Estimates suggest that male factors contribute to approximately half of all infertility cases, highlighting the critical need for effective and accessible treatments to address this significant public health concern (WHO, 2023; Ferlin et al., 2022). The etiology of male infertility is often complex and multifaceted, encompassing a broad spectrum of potential underlying factors that can make diagnosis and treatment particularly challenging. These factors can range from hormonal imbalances disrupting the intricate endocrine system, impacting sperm production, development, and motility, to genetic disorders like Klinefelter syndrome or Y-chromosome microdeletions, directly affecting sperm production or function. Furthermore, modifiable lifestyle factors, such as poor diet lacking essential nutrients, insufficient or excessive exercise, obesity, and substance use including smoking, excessive alcohol consumption, and illicit drug use, can negatively impact sperm quality. Also, unavoidable environmental exposures to toxins and pollutants, including pesticides, heavy metals, and radiation, can also contribute to male infertility, adding another layer of complexity to the diagnostic and treatment process. Understanding the specific cause or combination of causes is crucial for developing personalized and effective treatment strategies for men struggling with infertility (Dutta and Sengupta, 2025; Devranoğlu et al., 2024; Kaltsas et al., 2023; Pallotti et al., 2022).

Given the potential invasiveness, high financial burden, and occasionally disappointing outcomes associated with conventional infertility treatments like assisted reproductive technologies (ART), an increasing number of individuals and couples are proactively exploring alternative and complementary therapies (ACT) in their quest to conceive. This shift in perspective reflects a desire for more holistic and less interventionist approaches. In this context, the appeal of natural remedies, perceived as gentler and potentially less toxic, has surged. Moreover, the exploration of traditional medicine systems, repositories of centuries-old knowledge about health and healing, has gained momentum as people search for potential solutions to reproductive challenges. Among the diverse array of natural options being investigated, Ocimum gratissimum, commonly known as African Basil or clove basil, has garnered increasing attention within both traditional healing practices and contemporary research (Udi, 2025; Oyem et al., 2021). This interest stems from its long-standing traditional use in various cultures around the world for addressing a multitude of ailments, including those specifically related to reproductive health, sexual function, hormonal balance, and overall well-being. Its potential role in improving fertility outcomes is now being more closely scrutinized.

This review embarks on an exploration of the potential of Ocimum gratissimum (OG), to enhance male fertility. The study will analyze existing scientific literature, drawing upon both in vitro and in vivo studies, alongside traditional ethnobotanical knowledge regarding its use as a fertility-enhancing agent. A key focus of this review lies in understanding the burgeoning significance of the gut-testicular axis. This intricate and bidirectional communication system connects the gut microbiome – the complex community of microorganisms residing in the gastrointestinal tract – and the testes, influencing various physiological processes, including spermatogenesis and hormone production. The review will investigate how this critical interaction might be instrumental in mediating the observed and purported beneficial effects of Ocimum gratissimum (OG) on sperm quality parameters (such as motility, morphology, and count), hormone regulation (including testosterone, luteinizing hormone, and follicle-stimulating hormone levels), and overall male reproductive health. The study will also focus on the potential mechanisms by which OG might modulate the gut microbiome composition and subsequently impact testicular function. By carefully examining the interplay between traditional usage, rigorous scientific evidence, and the emerging understanding of the gut-testicular axis, this review endeavors to provide a holistic and nuanced understanding of the potential of Ocimum gratissimum as a natural and complementary approach in the management of male infertility, ultimately contributing to the development of novel therapeutic strategies and further research in this important area. Furthermore, the study will highlight gaps in current research and suggest future directions for investigating the efficacy and safety of Ocimum gratissimum in improving male fertility.

**Potential beneficial effects of *Ocimum gratissimum* on male fertility: implication of the gut-testicular axis**

For centuries, *Ocimum gratissimum* has held a significant place in traditional folk medicine, revered for its purported healing properties and employed to address a diverse spectrum of ailments (Udi et al., 2018). Of particular note is its traditional use in supporting reproductive health, across various cultures. Different parts of the plant, including the leaves, stems, and roots, are traditionally employed to manage a range of reproductive concerns, from helping to regulate menstrual irregularities and potentially enhancing fertility to serving as a post-partum remedy designed to aid in recovery after childbirth in certain cultural practices. The plant's diverse and potentially therapeutic effects are believed to stem from its complex and rich phytochemical composition, containing a variety of bioactive compounds that contribute to its medicinal properties. Further research is ongoing to fully elucidate the specific mechanisms of action and validate the traditional uses of *Ocimum gratissimum* (Cetiz et al., 2024; Udi et al., 2023; Soudah et al., 2023; Pandey et al., 2022). The phytochemical profile of Ocimum gratissimum (African basil) is remarkably diverse, encompassing a myriad of bioactive compounds that contribute to its pharmacological properties and economic value. Among the most prominent of these compounds are eugenol and thymol, both volatile phenylpropanoids that are responsible for much of the plant's characteristic scent. Eugenol, in particular, is frequently the major component of the plant's essential oil, often reaching high concentrations and thus playing a significant role in its aroma and diverse biological activities such as antimicrobial, anti-inflammatory, and analgesic effects. Beyond these volatile components, Ocimum gratissimum also contains a variety of flavonoids, a class of polyphenolic compounds known for their antioxidant and anti-inflammatory properties. Specific flavonoids identified in Ocimum gratissimum include quercetin and rutin, among others, which contribute significantly to the plant's overall antioxidant capacity, helping to neutralize free radicals and protect against oxidative stress. It's important to note that the relative abundance and composition of these phytochemicals within Ocimum gratissimum are not static characteristics. They can vary substantially depending on a range of factors including geographical location (influencing soil composition and climate), growing conditions (such as sunlight exposure, water availability, and nutrient levels), the plant's stage of development, and the methods employed for extraction and analysis of the plant material. This variability underscores the importance of considering these factors when studying or utilizing Ocimum gratissimum for medicinal or commercial purposes (Udi et al., 2025; Soudah et al., 2023).

The identified phytochemicals in Ocimum gratissimum are known to possess a wide range of established biological activities, making the plant a promising candidate for further investigation. Eugenol, for instance, exhibits potent antioxidant, anti-inflammatory, and antimicrobial properties. At the molecular level, it can scavenge free radicals, neutralizing their damaging effects on cells (Devi et al., 2024). It also inhibits inflammatory pathways, potentially reducing pain and swelling associated with various conditions. Furthermore, eugenol disrupts microbial cell membranes, contributing to its antibacterial and antifungal effects (Alwan et al., 2024). Thymol, another key component, also displays significant antimicrobial activity against a broad spectrum of bacteria and fungi, inhibiting their growth and proliferation (Kowalczyk et al., 2020). Moreover, the flavonoids present in O. gratissimum contribute significantly to the plant's overall antioxidant capacity. These flavonoids protect against oxidative stress and cellular damage by donating electrons to stabilize free radicals and preventing their chain reactions (Hernández-Rodríguez et al., 2019). These combined properties, arising from the synergistic action of multiple phytochemicals, suggest that O. gratissimum holds significant potential for therapeutic applications across various fields, including but not limited to, infectious disease control, wound healing, and management of inflammatory disorders (Ugbogu et al., 2021; Imosemi, 2020). Further research is warranted to fully elucidate the mechanisms of action and potential clinical applications of this valuable plant.

**Effects of Ocimum gratissimum on Male Reproductive Parameters**

*Ocimum gratissimum* has garnered considerable attention in the scientific community due to its potential impact on male reproductive health. Numerous in vitro (test tube or cell culture) and in vivo (animal or clinical) studies have been conducted to examine the effects of this plant on various aspects of male reproductive parameters (Udi et al., 2025; Ezeorba et al., 2024). The primary focus of these investigations is to understand the potential influence of *Ocimum gratissimum* on spermatogenesis, the process of sperm cell development. Researchers assess sperm quality by examining several key metrics, including sperm motility (the ability of sperm to move efficiently), morphology (the shape and structure of sperm cells), and count (the total number of sperm cells). In addition to sperm analysis, many studies also evaluate the impact of *Ocimum gratissimum* on testosterone levels and other essential reproductive hormones. By assessing hormonal influences, researchers aim to determine how the plant may affect the overall hormonal balance within the male reproductive system. Another significant area of interest is the role of *Ocimum gratissimum* in modulating testicular oxidative stress and enhancing antioxidant defenses in the testes (Adelakun et al., 2022; Inyang et al., 2022; Salemcity et al., 2021; Njan et al., 2019). Oxidative stress occurs when there is an imbalance between the production of reactive oxygen species (ROS) and the body's ability to detoxify their harmful effects. Antioxidant defenses help protect cells from the damaging effects of ROS, and maintaining a healthy balance is crucial for optimal male reproductive function (Unsal et al., 2020). Some studies even delve into the plant's influence on libido and overall sexual function (Salemcity et al., 2021; Njan et al., 2019). By examining these aspects, researchers can better understand the potential impact of *Ocimum gratissimum* on male sexual health and well-being. To fully comprehend the true implications of *Ocimum gratissimum* on male reproductive health, it is vital to conduct a thorough analysis of the methodologies employed in these studies. This includes evaluating sample sizes, dosages, administration routes, and the overall rigor of the experimental design. By critically assessing these factors, researchers can determine the reliability and applicability of the findings, ultimately contributing to a more comprehensive understanding of the potential benefits and limitations of *Ocimum gratissimum* for male reproductive health.

**The Gut-Testicular Axis: A Brief Overview**

The Gut-Testicular Axis represents a captivating and rapidly evolving area of research, highlighting the intricate bidirectional communication pathway that exists between the gut microbiota and the testes. This interaction transcends a simple one-way influence; rather, it's a dynamic interplay where the composition, diversity, and metabolic activity of the gut microbiome have a significant impact on testicular function, impacting spermatogenesis, steroidogenesis, and overall testicular health. Conversely, the testes, through hormonal signaling and other mechanisms, can influence the gut environment, shaping the composition and function of the gut bacterial community. The communication between these seemingly disparate organs occurs through several key and interconnected mechanisms. Firstly, the gut microbiota plays a crucial role in modulating the immune system. The gut-associated lymphoid tissue (GALT), comprising a significant portion of the body's immune cells, is constantly interacting with gut microbes. This interaction can trigger a cascade of immune responses, influencing both local inflammatory processes within the gut and systemic inflammation throughout the body. Dysbiosis, an imbalance in the gut microbiota, can lead to chronic inflammation, potentially impacting the testes by disrupting the delicate balance required for proper function and sperm development (Eduviere and Udi, 2025; Ashonibare et al., 2024; Chen et al., 2024; Valeri and Endres, 2021).

Secondly, the gut plays a pivotal role in endocrine signaling, particularly concerning the production and regulation of hormones crucial for testicular function. The gut microbiota can influence the bioavailability and metabolism of steroid hormones, including testosterone, which is essential for spermatogenesis and male reproductive health. Disruption of this hormonal balance can lead to impaired testicular function and fertility issues (Hampl and Stárka, 2020). Finally, the gut microbiota produces a diverse array of metabolites, some of which are beneficial while others can be detrimental. These metabolites, such as short-chain fatty acids (SCFAs) like butyrate, acetate, and propionate, are produced through the fermentation of dietary fibers. SCFAs can enter the bloodstream and exert systemic effects on distant organs, including the testes, by influencing gene expression, energy metabolism, and inflammatory pathways. Other metabolites, such as trimethylamine N-oxide (TMAO), produced from dietary choline and carnitine, have been linked to inflammation and cardiovascular disease and may also negatively impact testicular health (Fan and Pedersen, 2021). Understanding the specific roles of these metabolites in the gut-testicular axis is a crucial area of ongoing research.

The intricate relationship between the gut microbiome and male reproductive health is becoming increasingly clear, with gut dysbiosis emerging as a significant contributor to infertility. The disruption of the gut's microbial balance, characterized by an imbalance in the types and quantities of bacteria residing within it, can have far-reaching consequences for spermatogenesis, the highly sensitive and complex process of sperm production. Dysbiosis can negatively impact spermatogenesis in several ways, leading to reduced sperm count (oligospermia), compromised sperm motility (asthenospermia), and abnormal sperm morphology (teratospermia), ultimately affecting overall sperm quality and the ability to fertilize an egg (Ahmad et al., 2025; Magill and MacDonald, 2023; Fan, and Pedersen, 2021). Beyond its direct effects on sperm production, gut dysbiosis can disrupt the delicate hormonal equilibrium essential for optimal testicular function. The gut microbiome plays a crucial role in the metabolism and regulation of various hormones, including testosterone, the primary male sex hormone vital for spermatogenesis, libido, and overall reproductive health. Imbalances in the gut flora can interfere with the proper production and utilization of testosterone, potentially leading to hormonal deficiencies that further compromise testicular function and sperm production. Similarly, the production of other key hormones involved in the hypothalamic-pituitary-gonadal (HPG) axis, which regulates male reproductive function, can also be negatively affected by gut dysbiosis (Ahmad et al., 2025). Furthermore, the altered gut microbiota in dysbiosis can trigger systemic inflammation, a key factor implicated in a wide range of health problems. This inflammation, driven by the leakage of bacterial products like lipopolysaccharide (LPS) into the bloodstream, can directly inflame the testes, the organs responsible for sperm production. This testicular inflammation, often referred to as orchitis, can further impair their function, contributing to impaired spermatogenesis, reduced testosterone production, and ultimately, increased infertility risk. The inflammatory cascade can also disrupt the blood-testis barrier, a protective mechanism designed to shield developing sperm from the immune system, leading to autoimmune responses against sperm cells and further exacerbating infertility (Ma et al., 2024; Mukherjee and Gopalakrishnan, 2024). Disruptions to the gut flora, leading to dysbiosis, can negatively impact spermatogenesis, disrupt hormonal balance, and trigger systemic inflammation, all of which can contribute to male infertility (Beni et al., 2024). Therefore, strategies aimed at promoting a healthy gut microbiome, such as dietary modifications, prebiotic and probiotic supplementation, and lifestyle changes, are emerging as potential therapeutic interventions for improving male reproductive health and addressing infertility.

**Ocimum gratissimum and the Gut Microbiota**

*Ocimum gratissimum* (OG) offers a compelling case study for understanding the complex interplay between plant-derived compounds and the delicate environment of the gut. This aromatic herb possesses a unique chemical profile, particularly its abundance of compounds exhibiting antimicrobial activity. These inherent antimicrobial properties suggest a potential to selectively target and inhibit the growth of undesirable, pathogenic bacteria within the gut. By suppressing these harmful microbes, OG could effectively reduce competition for essential nutrients and physical space, thereby creating a more favorable environment for the proliferation of beneficial bacteria. Beyond simply suppressing harmful organisms, *Ocimum gratissimum* may also actively contribute to the flourishing of beneficial gut bacteria. The plant potentially contains prebiotic components – non-digestible fibers and other complex carbohydrates – that act as a preferred food source for these beneficial microbes. This nurturing effect would further stimulate their growth and metabolic activity, allowing them to thrive and contribute more effectively to gut health. The combined impact of these actions – the selective inhibition of harmful bacteria and the promotion of beneficial bacteria – results in a significant modulation of the gut microbiota composition. This shift favors a more diverse and balanced ecosystem, characterized by a greater abundance and variety of beneficial microbial species. Such a balanced gut microbiota is increasingly recognized as crucial for a myriad of health benefits, including improved gut barrier function, leading to reduced intestinal permeability and preventing the leakage of harmful substances into the bloodstream (Ogwu et al., 2025; Harikrishnan and Balasundaram, 2020). Furthermore, a healthy gut microbiota can enhance the absorption of essential nutrients from food, ensuring optimal utilization of dietary intake. Finally, a balanced gut environment plays a critical role in regulating the immune system and reducing inflammation throughout the body, contributing to overall well-being and potentially mitigating the risk of chronic diseases.

The emerging understanding of the gut-testicular axis, a complex and bidirectional communication pathway between the gut microbiome and the reproductive system, allows us to hypothesize a novel mechanism for *Ocimum gratissimum's* observed effects on male fertility. The study propose that *Ocimum gratissimum's* positive influence on gut health, potentially mediated by modifications to the gut microbiota composition and function, could indirectly but significantly impact testicular function and, consequently, male fertility parameters. A healthier gut environment, fostered by the plant's antimicrobial, anti-inflammatory, and prebiotic-like properties, could lead to a reduction in systemic inflammation. Chronic systemic inflammation is increasingly recognized as a key contributor to male infertility, in part due to its detrimental effects on the delicate process of spermatogenesis (Dutta et al., 2021; Sciorio et al., 2025). By mitigating systemic inflammation, *Ocimum gratissimum* may protect the testes from oxidative stress and inflammatory damage, thereby safeguarding sperm production and maintaining sperm quality, including motility, morphology, and DNA integrity.

Furthermore, a balanced and diverse gut microbiota, potentially promoted by *Ocimum gratissimum*, could enhance the absorption of essential nutrients crucial for optimal testicular function. These nutrients, including but not limited to zinc, selenium, and various vitamins (D, B12, etc.), serve as vital building blocks for healthy sperm development. They are also critical for the biosynthesis of testosterone, the primary male sex hormone responsible for regulating spermatogenesis and maintaining libido. Improved nutrient absorption would ensure that the testes receive an adequate supply of these essential compounds, supporting robust sperm production and maintaining optimal testosterone levels (Carrageta et al., 2024). Therefore, future research is crucial to further elucidate the specific mechanisms by which *Ocimum gratissimum* interacts with the gut microbiota, identify the key microbial metabolites involved, and subsequently, determine how these interactions affect testicular function at a molecular level. Studies should investigate the plant's impact on gut microbial diversity and composition, gut barrier integrity, and the production of short-chain fatty acids (SCFAs), which are known to influence systemic inflammation and immune function. Investigations into the effects of *Ocimum gratissimum* on testicular gene expression, hormone production, and sperm parameters are warranted. Validating this promising potential therapeutic avenue for male fertility enhancement through rigorous scientific investigation could offer a natural and potentially less invasive approach to addressing a significant and growing global health concern.

**Potential Mechanisms of Action through the Gut-Testicular Axis**

The gut-testicular axis, a bidirectional communication network connecting the gut microbiome and the male reproductive system, presents a promising avenue for Ocimum gratissimum to exert its potential fertility-enhancing effects. This intricate connection allows for a complex interplay of microbial metabolites and signaling molecules that can significantly impact testicular health and function. One key mechanism by which Ocimum gratissimum may influence fertility involves the modulation of gut microbiota composition. By fostering a more balanced and beneficial gut flora, characterized by an increase in beneficial bacterial species and a reduction in harmful pathogens, Ocimum gratissimum could contribute to reduced systemic inflammation and an improved immune response (Ugbogu et al., 2021; Imosemi, 2020). Dysbiosis, or an imbalance in the gut microbiome, is often associated with chronic inflammation that can negatively impact various organ systems, including the testes. Therefore, restoring a healthy gut microbiome can mitigate inflammatory damage and support optimal immune function within the testes, creating a more conducive environment for spermatogenesis. The activity of gut bacteria can result in the production of beneficial metabolites, primarily short-chain fatty acids (SCFAs) such as butyrate, acetate, and propionate. These SCFAs, produced through the fermentation of dietary fibers, have been shown to exert various positive effects, including supporting testicular function by providing energy to testicular cells and influencing gene expression related to steroidogenesis. Moreover, SCFAs can promote healthy hormone production, particularly testosterone, which is crucial for male fertility, libido, and overall reproductive success. They achieve this by influencing the expression of enzymes involved in testosterone synthesis within the Leydig cells of the testes (Edem et al., 2021; Ohiagu et al., 2021).

Finally, Ocimum gratissimum may influence endocrine signaling pathways involved in testicular function through gut-derived factors. The gut microbiota plays a crucial role in regulating the bioavailability and metabolism of various hormones. These gut-derived factors, modulated by the gut microbiota's response to the herb, could directly or indirectly regulate hormone synthesis and release, affecting the hypothalamic-pituitary-gonadal (HPG) axis, the central regulator of reproductive function (Lin et al., 2025). By influencing this axis, Ocimum gratissimum, via its impact on the gut microbiome, could contribute to improved sperm quality, enhanced sperm motility, and ultimately, improved reproductive success. Further research is warranted to fully elucidate the specific microbial changes induced by Ocimum gratissimum and the resulting impact on hormonal profiles and male reproductive outcomes.

**Conclusion and Future Directions**

In conclusion, the growing body of evidence strongly indicates that Ocimum gratissimum (OG), presents a compelling prospect as a natural therapeutic agent for enhancing male fertility. Preclinical studies, encompassing both in vitro and in vivo models, have consistently demonstrated the potential of OG extracts and compounds to improve critical sperm parameters, including sperm count, motility, and morphology. These studies also point towards a potential mechanism involving the elevation of serum testosterone levels, a crucial hormone for spermatogenesis, and the reduction of oxidative stress within the testes. This reduction in oxidative stress, often caused by an imbalance between reactive oxygen species production and antioxidant defense, likely contributes to improved testicular function and, consequently, enhanced reproductive outcomes.

A critical consideration highlighted by this review is the potential, and previously underappreciated, role of the gut-testicular axis in mediating the observed beneficial effects of Ocimum gratissimum. This intricate and bidirectional communication pathway between the gut microbiome and the testes suggests that the modulation of gut microbiota composition and subsequent production of beneficial metabolites, such as short-chain fatty acids, may be a key mechanistic link by which OG influences testicular function, sperm quality, and overall male reproductive health. Altered gut microbiota composition can lead to systemic inflammation and dysregulation of hormonal balance, potentially impacting testicular function. However, despite these promising findings, significant knowledge gaps remain that warrant further, rigorous investigation. Future research should prioritize the design and implementation of well-powered, placebo-controlled clinical trials adhering to strict methodological standards to rigorously evaluate the efficacy and safety of Ocimum gratissimum in treating male infertility in human subjects. These trials should incorporate comprehensive assessments of sperm parameters, hormonal profiles, and markers of oxidative stress. Furthermore, detailed studies are needed to elucidate the specific effects of Ocimum gratissimum administration on gut microbiota composition and function, employing advanced techniques such as 16S rRNA gene sequencing and metagenomic analysis. Understanding how these changes in the gut microbiome correlate with improvements in male fertility parameters is crucial for establishing causality. Finally, in-depth exploration of the specific metabolites produced by gut bacteria in response to OG consumption and the signaling pathways involved in the gut-testicular axis, as mediated by Ocimum gratissimum, will be crucial for a comprehensive understanding of its precise mechanism of action. This includes investigating which bacterial strains are specifically influenced by OG, identifying the metabolites they produce, and determining how these metabolites interact with testicular cells. Addressing these gaps through targeted and well-designed research will solidify the evidence base and further validate the potential of Ocimum gratissimum as a safe, accessible, and effective natural alternative or adjunct treatment for male infertility, potentially reducing reliance on more invasive and costly conventional treatments.

REFERENCES

Adelakun, S. A., Ogunlade, B., Akintunde, O. W., Omilachi, V. O. (2022). Long-term exposure to cimetidine induced gonado-toxicity in male rats: Modulating role of Ocimum gratissimum. *Revista Internacional de Andrología*, *20*, S2-S16.

Ahmad, F., Ahmed, S. H., Choucair, F., Chouliaras, S., Awwad, J., Terranegra, A., Medicine, S. (2025). A disturbed communication between hypothalamic-pituitary-ovary axis and gut microbiota in female infertility: is diet to blame? *Journal of Translational Medicine*, *23*(1), 92.

Alwan, S., Hatem, T., Abid, H. (2024). Molecular mechanisms of eugenol as an antitumour bioactive compound: A comprehensive review. In *BIO Web of Conferences*.125:03007). EDP Sciences.

Ashonibare, V. J., Akorede, B. A., Ashonibare, P. J., Akhigbe, T. M., Akhigbe, R. E. (2024). Gut microbiota-gonadal axis: the impact of gut microbiota on reproductive functions. *Frontiers in Immunology*, *15*, 1346035.

Beni, F. A., Saffarfar, H., Elhami, A., Kazemi, M. (2024). Gut Microbiota Dysbiosis: A Neglected Risk Factor for Male and Female Fertility. *Cellular Microbiology*, *2024*(1), 7808354.

Carrageta, D. F., Pereira, S. C., Ferreira, R., Monteiro, M. P., Oliveira, P. F., Alves, M. G. (2024). Signatures of metabolic diseases on spermatogenesis and testicular metabolism. *Nature Reviews Urology*, *21*(8), 477-494.

Cetiz, M. V., Isah, M., Ak, G., Bakar, K., Himidi, A. A., Mohamed, A., Zengin, G. (2024). Exploring of Chemical Profile and Biological Activities of Three Ocimum Species From Comoros Islands: A Combination of In Vitro and In Silico Insights. *Cell Biochemistry and Function*, *42*(7), e70000.

Chen, W., Zou, H., Xu, H., Cao, R., Zhang, H., Zhang, Y., Zhao, J. (2024). The potential influence and intervention measures of gut microbiota on sperm: it is time to focus on testis-gut microbiota axis. *Frontiers in Microbiology*, *15*, 1478082.

Devi, S., Chauhan, S., Mannan, A., Singh, T. G. (2024). Targeting cardiovascular risk factors with eugenol: An anti-inflammatory perspective. *Inflammopharmacology*, *32*(1), 307-317.

Devranoğlu, B., Gürbüz, T., Yurci, A. (2024). Male infertility: an overview of etiology, diagnosis and management. *Journal of Controversies in Obstetrics & Gynecology and Pediatrics*, *2*(2), 33-36.

Dutta, S., Sengupta, P. (2025). *Infections and Male Infertility: General Pathophysiology, Diagnosis, and Treatment*. Bentham Science Publishers.

Dutta, S., Sengupta, P., Slama, P., Roychoudhury, S. (2021). Oxidative stress, testicular inflammatory pathways, and male reproduction. *International journal of molecular sciences*, *22*(18), 10043.

Ezeorba, T. P. C., Chukwuma, I. F., Asomadu, R. O., Ezeorba, W. F. C., Uchendu, N. O. (2024). Health and therapeutic potentials of Ocimum essential oils: a review on isolation, phytochemistry, biological activities, and future directions. *Journal of Essential Oil Research*, *36*(3), 271-290.

Edem, E. E., Nathaniel, B. U., Nebo, K. E., Obisesan, A. O., Olabiyi, A. A., Akinluyi, E. T., Ishola, A. O. (2021). Lactobacillus plantarum mitigates sexual-reproductive deficits by modulating insulin receptor expression in the hypothalamic-pituitary-testicular axis of hyperinsulinemic mice. *Drug Metabolism and Personalized Therapy*, *36*(4), 321-336.

Eduviere, A.T., Udi, O.A. (2025). “Mechanisms Associated With Ginkgo Biloba and Future Research Directions: Implication of the Hypothalamic Pituitary-Testicular Axis”. Asian Journal of Medical Principles and Clinical Practice 8 (1):184-95

Fan, Y., Pedersen, O. (2021). Gut microbiota in human metabolic health and disease. *Nature Reviews Microbiology*, *19*(1), 55-71.

Ferlin, A., Calogero, A. E., Krausz, C., Lombardo, F., Paoli, D., Rago, R., Corona, G. (2022). Management of male factor infertility: position statement from the Italian Society of Andrology and Sexual Medicine (SIAMS) endorsing organization: Italian Society of Embryology, reproduction, and research (SIERR). *Journal of endocrinological investigation*, *45*(5), 1085-1113.

Hampl, R., Stárka, L. (2020). Endocrine disruptors and gut microbiome interactions. *Physiological research*, *69*(2), S211.

Harikrishnan, R., Balasundaram, C. (2020). Potential of herbal extracts and bioactive compounds for human healthcare. In *The Role of Phytoconstitutents in Health Care* (pp. 3-158). Apple Academic Press.

Hernández-Rodríguez, P., Baquero, L. P., Larrota, H. R. (2019). Flavonoids: Potential therapeutic agents by their antioxidant capacity. In *Bioactive compounds* (pp. 265-288). Woodhead Publishing.

Imosemi, I. O. (2020). A review of the medicinal values, pharmacological actions, morphological effects and toxicity of Ocimum gratissimum Linn. *Eur J Pharm Med Res*, *7*(7), 29-40.

Inyang, K. A., Edagha, I. A., Akpanyung, E. O., Edagha, E. I., Asuquo, I. E., Edem, D. O. (2022). Ocimum gratissimum attenuates diabetes-induced biochemical and histomorphological gonado-alterations. *Scientific African*, *16*, e01222.

Kaltsas, A., Zachariou, A., Markou, E., Dimitriadis, F., Sofikitis, N., Pournaras, S. (2023). Microbial dysbiosis and male infertility: understanding the impact and exploring therapeutic interventions. *Journal of personalized medicine*, *13*(10), 1491.

Kowalczyk, A., Przychodna, M., Sopata, S., Bodalska, A., Fecka, I. (2020). Thymol and thyme essential oil—new insights into selected therapeutic applications. *Molecules*, *25*(18), 4125.

Lin, X., Yu, Z., Liu, Y., Li, C., Hu, H., Hu, J. C., Chen, P. (2025). Gut–X axis. *iMeta*, *4*(1), e270.

Ma, Y., Yu, X., Liu, Y. F., Song, B., Sun, Z., Zhao, S. (2024). Immunoregulation and male reproductive function: Impacts and mechanistic insights into inflammation. *Andrology*.

Magill, R. G., MacDonald, S. M. (2023). Male infertility and the human microbiome. *Frontiers in reproductive health*, *5*, 1166201.

Mukherjee, A. G., Gopalakrishnan, A. V. (2024). Anti-sperm antibodies as an increasing threat to male fertility: immunological insights, diagnostic and therapeutic strategies. *Reproductive Sciences*, *31*(11), 3303-3322.

Njan, A. A., Olaoye, S. O., Afolabi, S. O., Ejimkonye, B. C., Soje, A., Olorundare, O. E., Iwalewa, E. O. (2019). Safety effect of fractions from methanolic leaf extract of Ocimum gratissimum on reproduction in male wistar rats. *Toxicology Reports*, *6*, 496-504.

Ugbogu, O. C., Emmanuel, O., Agi, G. O., Ibe, C., Ekweogu, C. N., Ude, V. C., Ugbogu, E. A. (2021). A review on the traditional uses, phytochemistry, and pharmacological activities of clove basil (Ocimum gratissimum L.). *Heliyon*, *7*(11).

Ogwu, M. C., Ogidi, O. I., Izah, S. C., Odubo, T. C. (2025). Therapeutic and Preventive Effects of Natural Compounds Derived from Microbes. In *Natural Products: Phytochemistry, Botany, Metabolism of Alkaloids, Phenolics and Terpenes* (pp. 1-34). Berlin, Heidelberg: Springer Berlin Heidelberg.

Ohiagu, F. O., Chikezie, P. C., Maduka, T. D., Enyoh, C. E., Chikezie, C. M. (2021). Bioactive compounds and medicinal usefulness of edible leaves of Vernonia amygdalina, Ocimum gratissimum, Piper guineense and Gongronema latifolium. *SAJ Pharma Pharmacol 7: 101 Abstract Keywords: Bioactive Compounds*, 2.

Oyem, J. C., Chris-Ozoko, L. E., Enaohwo, M. T., Otabor, F. O., Okudayo, V. A., Udi, O. A. (2021). Antioxidative properties of Ocimum gratissimum alters Lead acetate induced oxidative damage in lymphoid tissues and hematological parameters of adult Wistar rats. *Toxicology reports*, *8*, 215-222.

Pallotti, F., Barbonetti, A., Rastrelli, G., Santi, D., Corona, G., Lombardo, F. (2022). The impact of male factors and their correct and early diagnosis in the infertile couple's pathway: 2021 perspectives. *Journal of endocrinological investigation*, *45*(10), 1807-1822.

Pandey, P., Singh, S., Negi, A. S., Banerjee, S. (2022). Harnessing the versatility of diverse pentacyclic triterpenoid synthesis through hairy root cultures of various Ocimum species: An unprecedented account with molecular probing and up-scaling access. *Industrial Crops and Products*, *177*, 114465.

Salemcity, A. J., Agbaje, T. S., Effiong, M. E., Asuelimen, S. O. (2021). Aqueous Fraction of Ocimum gratissimum (L) Leaf Extract Protects Sperm Membrane Integrity in Plumbagin-induced Testicular Damage in Rats. *Free Radicals and Antioxidants*, *11*(2), 52-57.

Sciorio, R., De Paola, L., Notari, T., Ganduscio, S., Amato, P., Crifasi, L., Gullo, G. (2025). Decoding the Puzzle of Male Infertility: The Role of Infection, Inflammation, and Autoimmunity. *Diagnostics*, *15*(5), 547.

Soudah, B. O. M. A., Bignoate, K. O. M. B. A. T. E., Noumonzeme, B. I. D. E. M. A., Toï, N. F., Ibrahim, I. T. (2023). Antifungal Activities of Ocimum gratissimum L. Hydroethanolic Extract against Candida albicans ATCC 35659 and Toxicity Analysis on Oreochromis niloticus Larvae.

Udi, O. A. (2025). Bidirectional Communication Network: Exploring the Gut-Brain Axis as a Target for Ocimum Gratissimum Modulation in Neurodegenerative Disorder. *Journal of Applied Sciences and Environmental Management*, *29*(2), 407-416.

Udi, O. A., Igbigbi, P. S., Chris-Ozoko, L. E., Oyeleke, A. A. (2018). Lead II Acetate Induced Physio-Morphological Changes in Prefrontal Cortex of Ocimum gratissimum Fed Wistar Rats. *AJORIN*, *1*(1), 1e10.

Udi, O. A., Oyovwi, M. O., Adeogun, A. E. (2025). Exploring the cognitive-enhancing effects of Ocimum gratissimum: an ethnopharmacological and phytochemical review. *Discover Plants*, *2*(1), 1-18.

Udi, O. A., Ijeomah, T. A., Ogagayere, L. O., Okoro, G. O. (2023). Alfavaca aqueous leaf extract protective and ameliorative effects on lead induced hippocampus in wistar rats. *Asian Journal of Medicine and Health*, *21*(11), 8-15.

Ugbogu, O. C., Emmanuel, O., Agi, G. O., Ibe, C., Ekweogu, C. N., Ude, V. C., Ugbogu, E. A. (2021). A review on the traditional uses, phytochemistry, and pharmacological activities of clove basil (Ocimum gratissimum L.). *Heliyon*, *7*(11).

Unsal, V., Dalkıran, T., Çiçek, M., Kölükçü, E. (2020). The role of natural antioxidants against reactive oxygen species produced by cadmium toxicity: a review. *Advanced pharmaceutical bulletin*, *10*(2), 184.

Valeri, F., Endres, K. (2021). How biological sex of the host shapes its gut microbiota. *Frontiers in Neuroendocrinology*, *61*, 100912.

World Health Organization. (2023). *Infertility prevalence estimates, 1990–2021*. World Health Organization.