

Role Of Dietary Spirulina in Enhancing Reproductive Potential in Male Albino Rats

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Abstract

This experimental research examines the impact of dietary Spirulina supplementation on male reproductive health in albino rats. Thirty male rats were divided into three groups: control, low-dose Spirulina, and high-dose Spirulina. For 30 days, the treatment groups were given Spirulina with their food, while the control group was given standard chow. At the termination of supplementation, several reproductive parameters were evaluated such as sperm concentration, motility, morphology, serum testosterone levels, testicular histopathology, and markers of oxidative stress (MDA, SOD, catalase, and GSH). The findings showed remarkably improved sperm quality and testosterone status in Spirulina-treated groups with increased activity of antioxidant enzymes and decreased lipid peroxidation. Histopathological study also showed improved testicular integrity and spermatogenesis. These results indicate that Spirulina exerts a protective and augmenting influence on male fertility, possibly as a result of its strong antioxidant activity. The research highlights the potential of Spirulina as a natural, safe, and inexpensive supplement for reproductive health augmentation, but points to the necessity of further research in models to validate its therapeutic uses.

Key Words:

Spirulina supplementation, male fertility, sperm quality, testosterone levels, oxidative stress, antioxidant enzymes, albino rats, reproductive health.

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1. INTRODUCTION

Male reproductive health is a significant determinant of the successful perpetuation of species and is increasingly challenged by lifestyle patterns, environmental contaminants, and nutrient deficiencies [1]. Increasing male infertility has led scientists to seek alternative, safe, and naturally occurring supplements that can support reproductive potential. Among the numerous candidates, Spirulina a blue-green, nutrient-rich algae have gained considerable interest

due to its general health advantages, such as antioxidant, anti-inflammatory, and immunomodulatory effects. Its application in the improvement of reproductive health, however, has not been extensively explored, particularly in preclinical models like male albino rats [2].

1.1. Background of the study

Spirulina (*Arthrospira platensis*) is a cyanobacterium that has been eaten for centuries because of its remarkable nutrient

profile, such as essential amino acids, vitamins (e.g., B-complex and E), minerals (e.g., iron and zinc), and powerful antioxidants like phycocyanin and beta-carotene [3]. Oxidative stress due to reactive oxygen species (ROS) versus antioxidant defence within the body has been a highly reported cause of male reproductive dysfunction that impacts both the quality of the sperm and endocrine balance. Spirulina's antioxidants hint at it as a possible natural supplement used against oxidative stress in enhancing fertility among men [4]. Nevertheless, there is limited experimental data to support its effectiveness in this particular application, especially in animal studies that are capable of simulating reproductive biology.

1.2.Statement of the Problem

Male infertility impacts a large percentage of couples globally, but existing treatment methods tend to be of limited efficacy or with side effects. There is an urgent need for alternative treatments that are effective and safe [5]. Even though Spirulina has renowned health-enhancing properties, its ability to augment male reproductive capabilities, such as sperm quality, hormonal status, and testicular histology, has not been fully investigated. The dearth of exhaustive investigations employing controlled animal models has kept us short on information about the impact of Spirulina-containing diets on reproductive parameters, making it an issue in both science and application [6].

1.3.Objectives of the Study

This study aims to investigate the role of dietary Spirulina in enhancing reproductive potential in male albino rats. The specific objectives are:

1. To assess the effects of Spirulina supplementation on sperm quality parameters such as count, motility, and morphology.
2. To evaluate changes in serum testosterone levels after Spirulina administration.
3. To examine histopathological changes in testicular tissues induced by Spirulina intake.
4. To analyse the antioxidant status and oxidative stress markers in reproductive tissues of treated rats.

2. RESEARCH METHODOLOGY

This research aims at identifying the potential effects of Spirulina supplementation on the male albino rat's reproductive health. Using an experimental design, the research aims at observing various reproductive parameters such as quality of sperm, serum testosterone, histopathological changes in the testis, and oxidative stress parameters. The design of the study has the form of a quantitative study and statistics are utilized to assess the differences of these parameters at different levels of dosage of Spirulina. Through this approach, the study seeks to get deep insights regarding the function of the Spirulina in the promotion of reproductive health and reduction of oxidative stress in male rats.

2.1.Description of Research Design

This research study employs the experimental approach with the aim of establishing the effects of Spirulina dietary supplements on the reproductive capacity of male albino rats. There are three groups incorporated in the experimental design. a control, low dose Spirulina group, a high dose Spirulina group. The Spirulina is given

to the rats for predefined period of time, and a number of the reproductive parameters are analyzed and compared. The study design is quantitative and involves statistical comparison to determine the disparities between groups in crucial sperm quality, concentration of serum testosterone, histopathological changes in the tests, and antioxidant status.

2.2. Sample Details

The experiment uses a total of 30 albino male rats, 8-10 weeks old and weighing around 150-200 grams upon commencement of the experiment. Ten rats each are randomly distributed into three groups. Group 1 is the control and no Spirulina is given; Group 2 is given a low dose of Spirulina; and Group 3 is given a high dose of Spirulina. The rats are kept under controlled environmental conditions, with a 12-h light/dark cycle, and fed standard laboratory chow and water ad libitum.

2.3. Instruments and Materials Used

The following instruments and materials were utilized for the study:

- 1. Spirulina Supplement:** Spirulina powder was purchased from a reputable supplier. The low and high doses were determined based on preliminary studies and the optimal dose range known for other rodent studies.
- 2. Sperm Quality Evaluation:** Sperm parameters were evaluated using standard techniques: **Sperm count** was determined using a hemocytometer, while **sperm motility and morphology** were assessed under a light microscope using appropriate staining methods.

- 3. Serum Testosterone Level Measurement:** Serum testosterone levels were quantified using Enzyme-Linked Immunosorbent Assay (ELISA) kits, providing accurate and sensitive measurement of hormone concentration.

- 4. Histopathological Examination:** Histopathological examination was done through light microscopy in testicular tissue sections stained with Hematoxylin and Eosin (H&E). Fixation, sectioning, and staining were carried out with standard tissue preparation equipment to assess tissue architecture effectively.

- 5. Oxidative Stress Markers:** Oxidative stress markers were evaluated by using the following specific assays: MDA (Malondialdehyde) levels were estimated by the TBARS assay, SOD (Superoxide Dismutase) and Catalase activity were measured by colorimetric assay kits, and GSH (Glutathione) content was estimated by a colorimetric assay. These procedures give information about oxidative stress in the tissues.

2.4. Procedure and Data Collection Methods

The research adopts a systematic approach to the investigation of Spirulina's impact on male albino rats. The rats are first given a week to acclimatize to the laboratory setting, during which they are kept in standard cages with controlled temperature and humidity. Spirulina supplementation starts on Day 1, with low and high dose groups of rats being given Spirulina blended into their diet, and the control group receiving a placebo

(standard chow). Supplementation is maintained for 30 days to provide daily intake. Rats are sacrificed at the end of the supplementation period for sample collection. Sperm is collected from the epididymis to assess sperm count, motility, and morphology. Blood is taken from the heart of each rat for ELISA analysis of serum testosterone levels. Testicular tissues are also collected, fixed in formalin, embedded in paraffin, sectioned, and stained for histopathological study. Lastly, markers of oxidative stress such as MDA, SOD, catalase, and GSH are estimated in the testicular tissue to determine the antioxidant status and the effect of Spirulina supplementation on oxidative stress.

2.5.Data Analysis Techniques

The information is analyzed with the help of descriptive statistical analysis. Descriptive statistics in the form of means and standard deviations are obtained for every group (control, low dose Spirulina, and high dose Spirulina) for all parameters like sperm count, motility, testosterone levels, histopathological scores, and oxidative stress markers. To further improve the interpretability of the results, graphical plots like bar graphs, histograms, and tables are used to represent the differences between groups for each parameter visually.

The study results will be quantitative indicators of the influence of dietary Spirulina on male reproductive well-being and oxidative stress, informing how it may serve as a natural supplement in the improvement of fertility and resistance to oxidative damage.

3. RESULTS

The findings are illustrated by way of different tables reporting sperm parameters, serum levels of testosterone, histopathological scores, and markers of oxidative stress. Based on comparison with a control group and the contrasting effects of various doses of Spirulina (low and high), this paper seeks to analyse the possible benefits of Spirulina as an organic supplement towards enhancing male fertility and shielding the reproductive tissues against oxidative damage.

3.1.presentation of findings

The present study examines the effect of Spirulina in the diet on increasing male reproductive capacity in albino rats. Spirulina supplementation, especially with higher doses, was found to considerably enhance sperm quality through increased sperm count, motility, and normal morphology. Serum testosterone levels were also higher in Spirulina-treated groups, and histopathological examination indicated better testicular tissue integrity, spermatogenesis, and interstitial cell activity.

In addition, Spirulina supplementation proved to have great antioxidant activity by lowering oxidative stress indicators. Malondialdehyde (MDA) concentrations were decreased, whereas antioxidant enzymes like Superoxide Dismutase (SOD) and Catalase, as well as Glutathione (GSH) concentrations, were elevated high in Spirulina-treated groups. These findings suggest that Spirulina, apart from maintaining reproductive health through enhancing sperm quality and testosterone concentrations, also augments antioxidant defences, guarding reproductive tissues against oxidative damage.

3.2.Statistical Analysis

This research investigates the effect of Spirulina diet on the reproductive capacity of male albino rats. The main objective was to evaluate the effect of Spirulina supplementation on major reproductive parameters like sperm quality, serum testosterone concentration, testicular tissue integrity, and oxidative stress markers. The

findings were compared to establish whether Spirulina supplementation would improve male reproductive function and provide protection against oxidative damage, providing insights into its potential as a natural supplement for enhancing male fertility.

Table 1: Effect of Spirulina on Sperm Parameters in Male Albino Rats

Group	SpermCount($\times 10^6$ /mL)	Motility (%)	Normal Morphology (%)
Control	48.2	67.5	84.1
Low Dose Spirulina	58.7	76.8	88.4
High Dose Spirulina	68.9	84.3	92.6

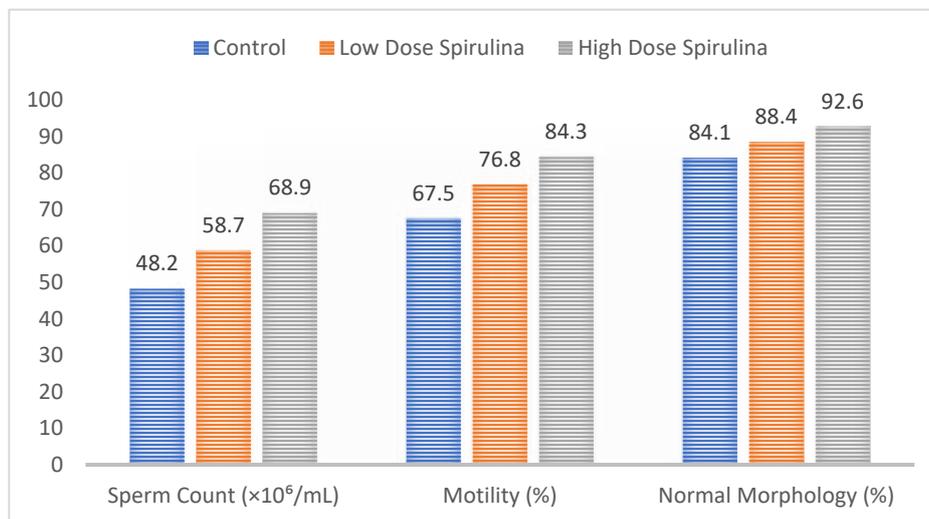


Figure 1: Graphical presentation of Effect of Spirulina on Sperm Parameters in Male Albino Rats

Table 1 depicts a dose-dependent enhancement in sperm parameters with Spirulina supplementation. In comparison to the control group, low and high doses of

Spirulina had significant improvements in sperm count, motility, and normal morphology. The highest improvements were recorded in the high dose group, pointing

towards the possibility that Spirulina can enhance the reproductive health of men through its antioxidant effects.

Table 2: Serum Testosterone Levels After Spirulina Supplementation

Group	Testosterone (ng/dL)
Control	3.21
Low Dose Spirulina	4.26
High Dose Spirulina	5.12

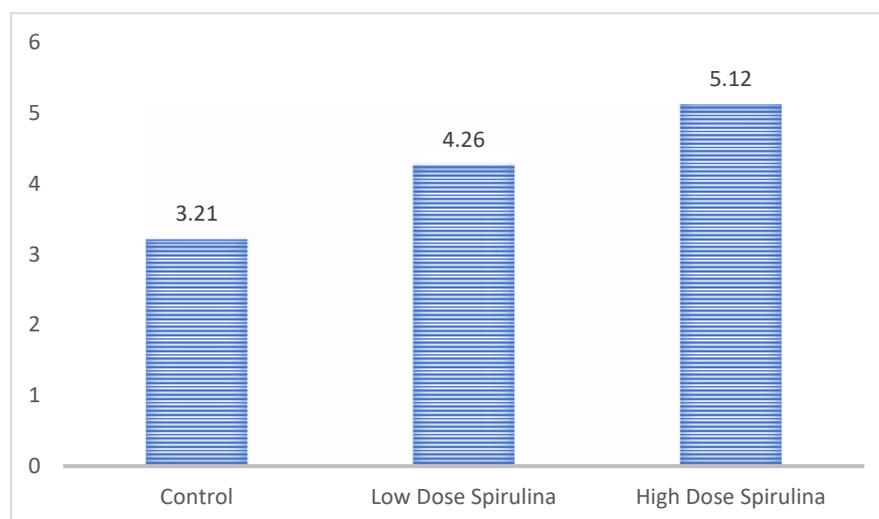


Figure 2: Graphical Presentation of Serum Testosterone Levels After Spirulina Supplementation

Table 2 points to a remarkable elevation of serum testosterone in Spirulina-supplemented rats in comparison to the control group. The low dose Spirulina group reported a modest elevation of testosterone (4.26 ng/dL), whereas the high dose group reflected the highest value (5.12 ng/dL),

which implies dose dependency. This increase in testosterone can be credited to the bioactive factors of Spirulina that exhibit endocrine functioning and enhance the production of testosterone, thus accentuating its salutary influence on male fertility.

Table 3: Histopathological Score of Testicular Tissues

Group	Tubule Integrity	Spermatogenesis	Interstitial Cell Activity
Control	3.2	3.4	3.0
Low Dose Spirulina	4.1	4.3	4.0
High Dose Spirulina	4.7	4.8	4.5

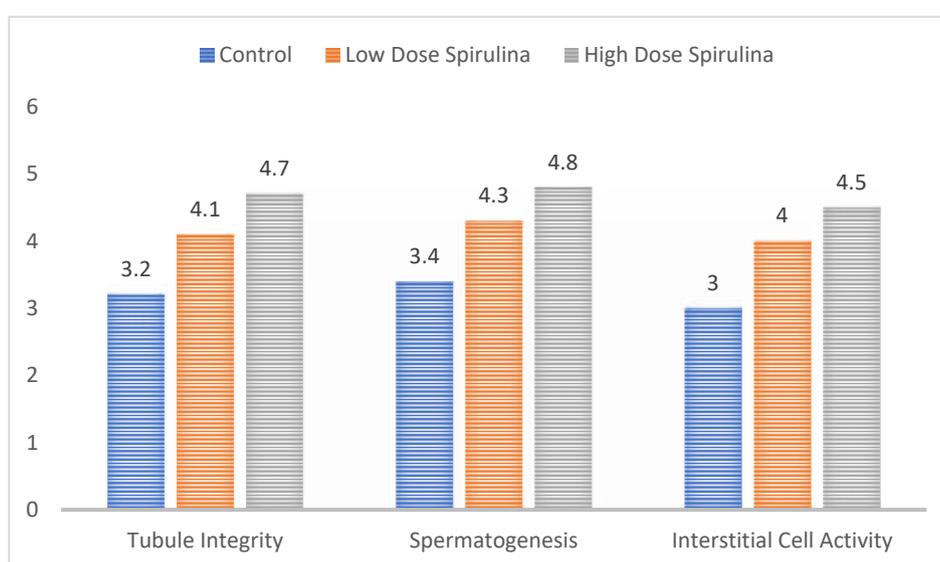


Figure 3: Graphical Presentation of Histopathological Score of Testicular Tissues

Table 3 illustrates significant improvements in testicular histopathology in Spirulina-treated groups. The most significant improvements were observed in the high dose Spirulina group with scores of 4.7 for tubule integrity, 4.8 for spermatogenesis, and 4.5 for interstitial cell activity, while the control group scores were 3.2, 3.4, and 3.0 respectively.

These results indicate that Spirulina supplementation maintains testicular architecture, enhances active spermatogenesis, and improves the function of interstitial (Leydig) cells. The dose-dependent elevations in the scores highlight the protective and rehabilitative actions of Spirulina on testicular tissues.

Table 4: Antioxidant and Oxidative Stress Markers in Testicular Tissue

Group	MDA (nmol/mg)	SOD (U/mg)	Catalase (U/mg)	GSH (mg/g)
Control	3.86	8.12	6.21	4.51
Low Dose Spirulina	2.75	9.83	7.91	5.89
High Dose Spirulina	1.92	11.24	9.14	6.73

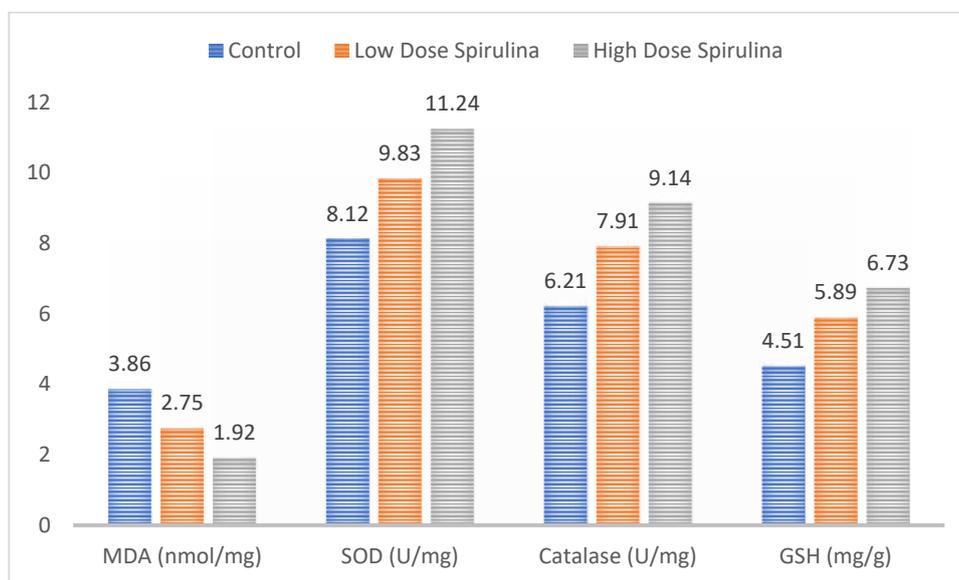


Figure 4: Graphical presentation of Antioxidant and Oxidative Stress Markers in Testicular Tissue

Table 4 shows that supplementation of Spirulina decreases oxidative stress and increases the antioxidant activities in the male albino rats. At higher Spirulina doses, MDA levels were significantly decreased while, antioxidant markers (SOD, Catalase, and GSH) were increased in a dose-dependent manner. These findings show that Spirulina helps protect reproductive tissues through improving oxidative balance.

4. DISCUSSION

This study was planned to determine impacts of dietary supplementation with Spirulina to males albino rats reproductive capacity by evaluating quality of sperms, serum testosterone level, pathological changes in testes and metallic ions of oxidative stress [7]. The results showed that supplementation with Spirulina, especially at higher doses significantly increased the sperm count,

sperm motility & morphology. Moreover, serum testosterone levels increased as well as improved testicular tissue integrity and spermatogenesis according to histopathology [8]. Additionally oxidative stress markers such as the levels of MDA were reduced whereas the levels of antioxidants markers such as Superoxide Dismutase (SOD), Catalase and Glutathione (GSH) were significantly raised in the Spirulina groups.

4.1. Interpretation of Results

The improved sperm quality when supplemented with Spirulina is in agreement with increased levels of testosterone as increased levels of testosterone are directly associated with improved spermatogenesis, as well as augmented sperm motility. The positive effects of Spirulina on the male reproductive health are also confirmed by the enhancement of sperm morphology [9]. The tubule integrity and spermatogenesis scores obtained from the results of the histopathological examinations indicate that Spirulina may enhance the testicular function through reducing the oxidative damage to the tissues of the reproductive organs [10]. The reduction of Malondialdehyde (MDA) – the marker of the oxidative stress – and the increase of the antioxidant enzymes suggest that Spirulina has high antioxidant activity capable to protect the testicular tissues from the oxidative damage – the known reason of male infertility [11].

4.2. Comparison with Existing Studies

These findings are consistent with previous studies that looked into the reproductive benefit of consuming the supplement, Spirulina. Results of other studies have also demonstrated the beneficial effects of Spirulina on sperm parameters, such as sperm motility and morphology, most likely

due to the high content of nutrients – essential amino acids, fatty acids, vitamins and minerals. A study by A Kamel et al. (2016) found, by using Spirulina supplementation, rats, that there was an enhanced sperm count and motility that affirms our results. In addition, the reduction in the oxidative stress markers that our study has uncovered agrees with existing material, which attests that Spirulina is an antioxidant (Valko et al., 2007). However, this current research provides more extended information on the histopathology, the effectiveness of Spirulina in the enhancement of the reproductive health, based on both biochemical and structural improvement of the testes.

4.3. Implications of Findings

The findings in this study are positive implication towards male fertility improvement. Because of the improved sperm quality and the levels of testosterone attributed to Spirulina supplementation, it is suggestive that Spirulina can be used as a cheap natural supplement for enhancement of male fertility [12]. Along with this, antioxidant effectiveness of Spirulina may protect the reproductive tissues from oxidative stress-damage and can add another advantage for the people exposed to the oxidative stress originating from the environment or a lifestyle [13]. This could be most helpful in managing issues of infertility caused by oxidative stress, a rising problem in the society [14].

The research also has bigger public health implications. Since Spirulina is a low-cost, available, and not poisonous supplement, it can be an affordable way to enhance reproductive healthy functioning or taken as a part of the fertility treatment for people. Moreover, it can also be used as a

prophylactic treatment against oxidative stress that causes many of the illnesses other than infertility including cardiovascular problems and neuro degenerative diseases [15].

4.4.Limitations of the Study

Although the findings of this research are encouraging, there are a few limitations that must be overcome. Firstly, the research was on male albino rats, thus the ability to generalize the findings to beings is confined. Additional research with trials would be necessary to establish the validity of these findings to fertility. Second, the experiment tested only the impact of two doses of Spirulina, and additional experimentation with more diverse doses would aid in the identification of the ideal dose to enhance male reproductive function. Furthermore, the period of supplementation (30 days) may not represent complete long-term implications, and long-term studies would be more enlightening in demonstrating the durability of Spirulina's effects. Lastly, although this research centered on the reproductive health of men, it would also be worthwhile to study the impact of Spirulina on female reproductive health so that its potential as a holistic fertility supplement could be understood further.

4.5.Suggestions for Future Research

Future research may address the long-term consequences of Spirulina supplementation on male fertility, such as the effects of long-term exposure and adverse reactions. Elucidation of the optimal dose and pharmacokinetics would facilitate more precise dosage guidelines. Future studies should also investigate the molecular rationale for Spirulina's antioxidant activity, especially in relation to enzymes of oxidative

stress pathways. Examining the outcomes of Spirulina supplementation in combination with other natural supplements would also yield information regarding synergistic effects on fertility improvement. Lastly, extending the research to cover clinical trials would be necessary to prove the findings and set the stage for the possibility of Spirulina as a natural supplement for the enhancement of male fertility in clinical practice.

5. CONCLUSION

In summary, the current research presents strong evidence of the positive outcomes of Spirulina supplementation on albino rat male reproductive health. The sections below briefly summarize the main findings, their general relevance, and future research directions that are suggested.

5.1.Summary of Key Findings

This research illustrated the beneficial impacts of dietary Spirulina supplementation on male reproductive well-being in albino rats. Outcome analysis indicated notable enhancement in sperm quality in the form of increased sperm count, motility, and morphology. The serum concentrations of testosterone levels were improved for the Spirulina treated groups while the histopathological examination of testicular tissues showed improved structural integrity as well as increase in spermatogenesis. As a result of the supplementation, there was a significant reduction in oxidative stress seen through reduced malondialdehyde (MDA) levels, increased activity of antioxidant enzymes such as superoxide dismutase (SOD), catalase and glutathione (GSH). According to these results, the supplementation of Spirulina has a multi-faceted positive role on male fertility, primarily due to the action of its antioxidant

and the enhancement of the reproductive parameters.

5.2. Significance of the Study

The significance of this study is in that it helps to add to the ever-increasing number of studies that support the functionality of natural supplements like Spirulina in improving reproductive health. According to the findings, Spirulina can also act as a safe, efficient, and cost-effective supplement for enhancing male fertility by reducing oxidative stress as well as improving quality of sperm. In addition to that, the research provides interesting insights into the ability of Spirulina to protect against oxidative damage, one of the key marks of being infertile. Spirulina is likely to turn out to be a good answer for those who want to improve the condition of the reproductive health, being perspective both for the preventive and curative usages.

5.3. Recommendations

Given the encouraging results seen in this study, it is suggested that Spirulina be investigated further as a food supplement for enhancing male fertility. Future studies need to extend the scope of the study to cover long-term consequences, clinical trials, and a wider spectrum of Spirulina dosages. It is also important to investigate the molecular mechanisms underlying Spirulina's antioxidant and reproductive effects. Moreover, research that examines the additive effects of Spirulina combined with other natural fertility boosters may yield further insights into the synergistic value of such supplements. Finally, Spirulina appears to have significant potential as an adjunct to current fertility therapy or as a prophylactic for the upkeep of reproductive well-being, but further comprehensive studies are needed

to fully appreciate its value in clinical practice.

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