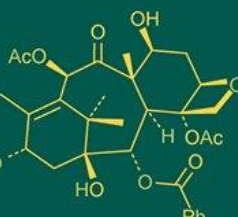
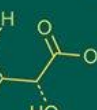
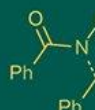


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
 ISSN Online: 2617-4707
 NAAS Rating (2026): 5.29
 IJABR 2026; 10(6): 1044-1051
www.biochemjournal.com
 Received: 17-03-2026
 Accepted: 20-04-2026

All authors' names and
 affiliations are given below,
 after the references.

Testicular biometric traits and seminal plasma biochemical markers as indicators of semen quality in Barbari bucks

Amrita Priyadershi, Anuj Kumar, Mukul Anand, Pratyanshu Srivastava, Anoop Kumar, Ashutosh Mishra, Nagendra Singh, Jitendra Agarwal, Atul Saxena and Ravi Dabas

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i6m.8817>

Abstract

The present study was conducted to evaluate the relationship between testicular biometric traits and seminal plasma biochemical markers in Barbari bucks and their association with seminal characteristics. Fifteen healthy Barbari bucks aged 1.5-2 years and weighing 25-30 kg were categorized into two groups based on scrotal circumference (Group I: 20-25 cm and Group II: >25-31 cm). Testicular biometric measurements, including scrotal circumference, testicular length, width, thickness, and volume, were recorded. Semen samples were collected using an artificial vagina, and seminal plasma was separated for biochemical analysis. Seminal plasma constituents including albumin, total protein, cholesterol, triglycerides, sodium, potassium, chloride, calcium, and phosphorus were estimated using standard biochemical procedures. Correlation analyses were performed to determine the association between testicular biometry, seminal plasma biochemical markers, and seminal attributes.

The results revealed that bucks with larger scrotal circumference exhibited greater testicular width and testicular volume. Correlation analysis demonstrated that testicular volume was positively associated with mass motility ($r = 0.674$; $p < 0.05$) in Group II bucks, indicating its potential as an indicator of reproductive performance. Albumin, total protein, cholesterol, and triglycerides showed weak to moderate correlations with seminal attributes and did not exhibit significant associations. Among mineral constituents, sodium showed a significant positive correlation with mass motility ($r = 0.465$; $p < 0.05$), whereas chloride exhibited a highly significant positive correlation with sperm concentration ($r = 0.717$; $p < 0.01$) in Group I bucks. Potassium demonstrated a significant negative correlation with semen volume ($r = -0.456$; $p < 0.01$) and sperm concentration ($r = -0.317$; $P < 0.05$) in Group II bucks. Calcium and phosphorus showed weak associations with seminal characteristics. The study concluded that testicular volume, sodium, and chloride are positively associated with important semen quality traits, whereas elevated potassium concentrations may adversely affect seminal characteristics. These findings suggest that testicular biometric traits and seminal plasma biochemical markers can serve as useful indicators for breeding soundness evaluation and selection of superior breeding bucks in Barbari goats.

Keywords: Barbari buck, Testicular biometry, Scrotal circumference, Seminal plasma, Biochemical markers, Semen quality, Correlation analysis, Reproductive performance

Introduction

Goat farming plays a significant role in the livelihood of rural households and contributes substantially to meat, milk, skin, and fibre production. Among indigenous goat breeds, Barbari goats are valued for their adaptability, prolificacy, and reproductive efficiency. Efficient reproductive performance of breeding bucks is essential for genetic improvement and enhanced productivity in goat production systems, as a single male can influence the reproductive success of numerous females (Katz, 2007; Ngoma *et al.*, 2016) [12, 18].

Evaluation of male reproductive potential is a key component of breeding soundness assessment. Testicular biometric traits such as scrotal circumference, testicular length, width, thickness, and volume are widely recognized as reliable indicators of reproductive capacity and semen production in breeding males (Pant *et al.*, 2003; Elmaz *et al.*, 2008) [8, 19]. Testicular size has been reported to be positively associated with body growth and sperm-producing ability, while scrotal circumference serves as an important predictor of testicular

Corresponding Author:
Amrita Priyadershi
 Department of Veterinary
 Gynaecology and Obstetrics,
 College of Veterinary Science
 and Animal Husbandry, U.P.
 Pandit Deendayal Upadhyaya
 Pashu Chikitsa Vigyan
 Vishwavidyalaya Evam Go
 Anusandhan Sansthan
 (DUVASU), Mathura, Uttar
 Pradesh, India

function and fertility (Ridler *et al.*, 2012; Maroto-Morales *et al.*, 2016) [16, 22].

Seminal plasma plays a crucial role in sperm metabolism, transport, protection, and fertilization. It contains a complex mixture of proteins, lipids, minerals, and other biochemical constituents secreted by the testes, epididymis, and accessory sex glands (Mann and Lutwak-Mann, 1981) [15]. Biochemical markers such as albumin, total protein, cholesterol, triglycerides, sodium, potassium, chloride, calcium, and phosphorus are involved in maintaining sperm viability, motility, membrane integrity, and fertilizing ability (Abdel-Rahman *et al.*, 2000; Juyena and Stelletta, 2012) [1, 10]. Previous studies have demonstrated associations between seminal plasma biochemical constituents and semen quality traits, indicating their importance in assessing reproductive performance (Arruda-Alencra *et al.*, 2012; Umar *et al.*, 2018) [3, 24].

Despite the recognized importance of testicular measurements and seminal plasma composition, information regarding their interrelationship in Barbari bucks remains limited. Understanding the association between testicular biometric characteristics and seminal plasma biochemical markers may provide valuable insights for the selection of superior breeding males and improvement of reproductive efficiency. Therefore, the present study was undertaken to evaluate the correlation between testicular biometric traits and seminal plasma biochemical markers in Barbari bucks.

Materials and Methods

Experimental Animals and Management

The study was conducted at the Buck Semen Analytical Unit, Goat Farm, Department of Veterinary Physiology, College of Veterinary Science and Animal Husbandry, U.P. Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan, Mathura, Uttar Pradesh, India, during 2023-2024. Fifteen healthy Barbari bucks aged between 1.5 and 2 years, weighing 25-30 kg, were selected for the study. All animals were maintained under a semi-intensive management system and fed according to standard farm practices.

Testicular Biometry

Testicular biometric measurements were recorded one day prior to semen collection. Scrotal circumference (cm) was measured at the widest diameter of the scrotum using a flexible measuring tape following the procedure described by Ball *et al.* (1983) [5] (Fig 1). The testes were gently positioned at the bottom of the scrotum, and the circumference was measured around the greatest diameter of the scrotum. Testicular length, width, and thickness (cm) were measured using a Vernier calliper as described by Raji *et al.* (2008) [21]. Testicular volume (cm³) was calculated according to the formula proposed by Bailey *et al.* (1998) [4]. (Fig 2)

$$\text{Testicular Volume} = 0.5236 \times \text{Testicular Length} \times (\text{Testicular Width})^2$$

Repeated measurements were taken for each animal, and the mean values were used for statistical analysis.



Fig 1: Measurement of SC by measuring tape

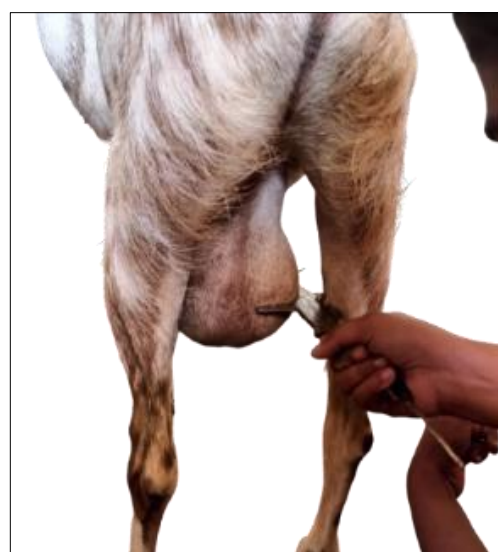


Fig 2: Measurement testicular width by measuring tape

Semen Collection and Seminal Plasma Separation

Semen samples were collected twice weekly from each buck using an artificial vagina maintained at 40-42 °C. Four ejaculates were collected from each buck during the study period. Following collection, semen samples were centrifuged, and the seminal plasma was separated and stored at -20 °C until biochemical analysis.

Analysis of Seminal Plasma Biochemical Markers

Seminal plasma samples were analyzed for albumin, total protein, cholesterol, triglycerides, sodium, potassium, chloride, calcium, and inorganic phosphorus using commercially available diagnostic kits and standard spectrophotometric procedures. Biochemical analyses were performed according to the manufacturer's protocols using a semi-automated clinical chemistry analyser (Ingenious AUTOCHEM) (Fig 3).



Fig 3: Biochemical Analyser

Statistical Analysis

Data were expressed as mean $\pm$ standard error of mean (SEM). Pearson's correlation coefficient was used to determine the relationship between testicular biometric traits and seminal plasma biochemical markers. Statistical analyses were performed using SPSS software (IBM Corp., 2021) [9], and significance was considered at $p < 0.05$.

Result and Discussion

The correlation coefficients among testicular biometric traits and seminal attributes are presented in Table 1. In Group I bucks (SC: 20-25 cm), scrotal circumference exhibited a moderate positive correlation with sperm viability ($r = 0.619$), indicating that bucks possessing larger scrotal circumference tended to have a higher proportion of viable spermatozoa. Semen volume was positively associated with testicular width ($r = 0.503$), whereas mass motility showed a positive correlation with testicular length ($r = 0.629$). Conversely, testicular thickness ($r = -0.774$) and testicular volume ($r = -0.698$) were negatively associated with sperm viability. In Group II bucks (SC: >25 -31 cm), testicular volume exhibited a significant positive correlation with mass motility ($r = 0.674$; $p < 0.05$), while the remaining testicular biometric traits showed weak to moderate relationships with seminal characteristics.

The positive relationship observed between testicular measurements and seminal traits highlights the importance of testicular development in determining reproductive efficiency. Testicular size is directly related to the amount of seminiferous epithelium present within the testes and consequently influences sperm production capacity. Scrotal circumference is widely recognized as one of the most reliable and easily measurable indicators of testicular function and sperm-producing ability. Bucks possessing larger testes generally have greater spermatogenic tissue mass, resulting in enhanced sperm production and superior semen quality. Similar observations have been reported by Kabiraj *et al.* (2011) [11], who found significant positive associations between scrotal circumference, testicular dimensions and semen quality traits in Black Bengal bucks. Bongso *et al.* (1982) [26] also reported positive relationships between scrotal dimensions and sperm output. Kumbhar *et al.* (2019) [13] observed that testicular length, testicular width

and scrotal circumference were positively associated with sperm concentration, live sperm count and mass activity in Osmanabadi bucks. More recently, Alam *et al.* (2024) [2] and Samir *et al.* (2024) [23] reported significant relationships between testicular biometry and semen quality parameters in goat bucks, suggesting that testicular measurements can be effectively used as indicators of breeding soundness and reproductive performance. The significant positive association between testicular volume and mass motility observed in the present study further supports the hypothesis that larger testes contribute to improved sperm production and sperm functionality.

The correlations between seminal plasma biochemical constituents (albumin, total protein, cholesterol and triglycerides) and seminal attributes are presented in Table 2. In Group I bucks, albumin exhibited a moderate positive correlation with semen volume ($r = 0.426$), whereas cholesterol showed positive associations with sperm concentration ($r = 0.326$) and sperm viability ($r = 0.254$). Total protein and triglycerides displayed weak relationships with most seminal attributes. Similarly, in Group II bucks, albumin, total protein, cholesterol and triglycerides demonstrated weak to moderate correlations with semen volume, mass motility, sperm concentration and sperm viability. None of these associations were statistically significant.

Seminal plasma proteins are known to play essential roles in sperm metabolism, transport, capacitation, membrane stabilization and fertilization. Albumin acts as an antioxidant and membrane-protective molecule that helps maintain sperm viability during storage and transport through the female reproductive tract. Total protein concentration in seminal plasma reflects secretory activity of the accessory sex glands and contributes to sperm nourishment and protection. Cholesterol is a major constituent of the sperm plasma membrane and regulates membrane fluidity, stability and capacitation processes. Triglycerides serve as an indirect source of energy for sperm metabolism. Therefore, even though correlations observed in the present study were weak to moderate, these biochemical constituents remain physiologically important for maintaining sperm functionality.

The findings of the present study are in agreement with Umar *et al.* (2018) [24], who reported positive associations between seminal plasma biochemical constituents and semen quality in Teddy goat bucks. Malik *et al.* (2018) [14] also reported relationships between biochemical constituents of seminal plasma and physical characteristics of Damani buck semen. Arruda-Alencar *et al.* (2012) [3] emphasized the importance of seminal plasma proteins in regulating sperm function and fertility, while Caballero *et al.* (2012) [7] described seminal plasma proteins as important modulators of sperm function and reproductive performance. Similarly, Juyena and Stelletta (2012) [10] reported that seminal plasma proteins contribute significantly to sperm membrane integrity and sperm survival. The absence of strong correlations in the present investigation may indicate that seminal plasma protein fractions influence sperm quality through complex biochemical interactions rather than direct linear relationships.

The correlation coefficients between seminal plasma mineral constituents and seminal attributes are presented in Table 3. In Group I bucks, sodium exhibited a significant positive correlation with mass motility ($r = 0.465$; $p < 0.05$),

while chloride showed a highly significant positive correlation with sperm concentration ($r = 0.717$; $p < 0.01$). Potassium displayed a negative association with sperm viability ($r = -0.394$), whereas phosphorus showed a moderate positive correlation with sperm concentration ($r = 0.331$). Calcium exhibited weak positive correlations with semen volume and sperm concentration.

In Group II bucks, potassium demonstrated a highly significant negative correlation with semen volume ($r = -0.456$; $p < 0.01$) and a significant negative correlation with sperm concentration ($r = -0.317$; $p < 0.05$). Sodium showed weak positive associations with all seminal characteristics, while chloride, calcium and phosphorus exhibited weak correlations with semen volume, mass motility, sperm concentration and sperm viability.

Mineral constituents of seminal plasma are indispensable for maintaining sperm metabolism, membrane integrity, osmotic balance and fertilizing capacity. Sodium and potassium ions are involved in regulating membrane potential and ion transport mechanisms that influence sperm motility. Calcium is particularly important for sperm capacitation, hyperactivation and acrosome reaction, whereas phosphorus contributes to cellular energy metabolism through ATP production. Chloride ions play a significant role in maintaining osmotic equilibrium and membrane stability within sperm cells.

The positive association between sodium concentration and mass motility observed in the present study is consistent with the findings of Umar *et al.* (2018) [24], who reported favourable relationships between seminal plasma mineral constituents and sperm motility in Teddy goat bucks. Similar observations were reported by Pesch *et al.* (2006) [20], who demonstrated significant associations between seminal plasma macro-mineral concentrations and semen quality traits. Massanyi *et al.* (2008) [17] also observed relationships between seminal plasma electrolytes and sperm characteristics. Abdel-Rahman *et al.* (2000) [1] reported that potassium and calcium concentrations were

positively associated with sperm viability and several seminal characteristics, emphasizing the importance of mineral balance for optimal sperm function. Furthermore, Mann and Lutwak-Mann (1981) [15] described seminal plasma minerals as essential regulators of sperm physiology and fertilization potential.

The highly significant positive association between chloride concentration and sperm concentration observed in Group I bucks suggests that chloride ions may contribute to maintaining an optimal environment for sperm production and survival. On the other hand, the significant negative relationship of potassium with semen volume and sperm concentration in Group II bucks may indicate that elevated potassium concentrations could adversely affect certain seminal characteristics. Similar variability in potassium associations has been reported previously by Abdel-Rahman *et al.* (2000) [1], Pesch *et al.* (2006) [20] and Massanyi *et al.* (2008) [17], and may be influenced by breed differences, physiological status, nutritional factors and secretory activity of the accessory reproductive glands.

The present investigation demonstrates that testicular biometry and seminal plasma biochemical composition are closely associated with reproductive performance in Barbari bucks. Among the testicular measurements, testicular volume emerged as the most important parameter due to its significant positive relationship with mass motility. Among seminal plasma constituents, sodium and chloride showed favourable associations with semen quality traits, whereas excessive potassium concentration was negatively associated with semen volume and sperm concentration. These findings suggest that testicular biometric traits together with seminal plasma biochemical markers can serve as useful indicators of breeding soundness and reproductive potential in Barbari bucks. Therefore, their incorporation into routine breeding soundness evaluation programmes may assist in the identification and selection of superior breeding males for genetic improvement and enhanced reproductive efficiency.

Table 1: Correlation coefficient between testicular biometry (Length, Width and Thickness) with seminal attributes (volume, concentration, mass motility and viability) in the fresh ejaculates of Barbari bucks

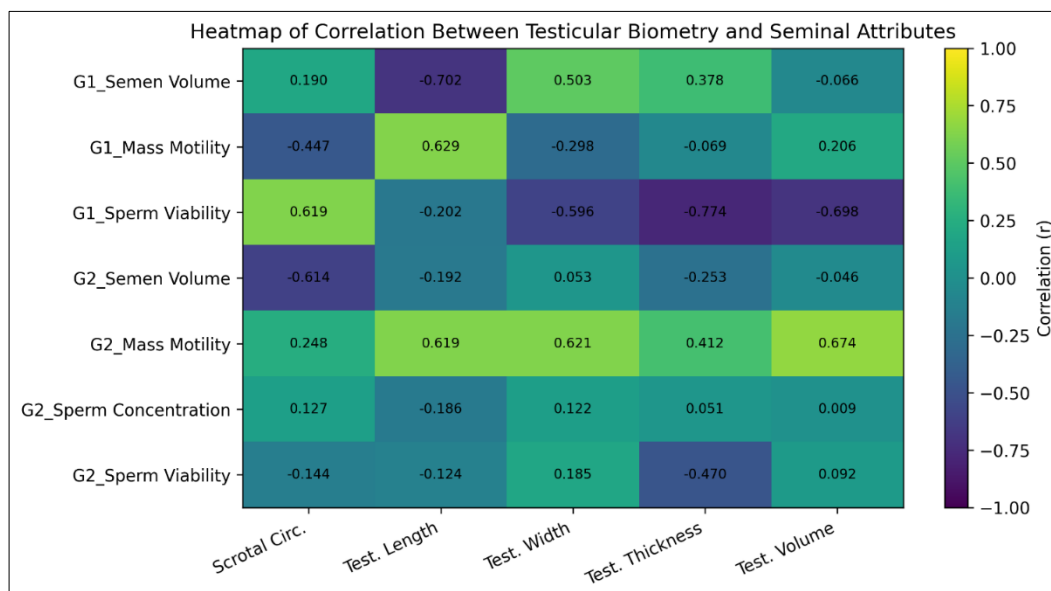
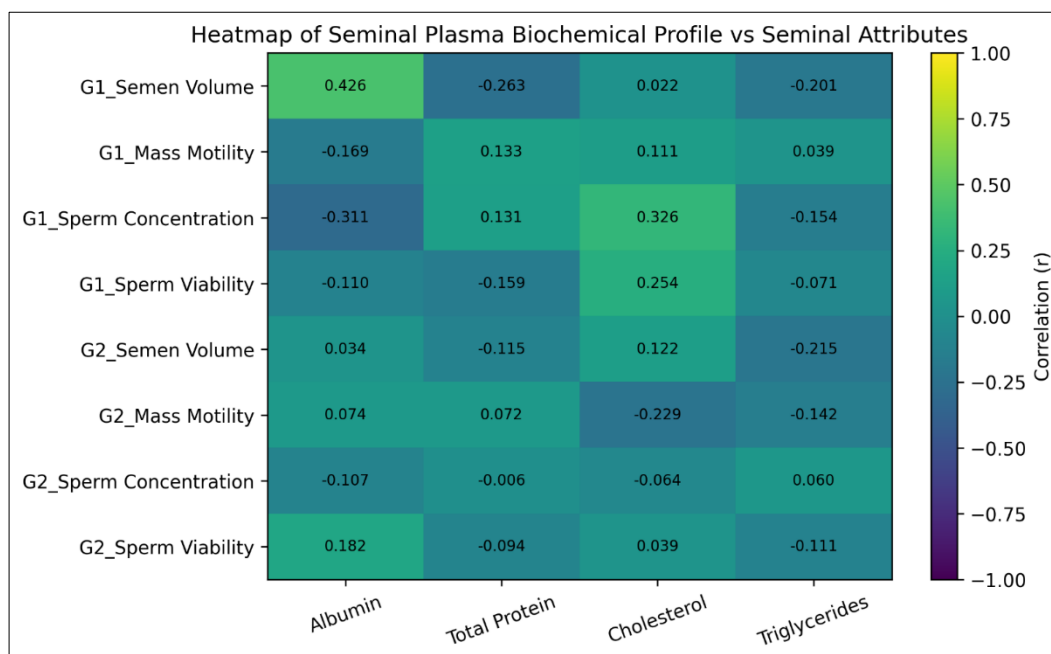
Group (SC range in cm)	Seminal attributes	Scrotal circumference	Testicular length	Testicular width	Testicular thickness	Testicular volume
Group I (20-25 cm)	Semen Volume	0.190	-0.702	0.503	0.378	-0.066
	Mass Motility	-0.447	0.629	-0.298	-0.069	0.206
	Sperm Concentration					
	Sperm Viability	0.619	-0.202	-0.596	-0.774	-0.698
Group II (>25 - 31 cm)	Semen Volume	-0.614	-0.192	0.053	-0.253	-0.046
	Mass Motility	0.248	0.619	0.621	0.412	0.674*
	Sperm Concentration	0.127	-0.186	0.122	0.051	0.009
	Sperm Viability	-0.144	-0.124	0.185	-0.470	0.092

Table 2: Correlation coefficient between seminal attributes with seminal plasma biochemical profile (albumin, total proteins cholesterol and triglycerides) in the fresh ejaculates of Barbari bucks

Group (SC range in cm)	Seminal attributes	Albumin (mg/dl)	Total protein (mg/dl)	Cholesterol (mg/dl)	Triglycerides (mg/dl)
Group I (20-25 cm)	Semen Volume	0.426	-0.263	0.022	-0.201
	Mass Motility	-0.169	0.133	0.111	0.039
	Sperm Concentration	-0.311	0.131	0.326	-0.154
	Sperm Viability	-0.110	-0.159	0.254	-0.071
Group II (>25 - 31 cm)	Semen Volume	0.034	-0.115	0.122	-0.215
	Mass Motility	0.074	0.072	-0.229	-0.142
	Sperm Concentration	-0.107	-0.006	-0.064	0.060
	Sperm Viability	0.182	-0.094	0.039	-0.111

Table 3: Correlation coefficient between seminal attributes with seminal plasma biochemical profile (sodium, potassium, chloride, calcium and phosphorus) in the fresh ejaculates of Barbari bucks

Group (SC range in cm)	Seminal attributes	Sodium (mmol/l)	Potassium (mmol/l)	Chloride (mmol/l)	Calcium (mg/dl)	Phosphorus (mg/dl)
Group I (20-25 cm)	Semen Volume (ml)	-0.332	0.107	0.083	0.068	-0.334
	Mass Motility (0-5 scale)	0.465*	-0.022	-0.025	-0.160	-0.256
	Sperm Concentration (million/ ml)	0.202	0.014	0.717**	0.245	0.331
	Sperm Viability (%)	0.035	-0.394	0.240	0.059	-0.028
Group II (>25 - 31 cm)	Semen Volume	0.031	-0.456**	-0.091	0.187	0.035
	Mass Motility	0.261	-0.242	0.056	-0.054	0.130
	Sperm Concentration	0.194	-0.317*	-0.117	-0.008	-0.204
	Sperm Viability	0.155	-0.104	-0.024	-0.075	0.041

**Fig 4:** Heatmap of Correlation Between Testicular Biometry and Seminal Attributes**Fig 5:** Heatmap of Seminal Plasma Biochemical Profile vs Seminal Attributes

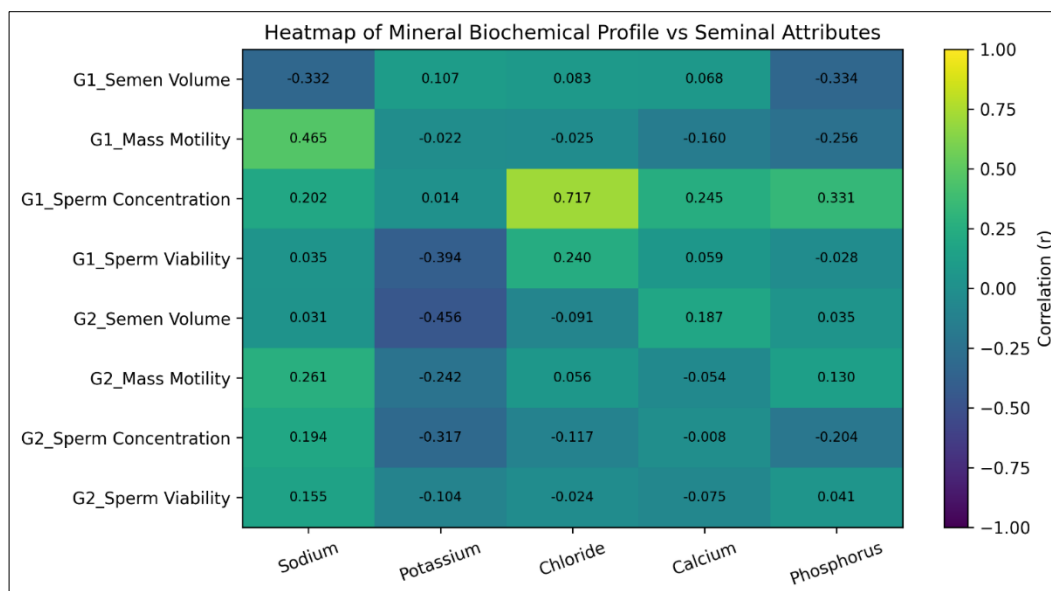


Fig 6: Heatmap of Mineral Biochemical Profile vs Seminal Attributes

Conclusion

The present study demonstrated that testicular biometric traits and seminal plasma biochemical constituents are closely associated with semen quality in Barbari bucks. Among the biometric parameters, testicular volume emerged as the most reliable indicator of reproductive performance owing to its significant positive association with mass motility. Sodium and chloride concentrations showed favourable relationships with key seminal attributes, whereas elevated potassium levels were negatively associated with semen volume and sperm concentration. These findings highlight the potential of integrating testicular biometry and seminal plasma biochemical profiling into breeding soundness evaluation programmes for the identification and selection of superior breeding bucks, thereby contributing to enhanced reproductive efficiency and genetic improvement in goat production systems.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this study.

Acknowledgements

The authors express their sincere gratitude to the faculty and technical staff of the College of Veterinary Science and Animal Husbandry, U.P. Pandit Deendayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan (DUVASU), Mathura, Uttar Pradesh, India, for providing the facilities and support required to carry out this research.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethical approval

This study was approved by the Institute Animal Ethics Committee, College of Veterinary Science and Animal Husbandry, U.P. Pandit Deendayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan

Sansthan (DUVASU), Mathura, Uttar Pradesh, India (Approval No.: IAEC/24/1/5).

References

1. Abdel-Rahman HA, El-Belely MS, Al-Qarawi AA, El-Mougy SA. The relationship between semen quality and mineral composition of semen in various ram breeds. *Small Ruminant Research*. 2000;38(1):45-49.
2. Alam K, Srivastava S, Kumar R, Verma AK, Verma SK, Jaiswal A, *et al*. Testicular biometry and its relationship with body weight and semen parameters of Sirohi and Jamnapari bucks. *Indian Journal of Animal Reproduction*. 2024;45(1):29-34.
3. Arruda-Alencar JM, Viana-Neto AM, Souza CE, Martins JAM, Moreno FB, Moreira ACOM, *et al*. Major proteins of the seminal plasma of New Zealand White rabbits and association with semen criteria. In: *Proceedings of the 10th World Rabbit Congress*; 2012; Sharm El-Sheikh, Egypt. p. 395-399.
4. Bailey TL, Monke D, Hudson RS, Wolfe DF, Carson RL, Riddell MG. Testicular shape and its relationship to sperm production in mature Holstein bulls. *Theriogenology*. 1998;50(6):881-887.
5. Ball L, Ott RS, Mortimer RG, Simons JC. *Manual for Breeding Soundness Examination of Bulls*. Fort Collins (CO): Society for Theriogenology, Colorado State University; 1983.
6. Bongso TA, Jainudeen MR, Zahrah AS. Relationship of scrotal circumference to age, body weight and onset of spermatogenesis in goats. *Theriogenology*. 1982;18(5):513-524.
7. Caballero I, Parrilla I, Almiñana C, Del Olmo D, Roca J, Martínez EA, *et al*. Seminal plasma proteins as modulators of sperm function and their application in sperm biotechnologies. *Reproduction in Domestic Animals*. 2012;47(Suppl 3):12-21.
8. Elmaz Ö, Dikmen S, Cirit Ü, Demir H. Prediction of postpubertal reproductive potential according to prepubertal body weight, testicular size, and testosterone concentration using multiple regression analysis in Kivircik ram lambs. *Turkish Journal of Veterinary and Animal Sciences*. 2008;32(5):335-343.

9. IBM Corp. IBM SPSS Statistics for Windows, Version 28.0. Armonk (NY): IBM Corp.; 2021.
10. Juyena NS, Stelletta C. Seminal plasma: an essential attribute to spermatozoa. *Journal of Andrology*. 2012;33(4):536-551.
11. Kabiraj SK, Hoque SM, Khandoker MA, Husain SS. Testicular biometry and its relationship with body weight and semen output of Black Bengal bucks in Bangladesh. *Journal of Cell and Animal Biology*. 2011;5(2):27-32.
12. Katz LS. Sexual behaviour of domesticated ruminants. *Hormones and Behavior*. 2007;52(1):56-63.
13. Kumbhar UB, Gulavane SU, Gaikwad SM, Shelar RR, Deshpande VP, Rebeiro R, *et al.* Correlation of testicular ultrasonography, testicular biometry, serum testosterone levels and seminal attributes in pre- and post-pubertal age for breeding soundness evaluation in Osmanabadi bucks. *Tropical Animal Health and Production*. 2019;51(6):1467-1480.
14. Malik MI, Jamil H, Qureshi ZI, Mehfooz A, Rizvi SN, Ullah S, *et al.* Investigation on the relationship of hormonal profile and biochemical constituents of seminal plasma with physical characteristics of Damani buck semen. *Pure and Applied Biology*. 2018;7(2):684-691.
15. Mann T, Lutwak-Mann C. Male Reproductive Function and Semen: Themes and Trends in Physiology, Biochemistry and Investigative Andrology. Berlin: Springer-Verlag; 1981.
16. Maroto-Morales A, García-Álvarez O, Ramón M, Martínez-Pastor F, Fernández-Santos MR, Soler AJ, *et al.* Current status and potential of morphometric sperm analysis. *Asian Journal of Andrology*. 2016;18(6):863-870.
17. Massanyi P, Weis J, Lukac N, Trandzik J, Bystricka J. Cadmium, zinc, copper, sodium, and potassium concentrations in rooster and turkey semen and their correlation. *Journal of Environmental Science and Health Part A*. 2008;43(6):563-565.
18. Ngoma L, Kambulu L, Mwanza M. Factors influencing goat semen fertility and storage: a literature review. *Journal of Human Ecology*. 2016;56(1-2):114-125.
19. Pant HC, Sharma RK, Patel SH, Shukla HR, Mittal AK, Kasiraj R, *et al.* Testicular development and its relationship to semen production in Murrah buffalo bulls. *Theriogenology*. 2003;60(1):27-34.
20. Pesch S, Bergmann M, Bostedt H. Determination of some enzymes and macro- and microelements in stallion seminal plasma and their correlations to semen quality. *Theriogenology*. 2006;66(2):307-313.
21. Raji AO, Igwebuike JU, Aliyu J. Testicular biometry and its relationship with body weight of indigenous goats in a semi-arid region of Nigeria. *ARP Journal of Agricultural and Biological Science*. 2008;3(4):6-9.
22. Ridler AL, Smith SL, West DM. Ram and buck management. *Animal Reproduction Science*. 2012;130(3-4):180-183.
23. Samir I, Ali F, Mohamed R, Yousef N, Elsebaey A, Ibrahim RM, *et al.* Testicular biometry, spermogram, and biochemical parameters in male goats. *Egyptian Journal of Veterinary Sciences*. 2024;55(3):671-679.
24. Umar S, Ahmad M, Ahmad I, Zubair M, Umar Z, Qureshi AS, *et al.* Correlation of biochemical constituents of seminal plasma with semen quality in

Teddy goat (*Capra hircus*) bucks. *Andrologia*. 2018;50(3).

Author Names and Affiliations

Amrita Priyadershi

Department of Veterinary Gynaecology and Obstetrics, College of Veterinary Science and Animal Husbandry, U.P. Pandit Deendayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan (DUVASU), Mathura, Uttar Pradesh, India.

Anuj Kumar

Department of Veterinary Gynaecology and Obstetrics, College of Veterinary Science and Animal Husbandry, U.P. Pandit Deendayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan (DUVASU), Mathura, Uttar Pradesh, India.

Mukul Anand

Department of Veterinary Physiology, College of Veterinary Science and Animal Husbandry, U.P. Pandit Deendayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan (DUVASU), Mathura, Uttar Pradesh, India

Pratyanshu Srivastava

Department of Veterinary Gynaecology and Obstetrics, College of Veterinary Science and Animal Husbandry, U.P. Pandit Deendayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan (DUVASU), Mathura, Uttar Pradesh, India.

Anoop Kumar

Department of Veterinary Gynaecology and Obstetrics, College of Veterinary Science and Animal Husbandry, U.P. Pandit Deendayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan (DUVASU), Mathura, Uttar Pradesh, India.

Ashutosh Mishra

Department of Veterinary Gynaecology and Obstetrics, College of Veterinary Science and Animal Husbandry, U.P. Pandit Deendayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan (DUVASU), Mathura, Uttar Pradesh, India.

Nagendra Singh

Department of Veterinary Gynaecology and Obstetrics, College of Veterinary Science and Animal Husbandry, U.P. Pandit Deendayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan (DUVASU), Mathura, Uttar Pradesh, India.

Jitendra Agarwal

Department of Veterinary Gynaecology and Obstetrics, College of Veterinary Science and Animal Husbandry, U.P. Pandit Deendayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan (DUVASU), Mathura, Uttar Pradesh, India.

Atul Saxena

Department of Veterinary Gynaecology and Obstetrics, College of Veterinary Science and Animal Husbandry, U.P. Pandit Deendayal Upadhyaya Pashu Chikitsa Vigyan

Vishwavidyalaya Evam Go Anusandhan Sansthan
(DUVASU), Mathura, Uttar Pradesh, India.

Ravi Dabas

Department of Veterinary Medicine, Guru Angad Dev
Veterinary and Animal Sciences University, Ludhiana,
Punjab, India.