International Journal of Reproductive BioMedicine
Volume 24, Issue no. 7, https://doi.org/10.18502/ijrm.v24i7.21577
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Review Article

The role of date palm pollen in women's health and fertility: A narrative review

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Received: 10 August 2025
Revised: 28 February 2026
Accepted: 18 May 2026

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Editor-in-Chief:
Aflatoonian Abbas M.D.

Abstract

Infertility is a significant challenge in today's industrialized world, affecting approximately 15% of couples of reproductive age. Around 10% of infertility cases worldwide remain unexplained. As a result, extensive research has focused on exploring natural resources and innovative approaches to preventing and treating infertility. One traditional remedy used since ancient times to enhance sexual potency and fertility in both men and women is date palm pollen (DPP). This study examines the various bioactive compounds in DPP that hold nutritional and therapeutic significance, including phenolic acids, flavonoids, proteins, fatty acids, vitamins, and minerals, which may contribute to fertility. It further analyzes the mechanisms and therapeutic effects of DPP. Evidence from animal and human studies suggests that DPP positively impacts hormonal balance, including estrogen, progesterone, and follicle-stimulating hormone levels, enhances ovarian function, improves egg quality, reduces oxidative stress, alleviates menopausal symptoms such as vaginal dryness and dyspareunia, and boosts women's sexual health. The mechanism of action of DPP appears to involve modulation of the hypothalamic-pituitary-gonadal axis, enhancement of steroidogenesis, and activation of antioxidant defenses. Additionally, it regulates nitric oxide signaling, modulates dopaminergic pathways, suppresses inflammation, and activates key signaling cascades, including PI3K/Akt, MAPK, and Nrf2/ARE. However, challenges remain in this advanced technological era, including variability in composition, pre-purification requirements, and a lack of standardized clinical protocols. Despite these challenges, DPP shows considerable potential for improving fertility. Future studies in the field should prioritize the systematic isolation of bioactive components, detailed mechanistic investigations, rigorous clinical validation, and integration into sustainable bioeconomy strategies.

Keywords: *Women's health, Date palm, Fertility, Phoenix dactylifera.*

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1. Introduction

One of the fundamental challenges faced by the modern industrialized world is infertility, which affects millions of individuals globally for various reasons (1). Approximately 15% of couples of reproductive age encounter this issue after 1 yr of regular, unprotected intercourse, with about 10% of these cases remaining unexplained (2). The causes of natural infertility are varied, including genetic predisposition, hormonal imbalances, infections, and environmental factors. Incorporating antioxidants, phytohormones, and essential micronutrients into a healthy diet can effectively reduce oxidative stress, improve ovulation, and preserve sperm DNA integrity (3).

Since ancient times, medicinal plants have been a cornerstone of primary healthcare. According to the World Health Organization, around 85% of people rely on traditional medicine to meet their essential health needs (4). Among these, date palm pollen (DPP) (*Phoenix dactylifera* L.) has been recognized in traditional medicine for its potential role in enhancing fertility. The date palm, a member of the Arecaceae family, is one of the oldest cultivated plants, with a history spanning over 6000 yr. It typically grows up to 15 m tall and thrives in hot, dry regions with low humidity and well-drained sandy soils (5, 6). The date palm is one of the oldest cultivated fruit crops in the arid regions of the Arabian Peninsula, North Africa, and the Middle East, likely originating near present-day Iraq. Over the past 3 centuries, date palm cultivation has expanded to various regions worldwide. The date palm exhibits unique biological and growth characteristics that necessitate specialized propagation, cultivation, and management practices (7).

Recent studies have identified DPP as a potential dietary supplement, particularly beneficial for fertility and reproductive health (8, 9). Research indicates that palm pollen is rich in vitamins, minerals, antioxidants, and phytochemicals that may enhance egg quality and help regulate sex hormones (10–13). In traditional medicine, it has been extensively used to address fertility issues (14, 15). A phytochemical analysis of DPP reveals the presence of flavonoids, phenolics, sterols, polysaccharides, amino acids, fatty acids, and vitamins, all of which can influence fertility (2). Animal studies suggest that these bioactive compounds in DPP may act as antioxidants, modulate hormonal activity, and regulate metabolism, potentially enhancing fertility (16).

Initial animal research indicated that palm pollen has gonadotropic effects, as aqueous extracts were found to increase testicular weight, stimulate spermatogenesis, and enlarge accessory reproductive organs in young rodents (17, 18). More recent studies suggest that supplementation with DPP may improve sperm concentration, motility, morphology, and DNA integrity by elevating levels of testosterone, estradiol, luteinizing hormone (LH), and follicle-stimulating hormone (FSH) (19, 20). Additional findings indicate modulation of dopaminergic pathways, increased libido, and enhanced sexual function (21, 22). Animal model studies have also demonstrated DPP's ability to influence female reproductive physiology, with phytogenic activity observed that led to increased vaginal receptivity, improved ovarian mass, enhanced folliculogenesis, and higher levels of estrogen and progesterone (23–25). In assessments of rabbit ovarian tissue, DPP was shown to increase pregnancy rates, enhance embryo quality, and improve litter viability by strengthening antioxidant defenses and

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boosting systemic immunity (26). These results highlight DPP's potential as a holistic regulator of reproduction, integrating endocrine control with various metabolic benefits. Both animal and human studies support the multifunctional role of DPP as a fertility-enhancing agent.

This study aims to review the evidence regarding the phytochemical composition of palm pollen, the biological mechanisms underlying its fertility effects, and its potential to enhance fertility, providing a clear framework for a more accurate evaluation.

2. Overview of the composition and properties of DPP

Over 2000 yr ago, Hippocrates famously stated, "Let food be your medicine and medicine be your food" (27). Among various natural substances, DPP from the plant *P. dactylifera* L. is notable for its medicinal and nutritional benefits. While its primary role is as a pollinator, surplus pollen has long been used as a traditional preventive and therapeutic agent for reproductive disorders in both men and women, which has contributed to its cultural significance and economic value. Current evidence indicates that DPP may enhance oocyte quality, regulate hormone levels, and reduce oxidative stress, thanks to its rich content of vitamins, minerals, proteins, and antioxidant compounds (28).

2.1. Phenolic compounds in DPP

DPP activity likely functions through a complex, interconnected network that influences fertility. The proposed mechanisms include changes in hormonal balance, enhanced antioxidant defenses, nitric oxide (NO)-driven vasodilation, stimulation of the dopaminergic system, gonadotropic activation, and suppression of inflammatory processes (29–31). Palm pollen contains a rich array of phenolic compounds, such as caffeic acid, gallic acid, p-coumaric acid, catechins, chlorogenic acid, quercetin, and rutin, along with flavonoids like isorhamnetin, apigenin, and lutein (11, 27, 32). Among these, pyrogallol and catechins are identified as the predominant phenolics in DPP extracts (33). Numerous experimental studies have investigated the effects of these phenolics on sexual and reproductive functions in laboratory animals. Daily administration of DPP aqueous and ethanolic extracts at doses ranging 120–240 mg/kg body weight has shown beneficial effects on testicular health, hormonal profiles, and sexual behavior (27). Notably, improvements have been observed in mating frequency, testosterone levels, sperm count, motility, and morphology, along with histological and physiological changes in reproductive organs. Additionally, the extracts have demonstrated positive effects on body weight and antioxidant status (20, 34, 35). The unique solubility characteristics of these extracts suggest the presence of polar bioactive constituents, including phenolic acids and flavonoids, which are associated with significant biological activities. These compounds interact with cellular components such as enzymes and receptors, modulating signaling pathways essential for reproductive function. While the precise mechanisms by which phenolic compounds and flavonoids enhance reproductive parameters in DPP are not fully understood, several hypotheses merit further investigation. Molecular evidence suggests that DPP modulates testosterone and estrogen biosynthesis by influencing steroidogenic enzymes CYP11A1 and CYP19A1, both critical to

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reproductive function. Additionally, mechanistic studies indicate that these compounds activate key signaling cascades, including the antioxidant pathways PI3K/Akt, MAPK, and Nrf2/ARE, thereby linking phytochemicals to tangible reproductive outcomes (36–38). Many phenolic compounds exhibit both hydrophilic and lipophilic properties, making them amphiphilic (39). This characteristic enables them to associate with cell membranes, potentially forming lipid bilayers and interacting with hydrophobic lipid chains. Through these interactions, polyphenols such as gallic acid, p-coumaric acid, and ellagic acid can scavenge free radicals by donating hydrogen atoms generated during lipid peroxidation, protecting membrane integrity from oxidative damage (40). Recent findings suggest that these polyphenols activate key molecular messengers, including the antioxidant pathways PI3K/Akt, MAPK, and Nrf2/ARE, which modulate extracellular signaling and the ERK/Nrf2 axis to enhance antioxidant defenses. This activation increases the expression of antioxidant enzymes, contributing to the observed antioxidant activity of certain phenolics (41).

2.2. Proteins in DPP

DPP is a significant source of high-quality proteins that supply essential amino acids required for hormone production and tissue development (Table I). The protein content in DPP varies considerably, ranging from 15.81–38.18%, influenced by factors such as genotype, geographical location, soil type, and climatic conditions. For instance, a study by Bacha et al. analyzed 13 different date palm cultivars in Riyadh, Saudi Arabia, revealing protein content between 15.81% and 18.02% (42). In another study conducted in Iraq, 2 DPP cultivars showed distinct protein levels: red sorghum pollen had a higher crude protein content of 27.24%, while Samasmi pollen contained a lower level of 23.42% (43).

Table I. DPP essential amino acids (44, 45)

Amino acid	Percentage range (%)
Arginine	0.15–5.17
Valine	1.81–5.16
Histidine	1.61–2.53
Isoleucine	1.49–4.37
Leucine	3.43–8.35
Lysine	2.95–7.73
Methionine	0.11–2.37
Phenylalanine	1.63–4.25
Threonine	1.72–4.70

DPP: Date palm pollen

The amino acids present in DPP serve as the building blocks of proteins and play a vital role in fertility. They are essential for synthesizing sex hormones and converting hormone precursors into their active forms. Hormones such as testosterone and estrogen bind to carrier proteins for transport to their target tissues (36, 46). Upon reaching these tissues, hormones interact with specific receptor

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proteins within cells, altering gene expression and initiating various cellular responses. Among the amino acids, arginine is particularly noteworthy for its beneficial effects on sperm quality and function. Research indicates that arginine can reduce oxidative stress and heat-related damage to sperm cells, enhancing their viability without adverse effects (47–49). Additionally, the antioxidant properties of amino acids contribute to maintaining the structural and functional health of reproductive tissues.

2.3. Carbohydrates in DPP

Research consistently shows variations in the carbohydrate content of DPP powder across different cultivars and geographic regions. For example, one study found that Moroccan DPP had the highest carbohydrate content at 26.51% (50). Similarly, the Iraqi Ghanami Ahmar cultivar exhibited a slightly lower carbohydrate content of 26.25% (51). Carbohydrates serve as a primary energy source for reproductive tissues, supplying energy through the breakdown of carbon-hydrogen bonds in their molecular structure. This energy is essential for various physiological processes related to reproduction, including hormone synthesis and cellular division within reproductive organs (52).

2.4. Fatty acids in DPP

Fatty acids are a crucial component of the dietary profile of DPP and play an indirect role in reproductive processes. They are essential for the structure and function of cell membranes, ensuring cellular integrity and efficient signaling. Essential fatty acids, particularly omega-3 and omega-6, are vital for numerous physiological functions that significantly impact reproductive health. These fatty acids assist in the synthesis and regulation of hormones, including prostaglandins, which are critical for processes such as ovulation and implantation. This highlights the importance of fatty acids in supporting overall reproductive health (53).

Moreover, omega-3 fatty acids, especially eicosapentaenoic acid and docosahexaenoic acid, have been shown to directly influence the synthesis of prostaglandins, which are crucial for regulating the menstrual cycle and initiating labor. These fatty acids also reduce inflammation and facilitate cellular communication within reproductive tissues, thereby enhancing fertility potential (54).

2.5. Minerals and vitamins in DPP

DPP is abundant in essential vitamins and minerals that play significant roles in health and well-being. It is particularly rich in B-complex vitamins (B1, B2, B3, and B6), vitamin C, and vitamin E, all of which are crucial for energy metabolism, cellular protection against damage, and immune system support. Additionally, DPP provides several important minerals vital for overall health and normal bodily functions, including zinc, selenium, iron, calcium, potassium, copper, and magnesium. Zinc is especially noteworthy for its positive effects on hormone production and its role in improving egg quality. Research indicates that zinc is essential for regulating testosterone and estrogen levels and enhancing the structural integrity of sperm and egg cells (55, 56). Calcium is essential for uterine contractions and the ovulation process, while magnesium helps regulate

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hormones and reduce oxidative stress, both critical for maintaining egg and sperm quality (57). The antioxidant properties of vitamin C, vitamin E, zinc, and selenium work synergistically to protect reproductive cells from oxidative damage, which is often linked to infertility (58).

Although DPP is a rich source of these nutrients, their concentrations can vary significantly depending on factors such as cultivar, collection location, and soil conditions. For example, studies have shown that Moroccan DPP tends to have higher mineral concentrations compared to Middle Eastern varieties (59).

2.6. Hormones

Gonadotropic components were first extracted from DPP by Solomon and Solomon, revealing the presence of FSH and LH that elicited reproductive responses in rats (18). Subsequent investigations isolated a steroidal saponin glycoside and a glycoprotein with gonadotropic activity (17, 31, 60). Thin-layer chromatography also confirmed the presence of estrone. However, no study to date has achieved complete purification and conclusive identification of gonadotropic hormones derived from DPP. Evidence has been reported of DPP's modulation of the hypothalamic-pituitary-gonadal axis, contributing to enhanced fertility (61). In males, components such as flavonoids, steroids, proteins, amino acids, zinc, vitamins, carbohydrates, and polyunsaturated fatty acids can stimulate the release of gonadotropins (LH and FSH), which subsequently increases testosterone production by Leydig cells and supports spermatogenesis (19, 62, 63).

In females, phytoestrogens like estriol and estradiol, often referred to as endogenous estrogens, regulate LH and FSH levels, ultimately enhancing folliculogenesis and ovulation (18). Additional compounds such as magnesium and zinc further support and enhance ovarian endocrine pathways, while phytoestrogens help maintain the estrogen-progesterone balance, crucial for endometrial receptivity and implantation (64, 65). Endocrine function is maintained by vitamins A, C, and E, which protect hormone-producing tissues from oxidative stress (66). Carbohydrates provide the energy required for hormone biosynthesis, while polyunsaturated fatty acids increase membrane fluidity and facilitate hormone-receptor interactions (52). Recent molecular findings indicate that DPP modulates key steroidogenic enzymes, including CYP11A1 and CYP19A1, which govern the biosynthesis of testosterone and estrogen. This underscores DPP's broad potential to optimize endocrine function in both sexes (67).

3. Enhancing sexual function and alleviating menopausal symptoms

Due to the limited research on the impact of DPP on female fertility (Table II), several clinical trials have been conducted since early 2017. One notable study, the Sadeghi clinical trial, found that a daily dose of 350 mg of palm pollen capsules for 35 days significantly improved vaginal lubrication and reduced menopausal dyspareunia in postmenopausal women compared to a control group that received a starch placebo (68). Another investigation revealed that administering 300 mg of DPP daily for 35 days to postmenopausal women led to increased vaginal lubrication and enhancements in the desire domain of the female

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sexual function index, although it did not show significant effects on arousal, orgasm, satisfaction, or pain compared to a control group receiving 300 mg of starch capsules (69). A parallel study indicated that the same dosage improved arousal, orgasm, vaginal lubrication, dyspareunia (pain during intercourse), and overall satisfaction in women (70).

In contrast, Yousefzadeh et al. (71) reported improvements in orgasm with the same pollen dosage in postmenopausal women, while Loripoor et al. (72) found that a daily intake of 300 mg of DPP aqueous extract for 4 wk did not lead to significant reductions in sexual dysfunction scores in this population. The differing outcomes across these studies may be attributed to variations in the genotypes of date palm sources and differences in the amino acid profiles of the raw pollen used, despite consistent dosages and durations (73).

Other clinical trials suggest that a daily intake of 3 gr of DPP for 3 months in women with polycystic ovary syndrome can modulate sex hormone profiles by reducing estrogen and LH levels, increasing progesterone and FSH, and promoting ovulation (28). While evidence supports that palm pollen can elevate sex hormone levels, enhance lubrication, and reduce dyspareunia, the exact mechanisms through which it improves fertility remain unclear, and other factors may also play a role. Given that palm pollen contains sterols and phytoestrogens, it may help modulate hormonal balance and influence libido (28). Additionally, vitamins and amino acids present in DPP could indirectly enhance libido by boosting energy levels and overall physical health (32). L-arginine, a naturally occurring amino acid in DPP, contributes to cardiovascular health and sexual function by serving as a precursor to NO, which is produced via NO synthase. This process increases NO bioavailability and stimulates the production of cyclic guanosine monophosphate, thereby modulating vascular tone and sexual function. Serine, another amino acid found in DPP, may participate in serotonin synthesis, a neurotransmitter involved in regulating sexual desire (74–76). Furthermore, the carbohydrates in DPP might increase sexual desire by providing a rapid energy boost. The alkaloids present in DPP could promote vasodilation, enhancing vaginal perfusion and contributing to greater lubrication and comfort. Lastly, psychological factors and interactions with the vaginal microbiota, along with the traditional use of DPP as an aphrodisiac, may also influence these outcomes (77).

Table II. Reproductive health consequences associated with DPP bioactive compounds: animal and human studies

Author, Yr (Ref)	Test group	DDP extract	Method	Dose	Duration	Result
Hassan *et al.*, 1947 (23)	Adult female rats	Aqueous suspension	Oral administration	N/A	N/A	Cornification in vaginal smears produces an effect similar to the injection of estradiol dipropionate
Jiheel and Arrak, 2015 (24)	Adult female rats	Ethanolic extract	Oral administration	100 mg/kg BW	28 days	↑GSH, FSH and LH levels

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Table II. Continued

Author, Yr (Ref)	Test group	DDP extract	Method	Dose	Duration	Result
Moshfegh *et al.*, 2015 (25)	Adult female mice	Aqueous suspension	Administration	100 and 200 mg/kg BW	18, 10 and 21 days	↑Mass and diameter of ovaries; ↑number of primary and secondary graph follicles and corpora luteal; ↑percentage of mating, body mass index and CR of embryos; ↑LH, FSH, estrogen and progesterone levels
Hosseini and Mehrabani, 2014 (78)	Adult female mice	Aqueous extract	Oral administration	100, 200 and 400 mg/kg BW	N/A	↑Testosterone, estrogen and progesterone levels; ↑number of antral and secondary follicles
Hammed *et al.*, 2012 (79)	Female rats	DPP water suspension	Oral administration	150 mg/kg BW/day	6 wk	↑Serum FSH and LH levels
Yosefzadeh *et al.*, 2017 (71)	Menopausal women	Powder	Oral administration	300 mg/daily	35 days	↑Orgasm
Sadeghi *et al.*, 2018 (68)	Menopausal women	Powder	Oral administration	350 mg/daily	35 days	↑Vaginal lubrication, ↓dyspareunia
Abd El-Wahed and Nasr, 2022 (28)	Women with PCOS	Powder	Oral administration	3 gr	3 months	↓Estrogen and LH levels; ↑progesterone and FSH levels; ↑ovulation
Salmani *et al.*, 2022 (69)	Non menopausal women	Powder	Oral administration	300 mg/daily	35 days	↑Lubrication; ↑desire domains of the female sexual function index
Jahromi *et al.*, 2022 (70)	Infertile women	Capsules	Oral administration	300 mg/daily	30 days	↑Arousal, orgasm, lubrication, pain during intercourse and satisfaction
Loripoor *et al.*, 2023 (72)	Postmenopausal women	Dried aqueous extract capsules	Oral administration	300 mg daily	4 wk	No change in sexual dysfunction

DPP: Date palm pollen, LH: Luteinizing hormone, FSH: Follicle-stimulating hormone, GSH: Glutathione, BW: Body weight, N/A: Not available, PCOS: Polycystic ovarian syndrome, ↑: Increase, ↓: Decrease

4. Nutritional components and their impact

The enhancements in lubrication and libido may stem from several factors inherent in DPP. It contains sterols and phytoestrogens that assist in regulating hormonal balance and potentially boost libido. Additionally, the vitamins and amino acids present in DPP can indirectly support sexual desire by promoting overall health and increasing energy levels. One significant amino acid in DPP is L-arginine, which is vital for blood circulation and sexual function. L-arginine enhances blood flow through its conversion into NO via NOS, playing a crucial role in improving circulation. This process raises levels of cyclic guanosine monophosphate, which are directly associated with improved vascular function and sexual performance (74, 75). Another amino acid found in DPP, serine, is involved in the synthesis of serotonin, a neurotransmitter that significantly influences sexual desire. Additionally,

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the carbohydrates present in DPP can provide quick energy, potentially enhancing interest in sexual activity (76). Research by Gautaman and Ganesan has shown that alkaloids in DPP exhibit vasodilator properties, promoting the dilation of blood vessels. This effect may improve vaginal blood circulation, resulting in enhanced lubrication and greater comfort during sexual activity (77). Moreover, DPP may act as a dopamine agonist, stimulating the release of dopamine and thereby enhancing various aspects of the sexual experience, including desire, arousal, and orgasm. Overall, these findings highlight the potential of DPP to support reproductive health and improve sexual well-being through its rich nutritional profile and diverse physiological effects (69).

5. History and traditional uses of DPP

5.1. Nutritional role

In various cultures, DPP is recognized as nutritious food source rich in protein, vitamins, and minerals. It is typically consumed fresh or dried, and is often incorporated into traditional recipes, desserts, and beverages, highlighting its adaptability as a functional food. Its nutritional density, including the presence of essential amino acids, antioxidants, and trace elements, makes it a valuable dietary supplement for enhancing overall health (80, 81).

5.2. Traditional medicine

In traditional Arabic medicine and other cultural practices, DPP is valued as a natural remedy for fertility issues. Recent studies support its potential to enhance egg quality, boost fertility hormone levels, and address infertility challenges. For men, it has been shown to improve sperm count and motility, while for women, it supports ovarian function and balances hormonal levels. Historically, palm pollen has been used as a fertility enhancer for both men and women in primitive societies, often mixed with honey or milk to amplify its effects (3).

5.3. Use in religious ceremonies

DPP also holds symbolic significance in various religious and cultural ceremonies. In many traditions, particularly within Islamic cultures, the palm tree and its products symbolize success, blessings, and new life. This symbolism is rooted in Quranic references and the role of the date palm in sustaining life in arid regions. The cultural reverence for the palm tree reflects its importance as both a practical and spiritual resource (3, 82, 83).

6. Toxicological implications and future research directions for DPP in fertility enhancement

Given the findings of previous studies and the potential of DPP to enhance fertility, it is crucial to conduct thorough toxicological evaluations. These evaluations will help identify possible side effects and establish safe dosage levels for medical use. In animal studies, particularly those involving rats, a dose of 140 mg/kg of aqueous DPP extract has shown a greater positive impact on reproductive parameters, including

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sexual behavior, compared to a higher dose of 350 mg/kg, which resulted in side effects like diarrhea (22). Other research has indicated that doses of 120 and 240 mg/kg of edible DPP significantly improved reproductive indices, while doses of 360 mg/kg and above did not yield notable differences compared to control groups (20).

Despite the concentration of human studies on the effects of single doses of DPP on fertility, significant knowledge gaps persist. Therefore, research aimed at elucidating the toxicological characteristics of DPP (including acute and chronic toxicity, mutagenicity, reproductive toxicity, and potential drug-drug interactions) will be invaluable. Additionally, implementing standardized production methods, robust quality control measures, and clear labeling is essential for ensuring safety, efficacy, and transparency for consumers.

Future research should prioritize well-designed, long-term safety evaluations, larger clinical trials, and epidemiological studies across diverse populations to accurately uncover the mechanisms by which DPP influences the reproductive system. Conducting these toxicological assessments will clarify the specific actions of palm pollen and help alleviate consumer concerns regarding its use in enhancing fertility (34, 84, 85).

7. Conclusion and future perspective

This study identifies DPP as a promising natural candidate for enhancing fertility in the future. The bioactive constituents of palm pollen, including flavonoids, phytoestrogens, fatty acids, proteins, vitamins, and essential minerals, may positively influence female reproductive function. DPP could enhance female fertility through various mechanisms, such as modulating the hypothalamic-pituitary-gonadal axis, reducing oxidative stress, enhancing NO signaling, exerting anti-inflammatory effects, stabilizing hormonal balance, promoting ovarian folliculogenesis, and improving embryo implantation rates. Given the side effects associated with artificial fertility treatments and the findings from existing studies, DPP may serve as a promising alternative to these artificial agents. Large-scale randomized trials are recommended to calibrate dosing, assess long-term safety, and verify effectiveness across diverse populations. On the industrial side, aligning pre-purification and extraction processes, establishing regulatory standards, and integrating DPP into sustainable food and pharmaceutical supply chains will be vital for global adoption. Thus, DPP emerges as a bioactive, multifunctional natural resource that bridges traditional medicinal wisdom with modern biomedical advancements. Its integration into reproductive health treatments and functional foods could revolutionize fertility management by offering safe, effective, and widely accessible options. By combining cutting-edge technology with rigorous clinical validation, DPP has the potential to evolve from a conventional nutrient into a foundational component of next-generation fertility therapies and functional food innovations.

Data Availability

This study is a narrative review based on previously published literature. All sources

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referenced are publicly available through academic databases and publications.

Author Contributions

S. Fallahi and F. Gholami developed main idea and were responsible for the article writing. The manuscript was written and reviewed by F. Dastsouz, and Z. Salehpour. All authors read and approved the final manuscript.

Acknowledgments

The authors would like to thank the Vice President for Research and Technology at Hormozgan University of Medical Sciences, Bandar Abbas, Iran for their support and for providing the resources necessary to conduct this research. The authors declare that no artificial intelligence tools were used in the preparation, writing, revision, or editing of this manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

References

[1] Thoma M, Fledderjohann J, Cox C, Adageba RK. Biological and social aspects of human infertility: A global perspective. In: McQueen DV. Oxford research encyclopedia of global public health. UK: Oxford University Press; 2021.

[2] Salhi S, Rahim A, Chentouf M, Harrak H, Bister JL, Hamidallah N, et al. Reproductive enhancement through phytochemical characteristics and biological activities of date palm pollen: A comprehensive review on potential mechanism pathways. *Metabolites* 2024; 14: 166.

[3] Shehzad M, Rasheed H, Naqvi SA, Al-Khayri JM, Lorenzo JM, Alaghbari MA, et al. Therapeutic potential of date palm against human infertility: A review. *Metabolites* 2021; 11: 408.

[4] Chhoud R, Said Bagga M, Ali Lassoued M, Jlizi S, Nabili A, Sfar S, et al. Chemical profile of the pits oil from the Tunisian 'Alig'cultivar of *Phoenix dactylifera* L.: In vivo wound healing potential evaluation of a cream formulated from the extracted oil and insights from molecular docking and SAR analysis. *Chem Biodivers* 2023; 20: e202200533.

[5] Awad S, Zhou Y, Katsou E, Li Y, Fan M. A critical review on date palm tree (*Phoenix dactylifera* L.) fibres and their uses in bio-composites. *Waste Biomass Valoriz* 2021; 12: 2853–2887.

[6] El-Far AH, Ragab RF, Mousa SA. Date palm bioactive compounds: Nutraceuticals, functional nutrients, and pharmaceuticals. In: Al-Khayoi JM. The date palm genome, Vol 2: Omics and Molecular Breeding. USA: Springer; 2021: 27–50.

[7] Chao CT, Krueger RR. The date palm (*Phoenix dactylifera* L.): Overview of biology, uses, and cultivation. *HortScience* 2007; 42: 1077–1082.

[8] Stanley RG, Linskens HF. Pollen: Biology biochemistry management. Germany: Springer Science & Business Media; 2012.

[9] Binding GJ. About pollen: Health food and healing agent. London: HarperThorsons; 1980.

[10] Selmani C, Chabane D, Bouguedoura N. Ethnobotanical survey of *Phoenix dactylifera* L. pollen used for the treatment of infertility problems in Algerian oases. *Afr J Tradit Complement Altern Med* 2017; 14: 175–186.

[11] Ibrahim FY, Khalil MM, Nezam EL Din A, Atieya K. Studies on biological effect of some selected foods (un-pollinated siwi date, date palm pollen and doum fruit). *J Food Dairy Sci* 2017; 8: 461–468.

[12] Fallahi S, Rajaei M, Hesam MJ, Koolivand M, Malekzadeh K. The effect of *Phoenix dactylifera* pollen on the expression of *NRF2*, *SOD2*, *CAT*, and *GPX4* genes, and sperm parameters of fertile and infertile men: A controlled clinical trial. *Int J Reprod BioMed* 2021; 19: 545.

[13] Hajb A, Salehpour Z, Aghaei R, Najafian A, Mahmoodi M, Latifi M, et al. The effect of palm pollen and black seed pollen on male sex hormones and sperm quality: A single-blind, placebo-controlled clinical trial study. *Int J Fertil Steril* 2022; 17: 75.

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[14] Bahmanpour S, Talaei-Khozani T, Vojdani Z, Panjeshahin R, Poostpasand A, Zareisedehizadeh S, et al. Effect of *Phoenix dactylifera* pollen on sperm parameters and reproductive system of adult male rats. *Iran J Reprod Med* 2006; 31: 208–212.

[15] Biglari F, AlKarkhi AF, Easa AM. Antioxidant activity and phenolic content of various date palm (*Phoenix dactylifera*) fruits from Iran. *Food Chem* 2008; 107: 1636–1641.

[16] Kaltsas A. Oxidative stress and male infertility: The protective role of antioxidants. *Medicina* 2023; 59: 1769.

[17] El-Ridi M, El Mofty A, Khalifa K, Soliman L. Gonadotrophic hormones in pollen grains of the date palm. *Zeitschrift Naturforschung B* 1960; 15: 45–49.

[18] Soliman F, Soliman L. The gonadotrophic activity of date palm pollen grains. *Experientia* 1957; 13: 411–412.

[19] Arfat Y, Mahmood N, Ahmad M, Tayyab M, Zhao F, Li D-J, et al. Effect of date palm pollen on serum testosterone and intra-testicular environment in male albino rats. *Afr J Pharm Pharmacol* 2014; 8: 793–800.

[20] Mehraban F, Jafari M, Toori MA, Sadeghi H, Joodi B, Mostafazade M, et al. Effects of date palm pollen (*Phoenix dactylifera* L.) and Astragalus ovinus on sperm parameters and sex hormones in adult male rats. *Iran J Reprod Med* 2014; 12: 705.

[21] Abedi A, Karimian SM, Parviz M, Mohammadi P, Roudsari HRS. Effect of aqueous extract of *Phoenix dactylifera* pollen on dopamine system of nucleus accumbens in male rats. *Neurosci Med* 2014; 5: 49–59.

[22] Abedi A, Karimian P, Roudsari HRS. The effect of aqueous extract of *Phoenix dactylifera* pollen grain on sexual behavior of male rats. *J Physiol Pharmacol Adv* 2012; 2: 235–242.

[23] Hassan A, Abou El Wafa MH. An oestrogenic substance in pollen-grains of date palm tree *Phoenix dactylifera* L., Palmae. *Nature* 1947; 159: 409–410.

[24] Jiheel MJ, Arrak JK. Effect of different doses of ethanolic extract of date palm pollen grains on serum gonadotropin and total Glutathione in mature female rats. *Kufa J Vet Med Sci* 2015; 6: 109–116.

[25] Moshfegh F, Baharara J, Namvar F, Zafar-Balanezhad S, Amini E, Jafarzadeh L. Effects of date palm pollen on fertility and development of reproductive system in female Balb/C mice. *J HerbMed Pharmacol* 2015; 5: 23–28.

[26] Baagar MAEA, El. Sherif Kh, Fouda SF. Influence of date palm pollen administration on reproductive performance, ovulatory response, antioxidants capacity and immunity of rabbit does. *J Anim Poult Product, Mansoura Univ* 2022; 13: 185–191.

[27] Rahman SU, Huang Y, Zhu L, Feng S, Khan IM, Wu J, et al. Therapeutic role of green tea polyphenols in improving fertility: A review. *Nutrients* 2018; 10: 834.

[28] Abd El-Wahed RM, Nasr AAA. Effects of date palm pollen on women with the polycystic ovarian syndrome. *Egypt J Hospital Med* 2022; 89: 4622–4625.

[29] Mir IN, Bhat IA. Modulation of hypothalamic-pituitary-gonadal (HPG) axis by phytotherapy using different delivery approaches. In: Sundaray JK, Rather MA, Kumar S, Agarwal D. Recent updates in molecular endocrinology and reproductive physiology of fish: An imperative step in aquaculture. Singapore: Springer; 2021.

[30] Elberry AA, Mufti ST, Al-Maghrabi JA, Abdel-Sattar EA, Ashour OM, Ghareib SA, et al. Anti-inflammatory and antiproliferative activities of date palm pollen (*Phoenix dactylifera*) on experimentally-induced atypical prostatic hyperplasia in rats. *J Inflamm* 2011; 8: 40.

[31] Otify AM, Hammam A-MM, Farag MA. *Phoenix dactylifera* L. date tree pollen fertility effects on female rats in relation to its UPLC-MS profile via a biochemometric approach. *Steroids* 2021; 173: 108888.

[32] Abdel Azim MHM, El-Mesalamy AMD, Yassin F, Khalil SA. Identification phenolic and biological activities of methanolic extract of date palm pollen (*Phoenix dactylifera*). *J Microb Biochem Technol* 2015; 7: 047–050.

[33] Grzesik M, Naparło K, Bartosz G, Sadowska-Bartosz I. Antioxidant properties of catechins: Comparison with other antioxidants. *Food Chem* 2018; 241: 480–492.

[34] Mohamed NA, Ahmed OM, Hozayen WG, Ahmed MA. Ameliorative effects of bee pollen and date palm pollen on the glycemic state and male sexual dysfunctions in streptozotocin-induced diabetic wistar rats. *Biomed Pharmacother* 2018; 97: 9–18.

[35] Karimi FZ, Salehian M, Hosseini H, Norouzi Z, Afiat M. The effect of the medicinal plants on sexual function in postmenopausal women in Iran: A systematic review of clinical trials. *J Sabzevar Univ Med Sci* 2023; 30: 144–162.

[36] Bikle DD. The free hormone hypothesis: When, why, and how to measure the free hormone levels to assess vitamin D, thyroid, sex hormone, and cortisol status. *JBMR Plus* 2021; 5: e10418.

CC BY-NC 4.0 OPEN ACCESS

[37] Lopes-Ferreira J, Matos J, Dias F, Siervo G, Gomes M. Protective effects of phenolic phytochemicals on male fertility: A narrative review. *Braz J Biol* 2025; 85: e288879.

[38] Zulkifli B, Fakri F, Gholib G, Akmal M, Adam M, Sabri M, et al. Herbal flavonoids in preserving testicular physiology under oxidative stress: A bibliometric analysis of systematic reviews. *Int J Trop Vet Biomed Res* 2023; 8: 37–50.

[39] Kumar N, Singh AK. Impact of environmental factors on human semen quality and male fertility: A narrative review. *Environ Sci Europe* 2022; 34: 6.

[40] Saibabu V, Fatima Z, Khan LA, Hameed S. Therapeutic potential of dietary phenolic acids. *Adv Pharmacol Sci* 2015; 2015: 823539.

[41] Abdelkhalek F, Said M, El Nabtity S, Darwish W. Nutritive value, and pharmacological effects of dates (*Phoenix dactylifera* L.): A mini review. *Zagazig Vet J* 2022; 50: 73–86.

[42] Bacha MA, Ali MA, Farahat FA. Chemical composition of pollen grains of some date palm males grown in Riyadh, Saudi Arabia. *Arab Gulf J Sci Res* 1997; 3: 783–803.

[43] Al-Anber LJM. Estimation of the content of lipids and fatty acids in pollen of *Phoenix dactylifera* (date palm) from Basrah, Iraq. *Bolivian J Chem* 2017; 34: 9–13.

[44] Sebii H, Karra S, Bchir B, Ghribi A, Danthine S, Blecker C, et al. Physico-chemical, surface and thermal properties of date palm pollen as a novel nutritive ingredient. *Adv Food Technol Nutr Sci Open J* 2019; 5: 84–91.

[45] Hassan HM. Chemical composition and nutritional value of palm pollen grains. *Glob J Biotech Biochem* 2011; 6: 1–7.

[46] Handgraaf S, Philippe J. The role of sexual hormones on the enteroinsular axis. *Endocr Rev* 2019; 40: 1152–1162.

[47] Liu W, Zhang L, Gao A, Khawar MB, Gao F, Li W. Food-derived high arginine peptides promote spermatogenesis recovery in busulfan treated mice. *Front Cell Dev Biol* 2021; 9: 791471.

[48] Chen J, Li Y, Li Z, Lu H, Zhu P, Li C. Dietary l-arginine supplementation improves semen quality and libido of boars under high ambient temperature. *Animal* 2018; 12: 1611–1620.

[49] De Luca MN, Colone M, Gambioli R, Stringaro A, Unfer V. Oxidative stress and male fertility: Role of antioxidants and inositols. *Antioxidants* 2021; 10: 1283.

[50] Salhi S, Chentouf M, Harrak H, Rahim A, Çakir C, Çam D, et al. Assessment of physicochemical parameters, bioactive compounds, biological activities, and nutritional value of the most two commercialized pollen types of date palm (*Phoenix dactylifera* L.) in Morocco. *Food Sci Technol Int* 2024; 30: 788–798.

[51] Al-Samarai A, Al-Salihi F, Al-Samarai R. Phytochemical constituents and nutrient evaluation of date palm (*Phoenix dactylifera*, L.) pollen grains. *Tikrit J Pure Sci* 2018; 21: 56–62.

[52] Ma X, Wu L, Wang Y, Han S, El-Dalatony MM, Feng F, et al. Diet and human reproductive system: Insight of omics approaches. *Food Sci Nutr* 2022; 10: 1368–1384.

[53] Collodel G, Castellini C, Lee JC-Y, Signorini C. Relevance of fatty acids to sperm maturation and quality. *Oxid Med Cell Longev* 2020; 2020: 7038124.

[54] Trop-Steinberg S, Gal M, Azar Y, Kilav-Levin R, Heifetz EM. Effect of omega-3 supplements or diets on fertility in women: A meta-analysis. *Heliyon* 2024; 10: e29324.

[55] Ebisch I, Thomas C, Peters W, Braat D, Steegers-Theunissen R. The importance of folate, zinc and antioxidants in the pathogenesis and prevention of subfertility. *Hum Reprod Update* 2007; 13: 163–174.

[56] Hunt JR. Bioavailability of iron, zinc, and other trace minerals from vegetarian diets. *Am J Clin Nutr* 2003; 78: 633S-639S.

[57] He FJ, MacGregor GA. Beneficial effects of potassium on human health. *Physiol Plant* 2008; 133: 725–735.

[58] Traber MG, Stevens JF. Vitamins C and E: Beneficial effects from a mechanistic perspective. *Free Rad Biol Med* 2011; 51: 1000–1013.

[59] El-Yazal SAS, El-Yazal MAS. Determination of five mineral element contents in pollen grains of different seedling date palm (*Phoenix dactylifera* L.) male trees grown in Fayoum Governorate, Egypt. *Horticult Int J* 2019; 3: 140–145.

[60] Mahran G, Abdel-Wahab S, Attia A. A phytochemical study of date palm pollen. *Planta Med* 1976; 29: 171–175.

[61] Jaiballah Z, Lji N, Younes M. The therapeutic potential of date palm pollen for testicular disorders induced by diabetes in male diabetic rats. *J Pure Appl Sci* 2023; 22: 207–214.

[62] Karimi M, Asbagh FA, Safavi M, Yekaninejad MS, Rahimi R, Pourmand G, et al. The effect of date palm (*Phoenix dactylifera* L.) pollen on the serum levels of testosterone, luteinizing, and follicle stimulating hormones in men. *Current Tradit Med* 2024; 10: 101–106.

CC BY-NC 4.0 OPEN ACCESS

[63] Al-Snafi AE, Marbut MM. The probable therapeutic effects of date palm pollen in thetreatment of male infertility. *Tikrit J Pharm Sci* 2005; 1: 30–35.

[64] Szukiewicz D. Insight into the potential mechanisms of endocrine disruption by dietary phytoestrogens in the context of the etiopathogenesis of endometriosis. *Int J Mol Sci* 2023; 24: 12195.

[65] Gałęska E, Wrzecińska M, Kowalczyk A, Araujo JP. Reproductive consequences of electrolyte disturbances in domestic animals. *Biology* 2022; 11: 1006.

[66] Vašková J, Klepcová Z, Špaková I, Urdzík P, Štofilová J, Bertková I, et al. The importance of natural antioxidants in female reproduction. *Antioxidants* 2023; 12: 907.

[67] Kim C, Jeong E, Lee Y-B, Kim D. Steroidogenic cytochrome P450 enzymes as drug target. *Toxicol Res* 2024; 40: 325–333.

[68] Sadeghi S, Yosefzadeh S, Rakhshandeh H, Dadghar S, Mazloum SR. The impact of date palm pollen capsule on vaginal iubrication and dyspareunia in menopausal woman. *J Midwif Reprod Health* 2018; 6: 1409–1418.

[69] Salmani R, Nasiri K, Javadzadeh Y, Salmani R, Clark CC, Aghamohammadi V. Effect of date palm pollen supplementation on female sexual function in non-menopausal women: A double blind randomized clinical trial. *Chin Herb Med* 2022; 14: 643–648.

[70] Jahromi AR, Mosallanezhad Z, Hosini FS, Jamali S, Sharifi N. The effect of date palm on sexual function in infertile couples: A double-blind controlled clinical trial. *BMC Res Notes* 2022; 15: 55.

[71] Yosefzadeh S, Sadeghi S, Rakhshandeh H, Dadghar S, Mazloum SR. The effect of date palm pollen capsule on orgasm and sexual satisfaction in menopausal women: A double-blind controlled clinical trial. *Iran J Obstet Gynecol Infertil* 2017; 20: 43–51.

[72] Loripoor M, Esmaeili F, Vazirinejad R, Dan S. The effect of palm pollen extract on sexual disorders in postmenopausal women: A randomized clinical trial. *Int J Commun Based Nurs Midwif* 2023; 11: 14.

[73] Abdel-Sattar M, Mohamed Y. Pollen viability of date palm from different sources in relation to its chemical composition. *Alexandria J Agricult Sci* 2017; 62: 149–155.

[74] Ito TY, Trant AS, Polan ML. A double-blind placebo-controlled study of ArginMax, a nutritional supplement for enhancement of female sexual function. *J Sex Marital Ther* 2001; 27: 541–549.

[75] Cieri-Hutcherson NE, Jaenecke A, Bahia A, Lucas D, Oluloro A, Stimmel L, et al. Systematic review of L-arginine for the treatment of hypoactive sexual desire disorder and related conditions in women. *Pharmacy* 2021; 9: 71.

[76] Croft HA. Understanding the role of serotonin in female hypoactive sexual desire disorder and treatment options. *J Sex Med* 2017; 14: 1575–1584.

[77] Gauthaman K, Ganesan AP. The hormonal effects of Tribulus terrestris and its role in the management of male erectile dysfunction-an evaluation using primates, rabbit and rat. *Phytomedicine* 2008; 15: 44–54.

[78] Hosseini S, Mehrabani D, Razavi F. Effect of palm pollen extract on sexual hormone levels and follicle numbers in adult female BALB/c mice. *Intern Med Today* 2014; 20: 139–143.

[79] Hammed MS, Arrak JK, Al-Khafaji NJ, Hassan AA. Effect of date palm pollen suspension on ovarian function and fertility in adult female rats exposed to lead acetate. *Diyala J Med* 2012; 3: 90–96.

[80] Al-Karmadi A, Okoh AI. An overview of date (*Phoenix dactylifera*) fruits as an important global food resource. *Foods* 2024; 13: 1024.

[81] Al-Shahib W, Marshall RJ. The fruit of the date palm: Its possible use as the best food for the future? *Int J Food Sci Nutr* 2003; 54: 247–259.

[82] Ali MM. Holy Quran. USA: Ahmadiyya Anjuman Ishaat Islam Lahore; 2011.

[83] El-Seedi HR, Khalifa SA, Yosri N, Khatib A, Chen L, Saeed A, et al. Plants mentioned in the Islamic Scriptures (Holy Qur'ân and Ahadith): Traditional uses and medicinal importance in contemporary times. *J Ethnopharmacol* 2019; 243: 112007.

[84] Durairajanayagam D. Lifestyle causes of male infertility. *Arab J Urol* 2018; 16: 10–20.

[85] Iftikhar S, Bashir A, Anwar MS, Mastoi SM, Shahzad M. Effect of date palm pollen (dpp) on serum testosterone levels in prepubertal albino rats. *Pak J Med Health Sci* 2011; 6: 639–644.

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