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The Impact of Diet on Male Fertility

Barbara Serkis

E-mail: lekbarbaraserkis@gmail.com

ORCID: https://orcid.org/0009-0001-8638-779X

5th Military Clinical Hospital with the SPZOZ Polyclinic in Cracow, Wrocławska 1/3, 30-901 Kraków

Zuzanna Bentkowska

E-mail: zuzabentkowska@gmail.com

ORCID: https://orcid.org/0009-0000-9702-2297

5th Military Clinical Hospital with the SPZOZ Polyclinic in Cracow, Wrocławska 1/3, 30-901 Kraków

Małgorzata Miazga

E-mail: malgorzatam97.mm@gmail.com

ORCID: https://orcid.org/0009-0005-1174-1597

Ludwik Rydygier Specialist Hospital in Kraków, Złotej Jesieni 1 Estate, 31-826 Kraków

Magdalena Celichowska

E-mail: magda.celichowska@gmail.com

ORCID: https://orcid.org/0009-0002-2128-9512

5th Military Clinical Hospital with the SPZOZ Polyclinic in Cracow, Wrocławska 1/3, 30-901 Kraków

Aleksandra Bogoń

E-mail: bogon.aleksandra@gmail.com

ORCID: https://orcid.org/0009-0002-1295-2423

1st Military Clinical Hospital with Polyclinic in Lublin 23 Racławickie Ave. 20-049 Lublin

Jagna Golemo

E-mail: jagnavlog@gmail.com

ORCID: https://orcid.org/0000-0002-2785-858X

5th Military Clinical Hospital with the SPZOZ Polyclinic in Cracow, Wrocławska 1/3, 30-901 Kraków

Izabela Kałuża

E-mail: izakaluza123@gmail.com

ORCID: https://orcid.org/0009-0006-4933-7247

5th Military Clinical Hospital with the SPZOZ Polyclinic in Cracow, Wrocławska 1/3, 30-901 Kraków

Justyna Szpyra

E-mail: justyna.szpyra1@gmail.com

ORCID: https://orcid.org/0000-0003-0041-9584

Ludwik Rydygier Specialist Hospital in Kraków, Złotej Jesieni 1 Estate, 31-826 Kraków

Julia Dębińska

E-mail: julia.debinska@o2.pl

ORCID: https://orcid.org/0009-0000-7792-658X

Independent Community Health Care Centre in Ustrzyki Dolne, 29 Listopada 57, 38-700 Ustrzyki Dolne

Gabriela Dziuba

E-mail: gdziuba8@gmail.com

ORCID: https://orcid.org/0009-0008-1622-7134

5th Military Clinical Hospital with the SPZOZ Polyclinic in Cracow, Wrocławska 1/3, 30-901 Kraków

ABSTRACT

Introduction:

Infertility is a reproductive health issue where the inability to conceive after 12 months of regular unprotected intercourse affects about 8 to 12% of couples of reproductive age. Factors such as diet, lifestyle, and exposure to toxins can negatively impact men's reproductive capacity, including semen parameters and gonadal function. The impact of diet on male fertility, including hormone levels and the process of spermatogenesis, is the subject of intense research.

Aim of the Study:

This study aims to review current scientific research on the impact of diet on male fertility to provide updated knowledge on this topic, essential for preventive and therapeutic actions in this field.

Materials and Methods:

A comprehensive review of scientific and medical literature was conducted using PubMed and Google Scholar databases. The search terms included: impact of diet on male fertility, impact of diet on semen parameters, impact of diet on semen quality, male fertility, diet and male fertility, types of diets and fertility.

Conclusion:

Diet plays a crucial role in male fertility, affecting semen quality. It is recommended to consume meat in moderation, especially organic, and to increase the intake of fish rich in omega-3 while avoiding contaminants. Regular consumption of fruits, vegetables, and grains improves semen parameters, while limiting sweets, sugary drinks, and alcohol, as well as quitting smoking, is beneficial for reproductive health. Men planning fatherhood should also consider reducing cannabis use. Future research should focus on the impact of individual dietary factors on male fertility.

Keywords: male fertility, diet and semen parameters, diet and male fertility, impact of diet on semen quality, types of diets and fertility.

INTRODUCTION

Infertility is a disease of the male or female reproductive system, characterized by the inability to conceive after 12 months of regular, unprotected intercourse. It is estimated that 8 to 12% of couples of reproductive age worldwide are affected by infertility. Men are solely responsible for 20–30% of infertility cases, but they contribute to 50% of cases in total. [1] Infertility can be primary or secondary. Primary infertility refers to individuals who have never conceived, whereas secondary infertility refers to those who have experienced at least one pregnancy. Male fertility is a crucial element of the reproductive capacity of the population and has garnered significant scientific and societal interest in recent years. Male infertility is most commonly caused by issues related to ejaculation, reduced sperm count or complete absence of sperm, abnormal sperm morphology, and reduced sperm motility. [1] Awareness is increasing regarding the impact of various factors, such as environmental, behavioral, and dietary influences, on male reproductive capability. In this context, scientific research is increasingly focused on understanding the role of diet in shaping this capability. Dietary factors, including the type and quality of consumed macronutrients (proteins, fats, carbohydrates), micronutrients (vitamins, minerals), and dietary supplements, have been identified as significant elements that can affect semen parameters and the function of male gonads. Lifestyle factors, such as obesity and smoking, can influence fertility. Additionally, exposure to environmental pollutants and toxins can negatively affect gametes, reducing their number and quality. Numerous studies suggest that poor dietary habits may be associated with decreased semen quality, reduced sperm count, and impaired sperm motility and morphology. [2,3] Despite existing evidence linking diet to male fertility, the molecular and biological mechanisms underlying this relationship remain the subject of intensive research. The impact of diet on sex hormone levels, spermatogenesis, endocrine gland function, and oxidative stress are just a few of the potential mechanisms involved in this process.

AIM OF THE STUDY

The aim of this study is to review current scientific research on the impact of diet on male fertility. By conducting a comprehensive analysis, this work aims to provide up-to-date

knowledge on the influence of diet on male reproductive capability, which may be of significant importance for preventive and therapeutic measures in the area of male fertility.

THE STATE OF KNOWLEDGE:

Meat and Animal Products

Both meat and animal products contain saturated fatty acids (SFAs) and trans unsaturated fatty acids (TFAs). These acids contribute to the increased incidence of obesity, coronary heart disease, diabetes, cancer, and infertility. [4] Several scientific studies have shown a negative correlation between a diet high in TFAs and sperm concentration, motility, morphology, ejaculate volume [5,6], and high testosterone levels [7]. Polyunsaturated fatty acids (PUFAs), also found in meat but in smaller quantities, particularly omega-3, have been shown in many studies to have a positive effect on semen pH, volume, sperm viability, concentration, and motility. [8] However, elevated SFA levels with low omega-3 concentrations negatively impact semen parameters. [9] This phenomenon can be explained by the low-grade inflammation induced by saturated fatty acids and the increased cholesterol levels in sperm membranes, which contribute to their structural damage. Additionally, mitochondria, due to the continuous accumulation of substrates, may not be able to oxidize all the acids, leading to the excessive production of reactive oxygen species (ROS) by sperm, negatively affecting motility and DNA integrity. [10] Moderate consumption of unprocessed meat may reduce the risk of asthenozoospermia, while frequent consumption of processed meat contributes to decreased sperm motility. The majority of consumed meat comes from intensive farming, which is associated with high levels of xenobiotics, mainly xenoestrogens (XEs) and anabolic steroids. [11] These compounds have estrogenic effects and can contribute to reduced male fertility by affecting semen quality and hormone levels. Scientific studies have noted an inverse proportionality between XE concentration and the total number of motile sperm. [12]

Fish, Shellfish, and Seafood

Both fish and seafood, including shellfish, are rich in polyunsaturated fatty acids (PUFAs) such as omega-3, which are known for their positive effects on semen parameters. Omega-3 is an essential component of sperm cell membranes, ensuring their flexibility and structural integrity. [13,14] Scientific studies have shown that in men affected by idiopathic

oligoasthenoteratospermia, omega-3 supplementation resulted in improved semen quality, particularly in terms of sperm count and motility. [15] Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) play crucial roles in the anti-inflammatory and antioxidant properties of enzymes such as superoxide dismutase. These properties are important as they protect sperm from oxidative stress and inflammatory conditions, which can damage their DNA and reduce motility. [16] However, attention must be paid to the potential presence of toxins in fish. Mercury is known to be present in high concentrations in the fatty tissue of marine fauna and has a negative impact on spermatogenesis. Additionally, a scientific study has demonstrated that organochlorine contaminants found in seafood negatively affect sperm motility and chromatin integrity, which can contribute to reduced semen quality. [17] Therefore, while the high content of PUFAs in fish and seafood is beneficial, it is essential to choose sources with low toxin levels to minimize adverse effects on male fertility.

Fruits, Vegetables, and Grains

Fruits and vegetables are sources of water, simple sugars such as fructose, fiber, phytochemicals, antioxidant vitamins, particularly vitamin C, A, folic acid, and minerals such as potassium, magnesium. Additionally, they are low in calories. In essence, they constitute the primary source of antioxidants in nature. There is a correlation between oxidative stress and the production of reactive oxygen species (ROS). Elevated ROS levels contribute adversely to sperm DNA, leading to reduced motility and viability, thereby increasing the incidence of miscarriages and developmental defects in offspring. [18,19] Some scientific studies have indicated a protective role of fruit juices in enhancing male fertility. The antioxidant activity of vitamins and phytochemicals present in fruits such as tomatoes, strawberries, pineapples, black currants, pomegranates, grapes, and raspberries may help restore normal testosterone levels in the blood, improve the morphological status of seminiferous tubules, and consequently enhance sperm morphology, concentration, and motility. [20,21] Folic acid, predominantly found in green leafy vegetables, protects DNA from damage by lowering homocysteine levels through its remethylation to methionine and plays a significant role in spermatogenesis. [2] Scientific studies demonstrate a lower incidence of several types of sperm aneuploidies in men consuming high levels of folic acid. [22] In a double-blind trial conducted on men with reduced and normal fertility, a substantial increase in normal sperm count and a slight increase in abnormal sperm count were observed following folic acid supplementation. [23] Fruits, vegetables, and grains are rich sources of

fiber. Some scientific studies have shown that fiber, by directly binding with unconjugated estrogens, contributes to reducing estrogen levels in the serum of men, thereby improving male fertility. [24,25]

Sweets and Sweetened Beverages

Consuming excessive amounts of sweets and sweetened beverages contributes to obesity, type 2 diabetes, and metabolic syndrome. All these disorders are characterized by insulin resistance, which leads to increased oxidative stress. [26] Additionally, glucose and insulin can disrupt the hypothalamic-pituitary-gonadal axis, potentially reducing sperm production. [27] Scientific studies have shown that consumption of sweetened beverages contributes to deterioration in sperm quality, including decreased total sperm count, motility, and overall semen volume. [3]

Alcohol

Most scientific studies confirm the negative impact of alcohol on male fertility. Daily alcohol consumption affects semen quality by reducing sperm count, motility, and overall ejaculate volume. Ethanol lowers the levels of hormones such as LH and FSH and induces testicular atrophy as well as changes in Leydig and Sertoli cells. [28] There is evidence that chronic alcohol consumption (more than 60 g per day) can contribute to azoospermia. [29] Conversely, cessation of alcohol consumption can restore normal spermatogenesis and help eliminate azoospermia. [30] Research also indicates that it is advisable to avoid alcohol consumption during medically assisted reproduction attempts. Live birth rates are significantly lower in the month preceding an attempt at conception. [31] One study found that chronic alcohol consumption significantly increased the sperm DNA fragmentation rate to 49.6%. In non-drinkers, this rate was 33.9%. Therefore, there is a biological explanation for the increased production of sperm with fragmented DNA. [32]

Tobacco

Smoking cigarettes is one of the main causes of reduced semen quality in men. Regular smoking leads to inflammation in accessory glands, which significantly affects sperm health. Increased DNA fragmentation, reduced acrosome integrity, and decreased mitochondrial activity are just a few of the negative effects of smoking. [33] In one study, DNA fragmentation in sperm was thoroughly analyzed. Among men who smoked, the percentage of

sperm with fragmented DNA was as high as 32%, while among non-smoking men it was only 25.9%. [34] This clearly demonstrates that smoking has a significant negative impact on the genetic structure of sperm. DNA fragmentation in sperm can lead to fertilization problems and complications in embryo development.

Cannabis

Cannabis disrupts the process of spermatogenesis through two mechanisms: central and peripheral. By blocking GnRH from the hypothalamus, it contributes to the inhibition of LH production by the anterior pituitary, thereby reducing testosterone secretion from Leydig cells. Additionally, the stimulation of G protein-coupled receptors inhibits the level of adenylate cyclase, thereby decreasing cAMP levels in testicular tissue, sperm, and the hypothalamus. [35] Scientific studies indicate that regular exposure to cannabis in men is associated with a decrease in sperm concentration and a reduction in sperm count. [36]

Popular Types of Diets and Their Impact on Male Fertility

Vegetarian and Vegan Diets

Both vegetarian and vegan diets are known for primarily consisting of plant-based products. A vegan diet is characterized by the elimination of all animal-derived products. In contrast, a vegetarian diet allows for the consumption of animal-derived products such as eggs and dairy. Both of these diets are rich in antioxidants such as vitamins C and E, and polyphenols, which, as previously mentioned, contribute to the reduction of oxidative stress and consequently improve semen quality. On the other hand, the potential deficiency of certain nutrients such as iron, essential fatty acids, and vitamin B12 may contribute to a decline in male fertility. Additionally, most individuals following either of these diets replace meat products with soy. Soy products are a significant source of isoflavones, which are known for their estrogen-like effects on sperm, potentially leading to feminization in men and thereby impairing their fertility. [37] In 2016, Orzyłowska et al. studied semen parameters by comparing 26 vegetarians, 5 vegans, and 443 non-vegetarians. It was found that vegetarians exhibited reduced sperm concentration and motility, although no changes were detected in sperm morphology and sperm chromatin integrity. [38] Among vegans, higher levels of DNA methylation in genes related to metabolism, altered fatty acid composition of sperm, and ineffective sperm hyperactivation were observed. In 2021, Kljajic et al. examined semen

quality in ten vegans and ten non-vegetarians. In this study, the sample size was smaller, but the groups were evenly divided. The study revealed, among other findings, greater DNA denaturation in non-vegetarians, whereas vegans had higher sperm concentrations and a greater percentage of rapidly progressive motile sperm. [39]

Ketogenic Diet

The ketogenic diet involves increasing the intake of high-fat foods and eliminating high-carbohydrate foods. The main purpose of this diet is to utilize ketones produced from the breakdown of fats as an energy source, serving as fuel for various tissues such as the central nervous system, skeletal muscles, and the heart. This diet is well-known for treating disorders such as epilepsy and headaches. [40] Regarding its use in treating infertility, research primarily focuses on women. The main advantages of this diet include reducing total body weight, hyperinsulinemia, and insulin resistance, which are observed in most infertile women and men. However, this diet can lead to high consumption of saturated fatty acids (SFA) and cholesterol, which is not beneficial for male fertility. In scientific studies conducted on animals, the ketogenic diet has shown a positive impact on increasing the number of sperm with normal morphology and improving their motility. This study, conducted on mice, did not observe an increase in testosterone levels. [41] In another study, also conducted on mice fed a low-carbohydrate diet with curcumin supplementation, an improvement in testosterone levels was observed, as well as a positive impact on sperm motility and morphology and a reduction in apoptosis in the testes. [42]

Western Diet

The Western diet is particularly typical of developed countries. This diet is rich in packaged foods, sweetened beverages, red meat, fried foods, butter, and other dairy products, while being low in fruits and vegetables, fish, and grains. It is known for its excessive energy balance, often leading to obesity, which is frequently a cause of infertility. Adipocytes produce two proteins: adiponectin and leptin. [43,44,45] Leptin contributes to the development of inflammation in the testes, which, as previously mentioned, leads to elevated ROS levels. High concentrations of ROS contribute to reduced sperm motility and concentration by damaging cellular and mitochondrial membranes, thereby causing male infertility. [46] Additionally, adiponectin inhibits the secretion of GnRH through AMPK and

PI3K signaling pathways, contributing to alterations in the reproductive axis and leading to infertility. [47]

Mediterranean Diet

The Mediterranean diet is rich in fruits, vegetables, nuts, and oils, while being low in red and processed meats. It allows for moderate consumption of dairy products, fish, poultry, and wine. The term was first used by Ancel Keys, who in 1960 demonstrated in his epidemiological study a lower incidence of cardiovascular diseases and cancer in the populations of countries around the Mediterranean Sea. [48] In one of the recent studies, it was shown that men adhering to the principles of the Mediterranean diet had a higher probability of normozoospermia, while men who did not adhere as strictly to the Mediterranean diet had at least one abnormality in over 90% of cases. [49] In another study, Montano et al. found higher sperm concentration and better motility after following the principles of the Mediterranean diet for four months. [50] Recently, Muffone et al., in their review, demonstrated that the Mediterranean diet contributes to the improvement of sperm quality. However, current evidence is not sufficient to support its clinical application.

CONCLUSION

Based on the gathered research, diet plays a pivotal role in shaping male fertility. Maintaining a balanced diet is crucial for sustaining good semen quality. Several conclusions can be drawn from this study. To minimize adverse health effects, moderate consumption of meat and preference for organically farmed products are recommended. Increasing intake of fish and other sources of omega-3 may benefit men's reproductive health. However, caution should be exercised in selecting these products to avoid harmful effects associated with environmental pollutants. Regular consumption of diverse fruits, vegetables, and grains can significantly contribute to improving semen parameters, making it worthwhile to incorporate these items into daily diet for their numerous health benefits. Limiting intake of sweets and sugary drinks is crucial for maintaining metabolic health and increasing chances of fatherhood. Reduction in alcohol consumption contributes to improving semen quality and enhances the likelihood of healthy offspring. Quitting smoking is a critical step in the context of reproductive health. Men planning for offspring should consider limiting or completely abstaining from cannabis use. Literature analysis indicates that nutrients, their quality, and the presence of potentially harmful substances in the diet significantly impact semen quality and the functioning of male

gonads. Future research should focus on further evaluating the influence of specific dietary factors on semen parameters and thereby men's reproductive capability.

DISCLOSURE

Author's contribution:

Conceptualization: Barbara Serkis, Zuzanna Bentkowska, Małgorzata Miazga, Magdalena Celichowska, Aleksandra Bogoń, Gabriela Dziuba, Jagna Golemo, Izabela Kałuża, Justyna Szpyra, Julia Dębińska

Methodology: Zuzanna Bentkowska, Barbara Serkis, Małgorzata Miazga, Magdalena Celichowska, Aleksandra Bogoń, Gabriela Dziuba, Jagna Golemo, Izabela Kałuża, Justyna Szpyra, Julia Dębińska

Software: Małgorzata Miazga, Magdalena Celichowska, Aleksandra Bogoń, Gabriela Dziuba, Jagna Golemo, Izabela Kałuża, Justyna Szpyra, Julia Dębińska, Barbara Serkis, Zuzanna Bentkowska,

Check: Gabriela Dziuba, Jagna Golemo, Izabela Kałuża, Justyna Szpyra, Julia Dębińska, Barbara Serkis, Zuzanna Bentkowska, Małgorzata Miazga, Magdalena Celichowska, Aleksandra Bogoń,

Formal Analysis: Jagna Golemo, Izabela Kałuża, Justyna Szpyra, Julia Dębińska, Barbara Serkis, Zuzanna Bentkowska, Małgorzata Miazga, Magdalena Celichowska, Aleksandra Bogoń, Gabriela Dziuba

Investigation: Aleksandra Bogoń, Gabriela Dziuba, Jagna Golemo, Izabela Kałuża, Justyna Szpyra, Julia Dębińska, Barbara Serkis, Zuzanna Bentkowska, Małgorzata Miazga, Magdalena Celichowska

Resources: Barbara Serkis, Zuzanna Bentkowska, Małgorzata Miazga, Magdalena Celichowska, Aleksandra Bogoń, Gabriela Dziuba, Jagna Golemo, Izabela Kałuża, Justyna Szpyra, Julia Dębińska

Data Curation: Zuzanna Bentkowska, Barbara Serkis, Małgorzata Miazga, Magdalena Celichowska, Aleksandra Bogoń, Gabriela Dziuba, Jagna Golemo, Izabela Kałuża, Justyna Szpyra, Julia Dębińska

Writing-Rough: Małgorzata Miazga, Magdalena Celichowska, Aleksandra Bogoń, Gabriela Dziuba, Jagna Golemo, Izabela Kałuża, Justyna Szpyra, Julia Dębińska, Barbara Serkis, Zuzanna Bentkowska,

Review and Editing: Magdalena Celichowska, Aleksandra Bogoń, Gabriela Dziuba, Jagna Golemo, Izabela Kałuża, Justyna Szpyra, Julia Dębińska, Barbara Serkis, Zuzanna Bentkowska, Małgorzata Miazga

Visualization: Aleksandra Bogoń, Gabriela Dziuba, Jagna Golemo, Izabela Kałuża, Justyna Szpyra, Julia Dębińska, Barbara Serkis, Zuzanna Bentkowska, Małgorzata Miazga, Magdalena Celichowska

Supervision: Barbara Serkis, Zuzanna Bentkowska, Małgorzata Miazga, Magdalena Celichowska, Aleksandra Bogoń, Gabriela Dziuba, Jagna Golemo, Izabela Kałuża, Justyna Szpyra, Julia Dębińska

Project Administration: Aleksandra Bogoń, Gabriela Dziuba, Jagna Golemo, Izabela Kałuża, Justyna Szpyra, Julia Dębińska, Barbara Serkis, Zuzanna Bentkowska, Małgorzata Miazga, Magdalena Celichowska

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