Research Article

Impact of Urea Moringa Molasses Multi-Nutrient Block Supplementation on Liquid Semen Quality and Fertility in Etawah Crossbreed Goats

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Abstract | This research was conducted to assess the quality and fertility of liquid semen from Etawah Crossbreed (EC) goats fed with a urea moringa molasses multi-nutrient block (UMMMB) supplement. Eight male goats were divided into two groups: four received the urea molasses multi-nutrient block (UMMB) as a control, while the other four were given the UMMMB as the treatment. Semen samples were collected weekly from weeks 4 to 8 of the feeding trial. At the same time, 21 adult female goats were artificially inseminated with semen from the control group, and 43 females were inseminated with semen from the treatment group. All did undergo estrus synchronisation using Lutalyse® before insemination. Results showed that sperm motility, viability, and the percentage of sperm with intact plasma membranes in the treatment group were significantly ($p < 0.05$) higher than those in the control group on days 2, 4, and 5 of storage, respectively (45.94% vs. 41.33%; 80.38% vs. 78.44%; and 50.50% vs. 42.25%). Additionally, the conception rate was substantially greater ($p < 0.05$) in the treatment group compared to the control (65% vs. 29%). The study concluded that supplementing EC goats with UMMMB improves the quality and conception rate of their liquid semen during storage at 3–5°C for up to four days.

Keywords | Etawah crossbreed, Liquid semen, *Moringa oleifera*, Multi-nutrient block, Semen quality

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INTRODUCTION

The Etawah Cross-breed (EC) goat is produced by crossing the Etawah (Jamnapari) goat with the Kacang goat. EC goats serve dual purposes, providing both meat and milk, which makes them popular among Indonesian farmers (Handayani *et al.*, 2024; Hariyono and Endrawati, 2023). These goats are capable of giving birth three times within two years, with each lactation period lasting 4-6 months and a dry period of 2-3 months, achieved by implementing a breeding program every eight months. Optimal reproductive performance, such as this, can be supported by effective reproductive management practices, including the use of artificial insemination technology.

Providing high-quality semen is essential for the success of artificial insemination programs. Liquid semen technology serves as an alternative method for semen supply and storage, especially to address the shortage of frozen semen in rural regions. Semen can be refrigerated at temperatures between 3-5°C, maintaining sperm viability for 2-4 days (Yang *et al*., 2018), making it a more practical, faster, and cost-effective option compared to frozen semen, which requires the use of liquid nitrogen. A major challenge in semen preservation is the reduction in sperm quality caused by free radicals (Rizal *et al*., 2025) and Reactive Oxygen Species (ROS) (Liang *et al*., 2023), which can damage sperm membranes, proteins, and nucleic acids, ultimately leading to sperm death.

The quality of semen during storage can be preserved by providing nutritious feed ingredients, such as moringa leaves. These leaves are rich in a wide range of essential nutrients, including protein, fat, calcium, magnesium, potassium, selenium, vitamin C, vitamin E, and polyphenolic compounds (Gangwar *et al*., 2024), all of which play a vital role in maintaining sperm viability. Additionally, moringa leaves contain phenolic compounds like flavonoids (Syarifuddin *et al*., 2025), which help reduce sperm damage during semen processing and enhance sperm fertility (Shah *et al*., 2022).

The use of moringa leaves as a feed supplement in the form of Moringa Multinutrient Block (MMNB) was developed by Alfian *et al*. (2025) and is well-suited for implementation by farmers in rural communities. Research by Syarifuddin *et al*. (2022) demonstrated that supplementing with Urea Moringa Molasses Multi-nutrient Block (UMMMB) enhances libido (including mounting and ejaculation), total sperm motility, and viability in male Etawah Crossbreed (EC) goats. Building on these findings, this study aims to assess the quality and fertility of liquid semen from EC goats fed with UMMMB supplements. The expected outcome is to offer goat farmers in rural areas an alternative source of high-quality liquid semen.

MATERIALS AND METHODS

Experimental design and ethical approval

This research involved eight Etawah Cross (EC) bucks with an average age of 36.72 ± 1.06 months and an average body weight of 54 ± 2.97 kg, sourced from the Pelaihari Breeding Centre. In addition, 64 adult female goats (does) belonging to the Rukun Jaya Makmur Farmer Group in Landasan Ulin District, Banjarbaru City, South Kalimantan Province, were included. The selected does were clinically healthy, aged 18–24 months, exhibited regular estrous cycles, and had previously given birth at least once.

The independent variable was the type of dietary supplementation (UMMB vs. UMMMB), while the dependent variables were fresh semen characteristics, liquid semen longevity, and conception rate. The number of experimental animals was determined based on previous studies with similar designs (Syarifuddin *et al*., 2025), ensuring sufficient statistical power to detect treatment differences.

All experimental procedures complied with ethical standards and were approved by the Animal Ethics Committee of the Faculty of Agriculture, University of Lambung Mangkurat (Approval No.:017/UN8.1.23.5/PG/2025) and adhered to Indonesian animal welfare guidelines.

Animals, feeding, and management

The bucks were housed individually in stage cages (1.25 m × 1.00 m, elevated 1 m above the ground) for eight weeks. Diets were formulated to meet the standard nutritional requirements for male goats, with fresh native grass provided as the basal diet and unlimited access to drinking water.

Four bucks were randomly assigned to receive native grass plus a 200 g block of UMMB (control), while the other four bucks received native grass plus a 200 g block of UMMMB (treatment). The feed block was offered first and forage was provided only after complete consumption of the block. The formulation of UMMB and UMMMB followed Syarifuddin *et al*. (2025), and their chemical composition, together with that of the native grass, is presented in Tables 1 and 2.

Table 1: Compositions of the multinutrient block used as supplements.

Feed ingredients (%)	UMMB (Control)	UMMMB (Treatments)
Moringa leaf powder	-	30
Palm kernel meal	25	-
Concentrate Laying Ducks (CP144®)	5	-
Fine rice bran	33	33
Molasses	20	20
Limestone	5	5
Common Salt	5	5
Urea (46% N)	5	5
Mineral Mix	2	2
Total	100	100

UMMB: Urea molasses multi-nutrient block; UMMMB: Urea moringa molasses multi-nutrient block.

Semen collection and evaluation

Semen was collected weekly during weeks 4–8 using an artificial vagina (AV) between 07:00 and 10:00 AM prior to feeding. Ejaculates were first evaluated macroscopically (volume, color, consistency), and subsequently examined microscopically for sperm concentration, motility, viability, and morphology. Concentration was determined using a hemocytometer.

Table 2: Nutrient Content of Native Grass, UMMB, and UMMMB (as % DM*).

Nutrient composition (%)	Native grass	UMMB	UMMMB
Dry matter	30.77	60.11	59.62
Ash	11.92	12.18	11.40
Crude Protein	10.79	19.75	21.41
Crude Fiber	31.52	3.11	2.59
Ether Extract	0.62	2.82	2.51
Calcium (Ca)	0.78	3.61	3.78
Phosphorus (P)	0.44	2.05	2.81
Nitrogen Free Extract	45.15	64.34	62.09
TDN (calculated)	55.38	83.44	83.14

Note: * Values were obtained from analysis conducted by Laboratory of Nutrition and Animal Feedstuff, Animal Science Department, Faculty of Agriculture, University of Lambung Mangkurat. UMMB: Urea molasses multi-nutrient block; UMMMB: Urea moringa molasses multi-nutrient block.

Motility was assessed subjectively under a phase-contrast microscope at 400× magnification, with ≥200 sperm observed per sample. Viability was evaluated using eosin–nigrosin staining. Abnormalities were determined from 200 spermatozoa per smear (Diansyah *et al*., 2025a).

Processing of liquid semen and quality evaluation

In week 8, ejaculates meeting the quality threshold (≥70% motility, ≥2 ml volume) were diluted with Andromed® extender. The diluent was prepared by mixing 5 ml of Andromed® with 20 ml of distilled water (1:4 ratio), homogenized, and equilibrated in a water bath at 38°C prior to use (Diansyah *et al*., 2025b). Semen was diluted to a final concentration of 100×10^6 sperm/ml and stored at 3–5 °C.

Sperm quality parameters (motility, viability, and plasma membrane integrity by hypo-osmotic swelling test) were assessed at 30 minutes post-dilution (day 0) and at 24-hour intervals for five consecutive days (Nirmala *et al*., 2025).

Artificial insemination (AI) and conception rate

Estrus synchronization was performed twice in all does using Lutalyse® (11-day interval). Does showing estrus 72 hours after the second injection were inseminated intracervically with 0.25 ml mini-straws containing liquid semen collected on day 0 (week 8) from UMMB- or UMMMB-supplemented bucks.

In total, 21 does were inseminated with semen from UMMB-fed bucks and 43 does with semen from UMMMB-fed bucks. Pregnancy was determined by the absence of estrus over two consecutive cycles and subsequently confirmed by birth data, following standard field practice. All 64 does underwent the same synchronization protocol without any superovulation treatment; therefore, the difference in the number of inseminated does (21 vs. 43) resulted solely from variation in estrus response after synchronization rather than from experimental manipulation**.** The conception rate was analyzed using a chi-square test, which appropriately accommodates unequal group sizes, and therefore the comparison remained statistically valid despite the unequal number of does.

Statistical analysis

All quantitative data (fresh and liquid semen traits) were expressed as mean ± standard error (SE). A repeated-measures ANOVA was applied to evaluate semen longevity across storage days, with treatment (UMMB vs. UMMMB) as a fixed factor and time as a repeated measure. Independent-sample t-tests were used for fresh semen characteristics. Conception rate (%) was analyzed by chi-square test. All analyses were conducted using SPSS® version 26 (IBM Corp., Armonk, NY, USA). A p-value < 0.05 was considered statistically significant.

Although mixed-effects models could provide a more detailed representation of hierarchical data structures (e.g., repeated ejaculates within bucks and conception outcomes nested by sire), the limited number of experimental animals restricted the use of such complex models. Therefore, the present analysis focused on fixed treatment effects using repeated-measures ANOVA, which remains appropriate for the dataset and study objectives.

RESULT AND DISCUSSION

Fresh semen quality

Bucks supplemented with UMMMB exhibited significantly higher sperm motility and viability compared with UMMB-fed bucks ($p < 0.05$; Table 3, Figure 1). All semen quality traits from both groups remained within the acceptable limits defined by the Indonesian National Standard (SNI 4869-3:2023), confirming their suitability for further processing into liquid semen. However, semen characteristics can vary among individual bucks, and the small sample size ($n = 4$ per group) may contribute to part of the observed variation thus, random allocation was used to minimize potential bias arising from pre-existing individual variation. The observed improvement in motility and

Table 3: The fresh semen quality traits of Etawah Crossbreed (EC) bucks.

Semen quality traits	UMMB (Control)	UMMMB (Treatment)	p-Value	References#
	(Mean ± SEM)			
Volume (ml)	0.94 ± 0.07	1.01 ± 0.07	0.45	1.0 (0.5 – 1.2)[1]
Consistency	Medium to Thick	Thick	-	Medium to Thick[2]
pH	6.6 ± 0.07	6.7 ± 0.12	0.43	5.9 – 7.3[3]
Mass Movement	++ (30%), +++ (70%)	+++ (100%)	-	++ to +++[2]
Sperm Motility (%)	73.75 ± 1.25[a]	79.29 ± 1.25[b]	0.04	60 – 80[3]
Concentration (×10^6/ml)	3.070 ± 35.38	3.470 ± 39.41	0.52	250 – 500[4]
Viability (%)	81.48 ± 1.02[a]	85.92 ± 0.77[b]	0.00	60 – 80[4]
Abnormality (%)	5.61 ± 0.56	5.41 ± 0.36	0.71	5 – 20[3]
Intact Plasma Membrane (%)	87.00±1.11	88.94±0.63	0.14	≥60[5]

Note: [ab] Mean in the same row without common letters are different at p<0.05. #Reported range of values for semen of EC bucks: [1]Syarifuddin *et al.*, 2025, [2]Susilawati, 2011, [3]Garner and Hafez, 2000, [4]Ax *et al.*, 2000, [5]Saratsi *et al.*, 2023. UMMB: Urea molasses multi-nutrient block; UMMMB: Urea moringa molasses multi-nutrient block.

viability among UMMMB-fed bucks may reflect enhanced nutrient intake and antioxidant activity, which supports spermatogenesis and protects spermatozoa against oxidative stress. Similar findings have been reported in small ruminants supplemented with phytogenic or plant-based feed additives that improved semen traits through antioxidant and metabolic pathways (Yusuf *et al.*, 2026; Nurlatifah *et al.*, 2025a).

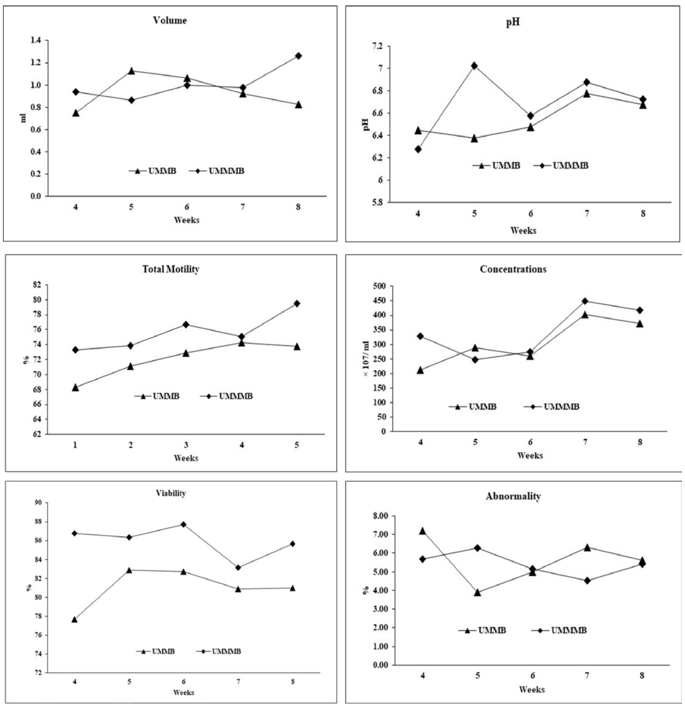

Figure 1: Weekly fresh semen quality of Etawah Crossbreed bucks fed UMMB and UMMMB from weeks 4 to 8.

Liquid semen quality

Sperm motility and viability declined progressively during cold storage (p < 0.05; Table 4). According to the Indonesian National Standard (SNI 4869-3:2023), semen should maintain a minimum motility of 40% during storage. Semen from UMMMB-fed bucks retained motility above the minimum threshold of 40% until day 4, whereas semen from UMMB-fed bucks fell below this limit earlier. Viability followed a similar pattern, with UMMMB maintaining values >50% up to day 4, which is considered the minimum requirement for AI (Kumar *et al.*, 2024). Plasma membrane integrity also remained higher in UMMMB semen (61.06% on day 4) compared with UMMB (59.67%), indicating better tolerance to cold storage. According to Rahayu *et al.* (2025), intact membrane integrity above 60% is essential for AI success, suggesting that UMMMB-fed bucks provided semen of superior preservability.

The superior performance of the UMMMB group can be attributed to the inclusion of *Moringa oleifera* leaf meal, which is rich in bioactive antioxidants such as flavonoids, polyphenols, vitamin E, and selenium (Alfian *et al.*, 2025). These compounds neutralize reactive oxygen species (ROS) generated during semen storage, thus protecting sperm membranes from lipid peroxidation and maintaining mitochondrial energy production. The block matrix facilitates a slow and steady nutrient release, improving nutrient utilization and antioxidant defense over time. This physiological mechanism explains why UMMMB-fed bucks produced semen with higher motility, viability, and membrane integrity during cold preservation (Syarifuddin *et al.*, 2025).

The progressive decline in motility and viability is consistent with previous reports attributing storage-related deterioration to lactic acid accumulation, pH reduction, and membrane destabilization under cold temperatures (Ibáñez-Arancibia *et al.*, 2021; Mohajer *et al.*, 2024). Membrane lipid phase transitions impair permeability and ATP synthesis, leading to loss of viability (Iqbal *et al.*, 2022).

Table 4: The sperm motility, viability, and intact plasma membrane of liquid semen stored for 5 days at 3-5 °C.

Semen quality	Day 1	Day 2	Day 3	Day 4	Day 5	References#
	Means ± SEM					
Sperm motility (%)						
UMMB	72.86±1.07[a]	67.81±0.64	59.67±1.65	41.33±0.91[a]	23.33±1.98	>40[1]
UMMMB)	78.75±1.11[b]	69.06±0.50	62.50±0.79	45.94±1.84[b]	29.17±2.53	
p-Value	0.03	0.14	0.13	0.04	0.08	
Viability (%)						
UMMB	81.03±0.85[a]	78.44±0.56[a]	62.50±0.79	55.33±1.33	39.67±1.69	>50[2]
UMMMB)	85.48±1.19[b]	80.38±0.54[b]	69.67±1.65	59.63±1.76	45.58±2.40	
p-Value	0.03	0.02	0.12	0.06	0.06	
Intact plasma membrane (%)						
UMMB	83.25±0.85	79.88±1.34	68.80±1.22	59.67±1.50	42.25±1.05[a]	≥ 60%[3]
UMMMB)	86.00±0.91	80.44±0.97	71.19±0.98	61.06±1.65	50.50±1.57[b]	
p-Value	0.14	0.74	0.13	0.54	0.00	

Note: [ab] Mean in the same column without common letters are different at p<0.05. # Reported range of values for semen of EC bucks: [1]Syarifuddin *et al*., 2025, [2]Ax *et al*., 2000, [3]Revell and Mrode, 1994. UMMB: Urea molasses multi-nutrient block; UMMMB: Urea moringa molasses multi-nutrient block.

Table 5: The conception rate of the does inseminated with liquid semen from bucks supplemented with UMMB and UMMMB.

Treatment	Number of acceptors (head)	Pregnant (head)	Not pregnant (head)	Conception rate (%)	References#
UMMB	21	6	15	28.57[a]	50 – 80%[1]
UMMMB	43	28	15	65.12[b]	

Note: [ab] Mean in the same column without common letters are different at p<0.05. # Reported range of values for semen of EC bucks: [1]Nurlatifah *et al*., 2025b. UMMB: Urea molasses multi-nutrient block; UMMMB: Urea moringa molasses multi-nutrient block.

However, the higher baseline semen quality in UMMMB-fed bucks appears to confer greater resilience against cold stress. Recent studies confirm that dietary antioxidants and phytogenic compounds can stabilize sperm membranes during preservation, thereby extending functional lifespan of spermatozoa (Song *et al*., 2025; Nurlatifah *et al*., 2025a).

Fertility of liquid semen

Artificial insemination with liquid semen collected from UMMMB-fed bucks yielded significantly higher conception rates compared with UMMB-fed bucks (65.12% vs. 28.57%, $p < 0.05$; Table 5). The conception rate achieved with UMMMB supplementation falls within the standard range for goat AI (50–80%) (Suyadi *et al*., 2021), whereas UMMB semen produced substandard fertility outcomes. A total of 21 does were inseminated with semen from bucks fed UMMB and 23 does with semen from bucks fed UMMMB, resulting in an unbalanced distribution between groups due to the field availability of synchronized females rather than selection bias. Conception rates were based on semen collected from four bucks per group, and although random allocation of does was applied to minimize bias, the potential influence of individual "buck effect" could not be entirely excluded. While the chi-square test used accommodates unequal sample sizes, slight variations in statistical precision may occur; however, the marked difference in conception rates still indicates a clear biological advantage of UMMMB supplementation. This improvement in conception is likely attributable to the higher motility, viability, and membrane integrity observed in UMMMB semen, all of which are critical determinants of fertilizing capacity (Bianchi and Wright, 2016; Shan *et al*., 2021). Sperm motility, in particular, is strongly correlated with fertilization success (Tanga *et al*., 2021; Pardede *et al*., 2020; Diansyah *et al*., 2025c), while plasma membrane integrity ensures proper ionic regulation, capacitation, and oocyte penetration. The superior fertility outcomes in the UMMMB group are therefore consistent with the enhanced semen preservation quality observed in this study.

Overall interpretation

The present findings demonstrate that UMMMB supplementation enhances both fresh and liquid semen quality in Etawah Cross bucks, which in turn translates into higher conception rates under field conditions. These improvements are consistent with reports highlighting the role of dietary bioactive compounds in improving male fertility parameters in small ruminants (Al-Bulushi *et al*., 2019; Nurlatifah *et al*., 2025b). The novelty of this study lies in demonstrating that a modified UMMB formulation can sustain semen quality during storage and improve AI outcomes, offering a practical strategy for goat reproduction programs in tropical environments.

Unlike conventional UMMB formulations that primarily provide energy and nitrogen sources, the modified UMMMB introduces functional phytochemicals from *Moringa oleifera* that improve reproductive performance through antioxidant and metabolic pathways. This methodological improvement demonstrates a practical innovation for on-farm semen quality enhancement in tropical smallholder systems.

CONCLUSION

This study demonstrated that dietary supplementation with UMMMB containing moringa leaf meal significantly improved semen quality and fertility outcomes in Etawah Cross bucks. Bucks receiving UMMMB exhibited higher sperm motility, viability, plasma membrane integrity, and conception rates compared with those fed standard UMMB. These findings highlight the potential of UMMMB as a practical nutritional strategy to enhance semen preservability and artificial insemination success in goats under tropical field conditions. Nevertheless, the limited number of experimental animals and potential variability among individual bucks warrant cautious interpretation of the findings. Further research involving larger populations, repeated experimental cycles, and biochemical profiling of antioxidant and metabolic markers is recommended to validate these results and elucidate the underlying physiological mechanisms.

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NOVELTY STATEMENT

This study demonstrates that dietary supplementation of Etawah Cross bucks with a urea moringa molasses multi-nutrient block (UMMMB) improves fresh semen quality while significantly enhancing the preservability and fertility of liquid semen during cold storage under field conditions. In contrast to conventional UMMB formulations, the inclusion of Moringa oleifera leaf meal supplies functional antioxidant compounds that help maintain sperm motility, viability, and plasma membrane integrity for up to four days at 3–5 °C. These findings provide a practical and scalable nutritional approach to improve artificial insemination success in smallholder goat production systems in tropical regions.

AUTHOR'S CONTRIBUTION

NAS, MR, MR, AW, and HH, conceived and designed the experiment. NAS, MR, MR, and AW performed the experimental procedures. NAS, and MR, supervised and coordinated the research and provided clinical data. Statistical analysis was conducted by AMD, ANC and RR. The initial draft of the manuscript was prepared by NAS, AMD, ANC and RR. All authors critically reviewed and approved the final version of the manuscript.

Generative AI and AI-assisted technology statement

The authors declare that no Generative AI was used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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