



Evaluation of Semen Quality among Farmers in Dhamtari District, Chhattisgarh: A Cross-Sectional Study of Occupational and Environmental Impacts

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ABSTRACT:

Introduction: Occupational and environmental exposures are known to affect male reproductive health. This study aimed to assess semen parameters among farmers from Dhamtari, Chhattisgarh, and identify the prevalence of abnormalities.

Objectives: To evaluate the semen quality and prevalence of abnormalities among farmers in Dhamtari, Chhattisgarh, and to assess the potential impact of occupational and environmental factors on male reproductive health.

Methods: A cross-sectional study was conducted involving 270 farmers between July 2020 and August 2024. Standard semen analysis was performed, evaluating liquefaction time, color, volume, pH, fructose presence, sperm count, motility, morphology, and leucocyte count. Data were statistically analyzed using Chi-square tests, with a significance threshold set at $p < 0.05$.

Results: Significant abnormalities were observed across all evaluated semen parameters. Delayed liquefaction (>40 minutes) was noted in 3.33% of cases, while 41.11% exhibited low semen volume (<1.4 mL). Abnormal sperm count (≤ 15 million/mL) was found in 18.5% of samples, and poor motility ($\leq 32\%$) in 28.88%. Abnormal morphology was detected in 59.26% of cases, and leucocytospermia (>1 million/mL) in 14.81%. All deviations from normal standards were statistically significant ($p < 0.0001$).

Conclusions: The findings reveal a high burden of semen abnormalities among farmers, suggesting occupational and environmental factors may impair reproductive health. Early screening, fertility counseling, and interventions addressing occupational risks are recommended to safeguard male fertility in rural populations. Further studies exploring exposure levels and hormonal profiles are warranted.

1. Introduction

Male fertility plays a critical role in successful reproduction and the continuation of generations. Semen analysis remains the cornerstone for assessing male fertility potential, providing valuable information about sperm quantity, motility, morphology, and the seminal plasma environment. Globally, infertility affects approximately 8–12% of couples, with male factors contributing to nearly 40–50% of cases (5,8). While genetic and physiological factors are implicated, growing evidence suggests that environmental exposures, occupational hazards, and lifestyle factors are

significantly influencing male reproductive health, particularly in rural and agricultural communities. Farmers represent a population uniquely vulnerable to environmental insults that may impair fertility. Regular exposure to pesticides, herbicides, fertilizers, heat, physical stress, and infectious agents can negatively impact spermatogenesis and seminal quality (3,6). Several studies have associated pesticide exposure with reduced sperm count, altered motility, and increased sperm DNA fragmentation. Additionally, chronic dehydration, poor nutrition, limited access to healthcare, and unregulated use of agrochemicals further compound



the risk for male reproductive dysfunction in farming populations (24,13,28).

India, being an agrarian country, has a significant portion of its workforce engaged in farming activities. However, research focusing on male fertility parameters among Indian farmers remains limited, especially at the regional level. Dhamtari, located in the state of Chhattisgarh, is one such agricultural district where farming is the primary occupation. Despite extensive agricultural activity, no systematic studies have yet evaluated the semen quality or reproductive health status of farmers in this region. Addressing this gap is crucial, as infertility not only carries personal and social stigma but also affects mental health, family dynamics, and economic productivity (1,3,7).

Semen is a complex biological fluid composed of spermatozoa suspended in seminal plasma, which is secreted by the testes, epididymis, seminal vesicles, prostate gland, and bulbourethral glands. Semen parameters typically assessed during routine analysis include volume, liquefaction time, viscosity, pH, color, sperm concentration, motility, viability, morphology, and the presence of leucocytes (25). Deviations from normal values can indicate underlying pathology such as infections, inflammations, hormonal imbalances, genetic defects, or exposure to environmental toxins. Liquefaction time is an important semen characteristic, as delayed liquefaction can hinder sperm motility and the ability to fertilize the oocyte. Normal liquefaction occurs within 20–30 minutes at room temperature. Abnormal semen color, such as yellowish or reddish hues, may suggest infection, presence of blood, or excessive white blood cells (17). Semen volume reflects the secretory function of accessory glands; volumes lower than 1.5 mL are associated with decreased fertility potential. Seminal pH, normally between 7.2 and 8.0, maintains sperm viability and motility, and abnormal pH may indicate infections or dysfunction of the seminal vesicles or prostate (14,19).

Fructose content in semen is vital for providing energy to spermatozoa, and absence of fructose often points toward seminal vesicle obstruction. Sperm count, motility, and morphology are directly related to fertilizing capacity. Low sperm concentration (oligospermia), poor motility (asthenozoospermia), or high rates of abnormal morphology (teratozoospermia)

can significantly compromise male fertility. Elevated leucocyte count, termed leucocytospermia, can indicate infection or inflammation, leading to oxidative stress and damage to sperm DNA integrity (11,15).

Multiple occupational studies have highlighted that farmers exposed to organophosphates, organochlorines, carbamates, and pyrethroids often demonstrate poor semen quality compared to the general population. Pesticides are known to exert endocrine-disrupting effects, interfere with spermatogenesis, and induce oxidative damage (4,6). Heat stress due to prolonged outdoor work during high-temperature seasons can impair spermatogenesis by affecting scrotal thermoregulation. Additionally, mechanical stress, inadequate hydration, and poor sanitation conditions prevalent in rural farming communities could also contribute to semen quality deterioration (9,10). Given these considerations, the present study was designed to evaluate the semen parameters among farmers from Dhamtari district, Chhattisgarh, to assess the prevalence of seminal abnormalities and identify potential reproductive health risks. A comprehensive semen analysis was conducted over four years (July 2020 to August 2024) involving 270 male participants engaged primarily in agricultural activities. Parameters such as liquefaction time, semen color, volume, pH, fructose presence, sperm concentration, motility, morphology, and leucocyte count were analyzed according to WHO standard guidelines (16,20,21).

Statistical analysis using Chi-square tests was employed to determine the significance of observed deviations from normal semen values. This approach provided robust evidence to identify the parameters most affected within the studied population. By correlating semen quality parameters with occupational and environmental exposure profiles, the study aimed to contribute valuable insights into the impact of farming-associated risk factors on male fertility (12,18).

Our research addresses a vital yet underexplored area, emphasizing the need for fertility awareness and occupational health interventions targeted at rural communities. Identifying the semen quality status among farmers also holds broader public health significance, particularly in regions like Chhattisgarh where fertility services are limited, and awareness about male reproductive health remains low. Thus, the present study



seeks to bridge the gap between occupational exposures and reproductive health in Indian farmers by providing baseline semen quality data, identifying deviations, and suggesting future pathways for improving male fertility health in rural India.

2. Objectives

The primary aim of this study was to evaluate the semen quality of farmers in Dhamtari district, Chhattisgarh, with a focus on identifying abnormalities in key seminal parameters. The research sought to assess liquefaction time, semen color, volume, pH, presence of fructose, sperm concentration, motility, morphology, and leucocyte count among 270 male participants engaged in agricultural work. Given the nature of their occupation, farmers are regularly exposed to environmental and occupational hazards such as pesticides, fertilizers, extreme heat, and physical stress, which have been implicated in the decline of male reproductive health globally. Therefore, a secondary objective of this study was to explore the potential link between such exposures and the observed alterations in semen parameters.

By conducting systematic semen analysis based on WHO guidelines and applying statistical tools like the Chi-square test, the study aimed to determine the significance of deviations from normal seminal values. The intention was not only to document the current reproductive health status of this rural population but also to highlight the role that farming-related environmental factors might play in impairing fertility potential. This research fills a crucial knowledge gap for rural India, where male infertility is often overlooked, and agricultural workers represent a large but under-assessed group. Findings from the study are expected to guide public health strategies, encourage early fertility screening, promote occupational safety measures, and lay the foundation for future research into mitigating the reproductive risks associated with agricultural occupations.

3. Methods

Semen collection and preservation: - Semen samples were collected after 3-5 days of ejaculatory abstinence in a sterile plastic container by the process of masturbation (WHO, 2021). The collected samples are allowed to liquefy at 37°C for 30 minutes and analyzed within one hour of collection.

Safety Considerations: Semen samples are potentially hazardous due to the presence of bacteria, protozoan related to sexually transmitted diseases and Human Immunodeficiency Virus).

Semen Analysis

Macroscopic Evaluation: Following liquefaction, the semen volume was measured using a graduated pipette. Appearance (color and opacity) and viscosity were assessed visually and by thread formation using a glass rod. Semen pH was measured immediately using pH paper strips (22).

Microscopic Evaluation

Sperm Concentration: After thorough mixing, semen samples were diluted 1:20 with a standard diluent and loaded onto a Neubauer hemocytometer. Spermatozoa were counted under phase-contrast microscopy, and concentration was expressed as $\times 10^6$ spermatozoa per milliliter.

Sperm Motility: A drop of liquefied semen was placed on a pre-warmed glass slide, covered with a coverslip, and examined at 200 \times magnification. A minimum of 200 spermatozoa were evaluated, and motility was categorized as progressive, non-progressive, or immotile. Results were expressed as percentages.

Sperm Morphology: Thin smears of semen were air-dried, fixed, and stained with Eosin-Nigrosin stain. Morphological evaluation was performed under oil immersion (1000 \times magnification) according to WHO strict criteria, with at least 200 spermatozoa assessed per sample (26).

Sperm Viability: An aliquot of semen was mixed with Eosin-Nigrosin stain, and smears were examined to distinguish live (unstained) from dead (stained) spermatozoa. A minimum of 100 sperm cells were evaluated.

Hypo-osmotic Swelling Test: Sperm vitality was assessed by incubating semen samples in a hypo-osmotic solution at 37°C for 30 minutes. Swollen sperm tails indicated intact membrane integrity.

Additional Observations: The presence of leukocytes was assessed using peroxidase staining, and sperm



agglutination or aggregation patterns were noted during motility evaluation.

Statistical Analysis: Data were entered into IBM SPSS Statistics version 26. Frequencies and percentages were calculated for categorical variables. Chi-square (χ^2) tests were applied to assess the association between semen parameters (liquefaction time, semen color, semen quantity, pH, fructose presence, sperm count, sperm motility, sperm morphology, leucocyte count) and their respective normality categories. A p-value <0.05 was considered statistically significant (23,27).

4. Results

Liquefaction Time:

Table 1. Distribution of Semen Liquefaction Time Among Farmers (n=270).

S. No.	Liquefaction Time	Number of Patients (n=270)	Percentage (%)
1	5–20 minutes (Normal)	240	88.88%
2	21–40 minutes (Normal)	21	7.77%
3	>40 minutes (Abnormal)	9	3.33%

Observation: Most samples (88.88%) showed normal liquefaction time.

Semen Color:

Table 2. Distribution of Semen Color Among Farmers (n=270).

S. No.	Color	Number of Patients (n=270)	Percentage (%)
1	Grey-white (Normal)	250	92.59%
2	Transparent white (Abnormal)	14	5.18%

3	Yellow (Abnormal)	6	2.22%
4	Reddish (Abnormal)	0	0.00%

Observation: 92.59% of semen samples exhibited normal grey-white color.

Semen Volume:

Table 3. Distribution of Semen Volume Among Farmers (n=270).

S. No.	Volume	Number of Patients (n=270)	Percentage (%)
1	Semen sample not collected	3	1.11%
2	<1.4 mL	111	41.11%
3	1.5–4.5 mL (Normal)	110	40.74%
4	>4.5 mL	46	17.03%

Observation: Approximately 41% had low semen volume (<1.4 mL).

Semen pH:

Table 4. Distribution of Semen pH Among Farmers (n=270).

S. No.	pH	Number of Patients (n=270)	Percentage (%)
1	<7.0 (Acidic, Abnormal)	12	4.44%
2	7.0–8.0 (Normal)	258	95.55%
3	>8.5 (Alkaline)	0	0.00%

Observation: pH was normal (7.0–8.0) in 95.55% of samples.



Fructose Presence:

Table 5. Distribution of Fructose Test Results in Semen Samples (n=270).

S. No.	Fructose Test	Number of Patients (n=170)	Percentage (%)
1	Positive	162	97.03%
2	Negative	8	2.96%

Observation: 97% of samples showed positive fructose, indicating functioning seminal vesicles.

Sperm Concentration

Table 6. Distribution of Sperm Count Among Farmers (n=270).

S. No.	Sperm Count (millions/mL)	Number of Patients (n=270)	Percentage (%)
1	0 (Azoospermia)	44	16.29%
2	<1	15	5.55%
3	1–20	52	19.25%
4	21–40	21	7.77%
5	41–60	33	12.22%
6	61–80	40	14.81%
7	81–100	19	7.03%
8	101–120	15	5.55%
9	121–140	12	4.44%
10	141–160	11	4.07%
11	>160	8	2.96%

Observation: Azoospermia (0 sperm count) was present in 16.29% of cases.

Sperm Motility

Table 7. Distribution of Sperm Motility Among Farmers (n=270).

S. No.	Motility (%)	Number of Patients (n=270)	Percentage (%)
1	0%	2	0.74%
2	1–10%	9	3.33%
3	11–20%	12	4.44%
4	21–30%	11	4.07%
5	31–40%	44	16.29%
6	41–50%	84	31.11%
7	51–60%	69	25.55%
8	61–70%	35	12.96%
9	71–80%	4	1.48%
10	81–100%	0	0.00%

Observation: Most participants had moderate motility between 41–60%.

Sperm Morphology

Table 8. Distribution of Sperm Morphology Among Farmers (n=270).

S. No.	Normal Morphology (%)	Number of Patients (n=270)	Percentage (%)
1	0%	2	0.74%
2	1–10%	7	2.59%
3	11–20%	19	7.03%
4	21–30%	132	48.88%
5	31–40%	43	15.92%
6	41–50%	41	15.18%
7	51–60%	26	9.62%



Observation: 48.88% had 21–30% normal sperm morphology.

Leucocyte Count

Table 9. Distribution of Leucocyte Count in Semen Samples (n=270).

S. No.	Leucocyte Count (mill/mL)	Number of Patients (n=270)	Percentage (%)
1	<1 mill/mL	230	85.18%
2	≥1 mill/mL	35	12.96%
3	>2 mill/mL	5	1.85%

Observation: 12.96% showed signs of leukocytospermia (≥1 mill/mL).

Chi square Test of All the Parameters Involved

Table 10. Summary of Chi-Square Test Results for Semen Parameters.

PARAMETER	CHI-SQUARE (X ²)	D.F.	P-VALUE	CONCLUSION
LIQUEFACTION TIME	270	2	<0.0001	Significant
SEMEN COLOR	270	1	<0.0001	Significant
SEMEN QUANTITY	109.4	1	<0.0001	Significant
PH	230.4	1	<0.0001	Significant
FRUCTOSE PRESENCE	240.2	1	<0.0001	Significant
SPERM COUNT	99.2	1	<0.0001	Significant
SPERM MOTILITY	45.2	1	<0.0001	Significant

SPERM MORPHOLOGY	9.26	1	0.003	Significant
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LEUCOCYTE COUNT	142.2	1	<0.0001	Significant
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5. Discussion

In the present study, semen analysis was conducted on 270 farmers from Dhamtari district, Chhattisgarh, over a four-year period. The evaluation focused on standard semen parameters, including liquefaction time, color, volume, pH, fructose presence, sperm count, sperm motility, morphology, and leucocyte count. Statistically significant associations were observed across all parameters when compared to standard normal values, as confirmed by Chi-square tests ($p < 0.05$). The majority of semen samples (88.88%) exhibited normal liquefaction within 5–20 minutes, which is consistent with WHO guidelines. However, 3.33% of samples exhibited delayed liquefaction (>40 minutes), suggesting possible enzymatic dysfunction or infection. Similarly, while 92.59% of samples showed the normal grey-white coloration, a small but notable proportion (7.4%) demonstrated abnormal colors such as transparent white or yellow, which may indicate infections or altered seminal plasma composition.

Semen volume was a critical finding in this cohort, with 41.11% of subjects presenting with low semen volume (<1.4 mL), suggesting a high prevalence of hypospermia. This could be attributed to environmental factors, occupational exposures (such as pesticides common in agriculture), dehydration, or accessory gland dysfunction, factors previously associated with impaired semen parameters in agricultural workers. The pH analysis indicated that 95.55% of samples were within the normal range (7.0–8.0), while a minority (4.44%) were acidic, possibly reflecting partial obstruction of seminal vesicles. Fructose presence, a marker for seminal vesicle function, was absent in 2.96% of cases, further supporting the possibility of accessory gland pathology in a subset of the study population.

Sperm count revealed significant abnormalities, with 16.29% azoospermia (no sperm), and 5.55%



oligospermia (<1 million/mL). Only 2.96% of individuals had sperm counts exceeding 160 million/mL. These findings are concerning, as low sperm concentration is a primary contributor to male infertility. Moreover, sperm motility and morphology were also impaired in a significant number of cases; only 31.11% had motility between 41–50%, and 48.88% of the samples had abnormal morphology in 21–30% of sperm. These findings underscore compromised spermatogenesis and potential structural sperm defects among the cohort. An elevated leucocyte count (>1 million/mL) was found in 12.96% of subjects, indicating possible seminal infections or inflammation, which could further compromise sperm function. The presence of leucocytospermia is known to generate reactive oxygen species, leading to oxidative stress and sperm DNA fragmentation.

Overall, the high prevalence of semen abnormalities observed in this population is consistent with studies linking occupational exposure to pesticides, high temperature, physical stress, and lifestyle factors to male infertility (García-Sánchez et al., 2019; Swan et al., 2003). The results suggest a need for targeted public health interventions, including awareness programs on fertility preservation and the implementation of safer agricultural practices. Our study is strengthened by the relatively large sample size and the use of standardized semen analysis protocols. However, limitations include the lack of detailed exposure assessment (e.g., pesticide levels, heat exposure) and absence of hormonal evaluations, which could provide deeper insights into underlying causes.

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