Journal of Population Therapeutics & Clinical Pharmacology

REVIEW ARTICLE
DOI: 10.53555/jptcp.v31i1.3955

NUTRITIONAL INTERVENTIONS FOR MALE REPRODUCTIVE HEALTH: A COMPREHENSIVE REVIEW ON THE IMPACT OF ALMONDS, WALNUTS, AND CASHEW NUTS

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Abstract

Objective: This review aims to investigate the potential impact of dietary interventions involving almonds, walnuts, and cashew nuts on preventing reproductive disorders and improving fertility in males.

Methodology: A thorough literature search was conducted across scientific databases, including Google Scholar, PubMed, and Web of Science, to identify relevant studies published up to the present date. Keywords such as "male fertility," "reproductive disorders," "almonds," "walnuts," and "cashew nuts" were used to filter articles. Studies focusing on the effects of these nuts on male reproductive parameters, including sperm quality, hormone levels, and overall reproductive health, were included in this review.

Results: Almonds, walnuts and cashew nuts have been found to contain a variety of bioactive compounds, including vitamin E, folate, zinc, copper, omega-3 fatty acids, and polyphenols that are associated with improved sperm productions, quality and protect sperms against oxidative stress, which can prevent the damage of sperm DNA and improves fertility. Additionally, these nuts may contribute to the reduction of inflammation, which is also a known contributor to reproductive disorders and infertility in males.

Conclusion: The present reviewed literature suggests a potential link between the consumption of almonds, walnuts, cashew nuts and improved male reproductive health. However, further well-designed clinical studies are needed to establish causal relationships and determine optimal dietary patterns. Including these nuts as part of a balanced and nutritious diet may offer a holistic approach to prevent reproductive disorders and enhance fertility in males.

Keywords: Male Fertility**,** Sperms Quality, Almonds, Walnuts, Cashew Nuts, Reproductive Disorders, Sperm Quality

Introduction

Nutrition plays a vital role in overall health and well-being, including reproductive health. Particularly male reproductive health, has gained significant attention in recent years due to the increased prevalence of fertility issues and concerns about declining sperm quality and quantity (1). Infertility is defined as an inability to achieve a successful pregnancy after 1 year of regular unprotected intercourse (2). It is estimated that approximately 15% of couples globally experience infertility issues, accounting for almost 48.5 million couples with male factors accounting for approximately 40-50% of these cases (3). Current meta-analysis studies showed that male factors are present in 20–70% of infertility cases (4-6). The impact of male reproductive disorders and infertility is often considered to be the leading cause of psychological distress and straining relationships (7). Male reproductive disorders and infertility can arise from various factors, including genetic, hormonal, anatomical, environmental and lifestyle causes (8). Genetic abnormalities, such as chromosomal disorders or gene mutations, can significantly impact male fertility. For instance, conditions like Klinefelter syndrome, Y chromosome microdeletions, and cystic fibrosis gene mutations have been linked to male infertility (9). In response to these concerns, researchers and healthcare professionals have explored various nutritional interventions that could potentially enhance male reproductive health. This comprehensive review aims to examine the existing scientific literature on the potential benefits of almonds, walnuts, and cashew nuts for the prevention from reproductive disorders and improving fertility in males.

Factors Involved in Male Infertility

Hormonal Imbalances Involved in Male Infertility

Hormonal imbalances are considered as the major contributor to male reproductive disorders and infertility. Gonadotropins Releasing Hormones (GnRH) is secreted by hypothalamus which stimulates the pituitary gland to synthesize and secrete follicle stimulating hormone (FSH) & luteinizing hormone (LH). FSH is crucial for the production of sperms (spermatogenesis), while LH helps to stimulate the synthesis and secretion of testosterone by further stimulating the leydig cells present in testes in order to synthesize testosterone hormone, that acts in combination with FSH on the seminiferous tubules (sperm producing tubes) present in testes for making sperms (10). Therefore, disruptions in the production or regulation of these hormones can impair the development and functions of sperms. The conditions including hypogonadism, pituitary disorders, and thyroid dysfunction can lead to hormonal imbalances and subsequent fertility issues (11,12).

Anatomical Abnormalities Involved in Male Infertility

Anatomical abnormalities play a significant role in male infertility by disrupting the normal processes involved in sperm production, transport, and ejaculation. These abnormalities can be broadly categorized as congenital or acquired, and they encompass a range of conditions that affect different parts of the male reproductive system. These abnormalities may be congenital or acquired through infections, surgeries, or injuries (13). Congenital abnormalities are present from birth and may arise due to developmental issues or genetics during fetal growth. These conditions can affect various components of the male reproductive tract, leading to fertility challenges later in life. As an example, hypospadias, is a congenital disease that involves the opening of urethra located on the underside of the penis instead of the tip. While it may not directly affect sperm production, severe cases can result in challenges during ejaculation (14). While, acquired abnormalities develops later in life and can be a consequence of infections, surgeries, injuries, or other environmental factors. These abnormalities can directly impact the function of the male reproductive system. As an example, varicoceles that includes the enlarged veins within the scrotum, similar to varicose veins. They can lead to increased testicular temperature, which negatively affects sperm production and quality. While another condition including ejaculatory duct obstruction, that leads to blockages in the ejaculatory ducts, that is responsible for transporting sperm from the testicles to the urethra during ejaculation, that ultimately leads to the absence of sperm in the ejaculate, leading to infertility (15, 16).

Association Between Poor Nutritional Status and Male Infertility

Emerging researches suggest that diet and nutritional status play a crucial role in male reproductive health and fertility. A balanced diet rich in essential nutrients is vital for the production, maturation, and function of healthy sperm. In contrast, an inadequate diet lacking key nutrients may contribute to male reproductive disorders and infertility (17,18).

Several nutrients have been identified as essential for male reproductive health. For instance, antioxidants, including vitamin E, folate, zinc, copper, omega-3 fatty acids, and polyphenols that are associated with improved sperm productions, quality and protect sperms against oxidative stress, which can damage sperm DNA and impair fertility (19, 20). Deficiencies in these nutrients, often resulting from poor dietary choices, may compromise male fertility. Furthermore, obesity and poor diet quality have been linked to male reproductive disorders and infertility. Excessive body weight and high body mass index (BMI) have been associated with hormonal imbalances, decreased sperm quality, and increased risk of erectile dysfunction (21, 22). Diets high in processed foods, saturated fats, and added sugars have been shown to negatively affect sperm parameters, potentially reducing fertility (23, 24).

Environmental Factors Involved in Male Infertility

Several environmental factors can also contribute to male reproductive disorders and infertility. Numerous studies have investigated the association between pesticide exposure and male infertility. For instance, a study conducted by Swan *et al.*, (25) examined 36 male subjects exposed to organochlorine pesticides. The researchers found a significant decrease in sperm concentration and motility among the exposed group compared to the control group. The study utilized a case-control design with semen analysis as the primary outcome measure. Similarly, endocrine-disrupting chemicals have also gained significant attention due to their potential adverse effects on male reproductive health. A study by Meeker *et al.*, (26) examined the relationship between semen quality and phthalate exposure. The study found a negative association between concentration, motility, and morphology and phthalate exposure. Furthermore, exposure to certain radiations can also harm sperm production and function. Prolonged exposure to radiation from sources like X-rays or laptops placed on the lap may increase the risk of infertility (27).

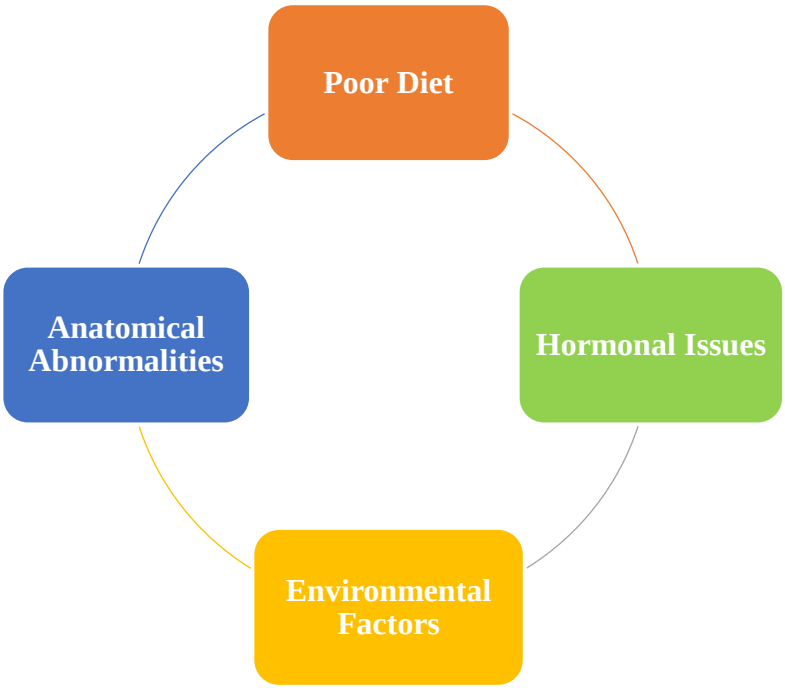

Figure 1. Factors Involved in Male Infertility

Almonds (*Prunus amygdalus*)

Proximate and Phytochemical Composition of Almonds (*Prunus amygdalus*)

The nutrient composition of almonds has prominent effect on male reproductive health. According to the proximate analysis of almonds, it has a dry matter (95.63%), moisture content (4.37%), crude protein (22.83%), ether extract (52.08%), crude fiber (12.2%) ash (3.82%), and nitrogen free extract (16.9%) as represented in the Figure 2. Moreover, further analysis revealed that it contains vitamin E, in significant concentration (77.67 mg per 100g), that is renowned for its antioxidant properties, which can protect sperm cells from oxidative stress. High Vitamin E content in almonds may play a protective role in maintaining sperm quality. While mineral contents revealed that zinc present in the amounts (52.25 mg per kg), is crucial for various aspects of male reproductive function, including sperm production and testosterone synthesis. Moreover, it contains calcium (0.23%), phosphorus (0.53%), potassium (6656 mg per kg), magnesium (2864 gm per kg), iron (119.9 mg per kg), selenium (68.71 mg per kg) and copper (13.55 mg per kg) (28, 31).

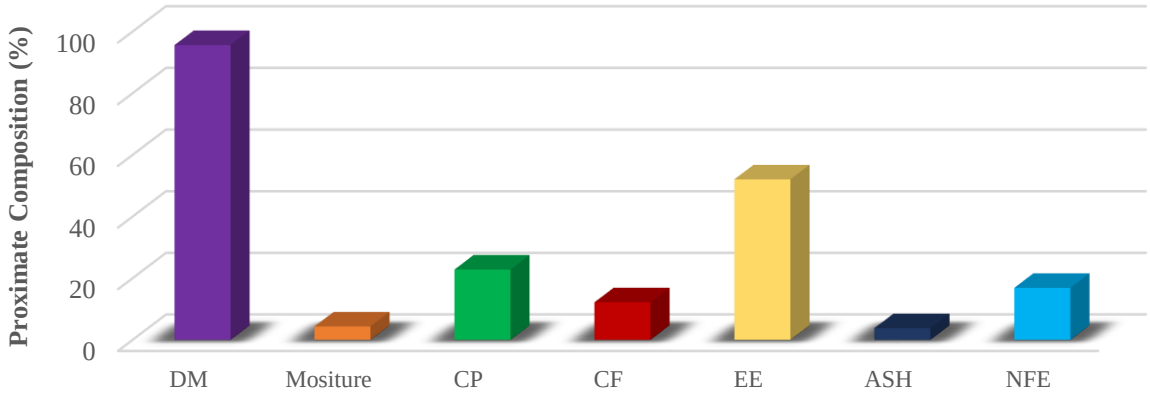

Figure 2. Proximate Composition of Almonds

Therapeutic Potential of Almonds to Improve Male Reproductive Health

In the traditional Islamic medicine, almonds have been recommended in order to increase the fertility in males (32). Almonds have been consumed for centuries and are known for their nutritional benefits. In recent years, several studies have focused on the potential mechanisms of almonds in preventing male reproductive issues and improving male's fertility (33). A randomized controlled trial conducted by Salas-Huetos *et al.* (34) with 2 parallel interventions, demonstrated that by adding 60 grams of mixed nuts per day (and 15g of hazelnuts, 15g of almonds, 30g of walnuts,) to a western style diet for about 14 weeks showed the improvements in the parameters of sperm quality (vitality, the total sperm count, morphology and motility of sperm) in the group of healthy adult participants as compared to the control group. Moreover, another study conducted by Rehman *et al.*, (35) to assess the impact of Atenolol and almond oil on sperm morphology in Balb C mice. Therefore, 120 mice were divided into Group A (Control) received 1 cc water along with 1 cc DMSO (Atenolol solvent). Group B mice were given Atenolol at a dosage of 18 mg per Kg body weight per ml of DMSO, Group C mice received almond extract at 100 mg/Kg, and mice of Group D were administered both Atenolol at 18 mg per Kg body weight per ml of DMSO and almond extract of 100 mg per Kg orally once daily for a duration of 3 months. The study proved that the diverse chemical constituents of *Prunus amygdalus* were found to enhance overall fertility parameters. The administration of antioxidants, present in almonds, was also found to improve contralateral spermatozoid production and various fertility

parameters. Furthermore, the presence of zinc in almonds, also known to boost testosterone levels, adds an additional layer of significance to the potential reproductive health benefits associated with almond consumption.

Moreover, oxidative stress is also the leading cause of erectile dysfunction that can lead to infertility (36). Therefore, a research was conducted by Adebayo *et al.*, (37) to explore the therapeutic effect of almonds on erectile dysfunction in diabetic male rats. Because, almonds are naturally rich in antioxidant, and have potential in neutralizing the impact of free radical induced oxidative stress for the management of diabetes related erectile dysfunction. The main purpose of the study was to explore the effects of almonds on smooth muscle-to-collagen ratio, nuclear factor erythroid 2 related factor 2 (nrf-2) levels, and other biochemical indices in the penile tissues. 6 rats were kept as controlled without diabetes while thirty-six male diabetic rats were divided into 6 groups (n = 6). They were fed with almonds supplemented diets. At the end of the trial, the study revealed that the diets rich in almonds, have restored the smooth muscle-to-collagen ratio, significantly increased the levels of nrf-2, and elevated total thiol levels in diabetic rats as compared to the control group, thereby, potentially contributed to improved neurotransmission and erectile function.

Walnuts (*Juglans regia L.*)

Proximate and Phytochemical Composition of Walnuts (*Juglans regia L.*)

The proximate and phytochemical composition of walnuts (*Juglans regia L.*) can vary depending on the factors such as growing conditions, variety of the walnut, and other environmental factors. According to the study conducted by Ali *et al.*, (38) on the nutrient composition and properties of different varieties of walnuts grown in Pakistan. According to the proximate analysis of Swat-1 (Kaghzai) walnuts variety, they contain moisture (3.56%), crude protein (15.96%), ether extract (66.72%), ash (1.95%) and carbohydrates (11.81%) respectively as represented in the Figure 3. The results of the mineral composition show the level of K is (3551 - 4827 ppm), sodium (40.9 - 64.5 ppm), iron (30.08 - 41.20 ppm), calcium (925 - 1250 ppm), zinc (11.75-25.5 ppm), copper (1.96 - 2.75 ppm), magnesium (1059-1765 ppm), and lead (0.69 - 1.06 ppm). Mineral composition of 6 Pakistani-walnut cultivars showed the higher levels of Mg, K, Ca, Na and Fe while the levels of Pb were the lowest.

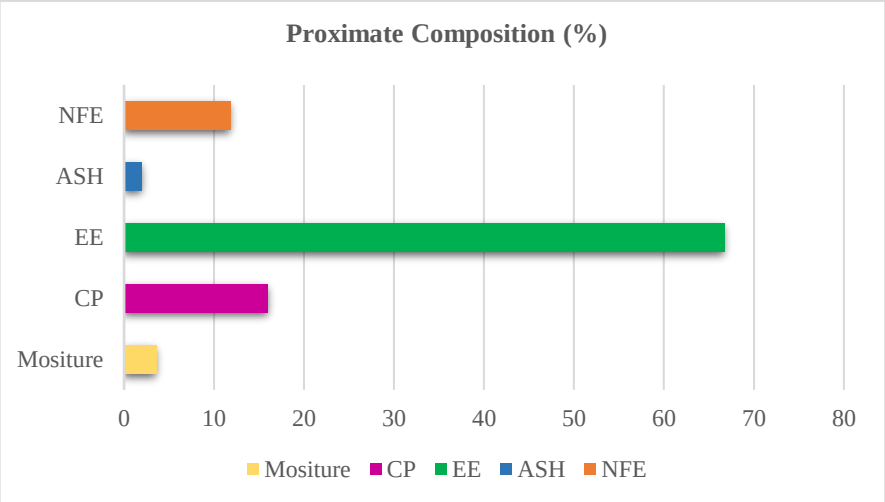

Figure 3. Proximate Composition of Walnuts

Therapeutic Potential of Walnuts to Improve Male Reproductive Health

Walnuts, scientifically known as *Juglans regia*, are nutrient-rich nuts that have been consumed for centuries due to their various health benefits. In recent years, researches have focused on the potential therapeutic effects of walnuts on male reproductive health (39). According to a randomized controlled trial conducted by Robbins *et al.*, (40), to evaluate the effects of a walnut-enriched diet on semen

quality in healthy young men. The study included 117 participants aged 21-35 years, who were randomly assigned to either a control group or a walnut-enriched diet group. The walnut-enriched diet group consumed 75 grams of walnuts daily for 12 weeks. The study found that the walnut-enriched diet group exhibited significant improvements in sperm motility, vitality and morphology as compared to the control group who avoided the consumption of tree nuts. Moreover, serum fatty acid profiles also improved in the walnut group, showing increases in omega-3 and omega-6 fatty acids.

Another study conducted by Masterson *et al.,* (41) on 75 infertile men, aged 27-61 years, to examine the impact of walnuts for improving semen quality. They were administered with the >45 gm whole shelled walnuts per day in their diet for 12 weeks. At the end of the trial, the results showed the significant improvements in sperm motility. This suggests that dietary modifications, specifically the addition of walnuts, can serve as a safe and cost-effective method to enhance semen parameters.

In another study conducted by Ikwuka *et al.,* (42), on Wistar rats. They were administered 1 ml per day of nicotine (NIC) and fed with 6% and 12% walnut-rich feed, for 28 days' period. At the end of the trial, sperm parameters were analyzed and the results showed that nicotine significantly decreased the sperm count, motility and caused the moderate spermatogenic arrest in the group who received 1ml per kg NIC. But, the administration of 6% and 12% walnuts in the diet of rats, significantly increased the NIC induced reduction in sperm motility, sperm count, thereby effectively reduced the testicular damage.

While another study conducted to explore the potential of walnut oil on the Pre and Post Puberty testosterone levels in male rats. Therefore, 48 male wistar albino rats were randomly divide into 2 groups depending on pre and post-puberty status. The experimental group received the walnut oil via the gavage tube at a dose of 20 mg per kg per day for 30 days. At the end of the trial, results proved that pre-puberty as well as post-puberty groups who received walnut oil, have significantly increase levels of testosterone. Because the presence of important unsaturated fatty acids, such as alpha-linolenic acid (ALA) and Omega-3 fatty acids have a positive effect on the pituitary–testicular axis Bostani *et al.,* (43).

Cashew Nuts (*Anacardium occidentale*)

Proximate and Phytochemical Composition of Cashew Nuts (*Anacardium occidentale*)

Cashew nuts (*Anacardium occidentale*) are a versatile and nutritious food source that has gained global popularity for their distinctive taste and numerous health benefits (44). The cashew tree, belonging to the Anacardiaceae family, produces both the cashew apple and the nut. Proximate analysis of cashew nut revealed that they contain moisture (3.80%), crude protein (11.11 %), ether extract (39.50%), crude fiber (4.33%), ash (2.40%) and carbohydrates (42.62%) as mentioned in the Figure 4. Moreover, they are rich in minerals such as sodium (108.06 mg per 100g), potassium (437.79 mg per 100g), calcium (4.90 mg per 100g), phosphorus (10.44 mg per 100g), iron (1.33 mg per 100g), and vitamin C (7.80 mg per 100g) Ahmad *et al.,* (45).

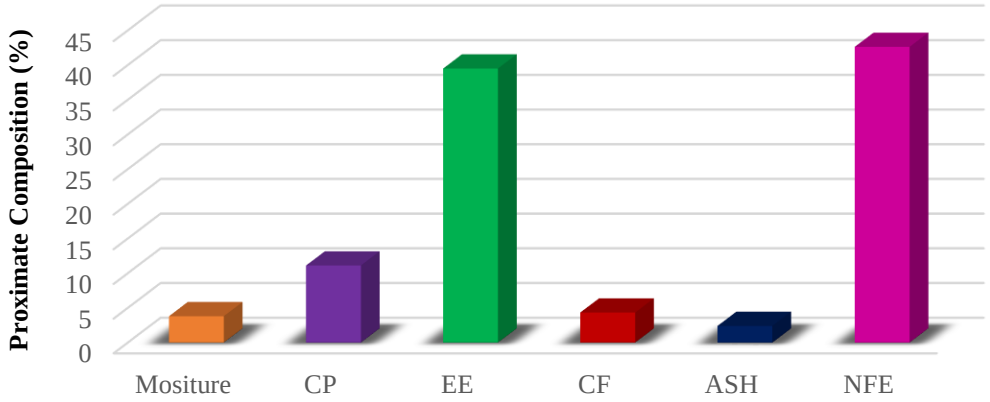

Figure 4. Proximate Composition of Cashew Nuts

Therapeutic Potential of Cashew Nuts to Improve Male Reproductive Health

Cashew nuts, derived from the tropical evergreen tree, *Anacardium occidentale*, have long been recognized for their rich nutritional profile and health benefits. Packed with essential nutrients such as vitamins, minerals, and healthy fats, cashews contribute to overall well-being. Beyond their general nutritional value, recent studies have explored the potential impact of cashew nuts on male reproductive health, particularly in the context of addressing concerns related to declining sperm count, and male infertility (46).

In the current decades, concerns have arisen regarding the reduction of sperm count in humans and the fertility effect of clomiphene citrate (CC), a synthetic estrogen antagonist. Therefore, a study conducted Akomolafe *et al.,* (47), in order to investigates the effect of cashew nuts present in the diet on fertility activity of CC in male rats. The rats were fed a basal diet with oral CC administration along with a diet containing 10% processed cashew and other group of rats were fed with a diet containing 20% processed cashew nut and given CC orally for fourteen days. At the end of the trial, the results showed the significant increase in total testosterone levels, epididymal sperm count, viability, and motility. Moreover, results also revealed that total antioxidant capacity and the levels of nitric oxide were also improved in both groups.

Similarly, another study conducted by Omobolanle *et al.,* (48) to explore the impact of methanolic extract of cashew nuts on the weight of reproductive organs in diabetic rats. Following the induction of diabetes by streptozotocin, the weights reproductive organs like testes, epididymis, prostate gland and seminar vesicle reduced in the diabetic rats as compared to the control group of rats. They were administered with the methanolic extract of *A. occidentale* nuts with 100 mg per kg body weight and 200 mg per kg body. After the administration of nut extract, the results revealed that testosterone (TST) and other androgens showed an anabolic response by increasing protein synthesis that leads to increase in muscle mass, thereby increasing the weight and volume of testis and epididymis due to increase in androgen response. Nut extract also leads to increase in the luteinizing and follicle stimulating hormone concentrations.

Conclusion

In conclusion, the review highlights the significant impact of almonds, walnuts, and cashew nuts on male reproductive health. These nuts, rich in essential nutrients and antioxidants, show promising therapeutic potential in addressing the factors contributing to male infertility, including hormonal imbalances and poor nutritional status. Almonds, with their vitamin E content, may protect sperm cells from oxidative stress, while walnuts demonstrate positive effects on semen quality, including sperm motility and morphology. Cashew nuts, when supplemented with clomiphene citrate, exhibit improvements in testosterone levels and sperm parameters. The studies emphasize the intricate connection between nutrition and male fertility, advocating for a balanced diet to enhance

reproductive well-being. Moreover, it highlights the understanding that male infertility can be exacerbated by exposure to environmental factors such as pesticides and radiations.

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