

THE EVALUATION OF FROZEN SEMEN PRODUCTION POTENTIAL IN ETAWAH GRADE AND ANGLO-NUBIAN BREEDS

(Evaluasi Potensi Produksi Semen Beku pada Kambing Peranakan Etawah dan Anglo Nubian)

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ABSTRAK

Penelitian ini bertujuan untuk mengevaluasi potensi produksi semen beku pada kambing Peranakan Etawah dan Anglo Nubian berdasarkan karakteristik semen segar serta menilai variasi antar individu dan antar rumpun. Penelitian dilakukan di Balai Inseminasi Buatan Lembang, Kabupaten Bandung Barat, menggunakan data primer dari lima kali ejakulasi per individu serta data sekunder tahun 2024. Evaluasi semen segar meliputi volume semen, motilitas sperma, dan konsentrasi sperma yang mencerminkan jumlah dosis yang dapat dihasilkan per ejakulasi. Potensi produksi semen beku dihitung berdasarkan volume semen, motilitas sperma, dan konsentrasi sperma. Hasil penelitian menunjukkan adanya perbedaan yang sangat nyata ($P < 0,01$) dalam potensi produksi baik antar individu maupun antar rumpun. Potensi produksi tertinggi ditemukan pada pejantan Andromeda ($122,45 \pm 2,07$ dosis), yang secara signifikan lebih tinggi dibandingkan individu lainnya dan rumpun Anglo Nubian menunjukkan potensi produksi yang lebih tinggi ($105,76 \pm 2,54$ dosis) dibandingkan dengan Peranakan Etawah ($91,63 \pm 1,92$ dosis). Pejantan Peranakan Etawah menunjukkan motilitas sperma yang relatif lebih baik. Faktor individu dan rumpun berpengaruh signifikan terhadap potensi produksi semen beku. Kambing Anglo Nubian memiliki kapasitas produksi yang lebih tinggi sedangkan kambing Peranakan Etawah berpotensi memiliki kualitas sperma yang lebih baik. Temuan ini memberikan informasi penting dalam optimalisasi strategi pemuliaan dan perencanaan produksi semen dalam program inseminasi buatan.

Kata-kata kunci: Anglo nubian, karakteristik semen, peranakan etawah, potensi produksi semen beku

ABSTRACT

This study aimed to evaluate the potential of frozen semen production in Etawah Grade and Anglo-Nubian breeds based on fresh semen characteristics and to assess variations among individuals and breeds. The research was conducted at the Lembang Artificial Insemination Center, West Bandung, using primary data from five ejaculations per individual and secondary data from the year 2024. Fresh semen was evaluated for semen volume, sperm motility, and sperm concentration, reflecting the number of straws that can be produced per ejaculation. Frozen semen production potential was calculated based on semen volume, sperm motility, and sperm concentration. The results showed significant differences ($P < 0.01$) in production potential among individuals and between breeds. The highest production potential was observed in the buck named Andromeda (122.45 ± 2.07 straws), which was significantly higher than that of other individuals. Anglo-Nubian breed showed a higher production potential (105.76 ± 2.54 straws) compared to Etawah Grade (91.63 ± 1.92 straws). However, Etawah Grade bucks exhibited relatively better sperm motility. In conclusion, both individual and breed factors significantly influence frozen semen production potential. Anglo-Nubian bucks have higher production capacity, while Etawah Grade bucks may offer better sperm quality.

These findings provide important insights for optimizing breeding strategies and semen production planning in artificial insemination programs.

Keywords: Anglo-nubian, semen characteristics, etawah grade, frozen semen production potential

INTRODUCTION

The artificial insemination (AI) program for goats is one of the strategic approaches to improve reproductive efficiency and expand the genetic distribution of superior males. The AI introduces sperm into the female reproductive tract to facilitate fertilization, thereby enabling the wider use of superior males, improving genetic quality and livestock productivity, and reducing the risk of spreading reproductive diseases (Dhara *et al.*, 2023). The success of AI programs is not only determined by the quality of fresh semen used, but also by the quality of frozen semen produced and by production units' ability to plan sustainable semen production capacity to ensure the availability of straws in insemination programs (Sophian *et al.*, 2025). Therefore, information on the potential production of semen from each male is a key factor in determining the number of males that must be maintained to meet frozen semen production targets.

The potential for frozen semen production is defined as the number of straws of frozen semen that can be produced from a single ejaculation of a buck. This evaluation is an important indicator of the capacity and efficiency of frozen semen production potential in supporting the AI program, as well as the basis for calculating the number of bucks needed to achieve frozen semen production targets. Semen volume, sperm motility, and sperm concentration are the main variables that determine the amount of frozen semen that can be produced from each ejaculate. These semen characteristics can vary between individuals and breeds due to differences in sperm plasma membrane characteristics and physiological functions, including sperm motility (Simsek *et al.*, 2025). These differences in physiological and genetic characteristics can lead to variations in frozen semen production potential between individuals

and breeds. Thus, evaluating the potential for frozen semen production potential between individuals and breeds is an important basis for developing breeding strategies and determining the optimal breeding population structure in semen production units.

The frozen semen production process also needs to consider the fresh semen quality requirements set out in national standards. Based on SNI 4869-3:2023 concerning frozen semen production for goats and sheep, fresh semen to be processed into frozen semen must have a minimum sperm motility of 70% to be suitable for use in frozen semen production for AI (BSN, 2023). Compliance with these standards will affect the utilization rate of ejaculates and the efficiency of converting fresh semen into frozen semen. Therefore, evaluating the potential for frozen semen production can determine the actual capacity in a standardized production system.

Etawah Grade and Anglo-Nubian bucks are breeds widely developed in Indonesia because they have high economic value and potential as a source of males for AI programs. Differences in genetic background and biological characteristics between these breeds may affect their potential to produce frozen semen. Several studies on the potential for frozen semen production have been reported in Bali cattle (Nugraha *et al.*, 2022; Fatmila *et al.*, 2025), Pasundan cattle (Baharun *et al.*, 2023), and Aceh cattle (Sophian *et al.*, 2025). Research on the potential for frozen semen production in goats has not been widely reported. This study aims to evaluate the potential for frozen semen production among individuals and breeds of Etawah Grade and Anglo-Nubian as a basis for planning frozen semen production potential and determining the structure of the male population in support of the AI program.

RESEARCH METHODS

Research Materials

The research was conducted at the Lembang Artificial Insemination Center, West Bandung Regency. All research procedures were approved by the Animal Ethics Committee, School of Veterinary Medicine, and Biomedicine, IPB University, with number 351/KEH/SKE/VII/2025. This study used primary and secondary data. Primary data were obtained from five ejaculation collections conducted on Etawah Grade and Anglo-Nubian goats from July to September 2025. Secondary data were obtained from goat frozen semen production data in 2024.

Semen Collection

Semen was collected twice a week in the morning using an artificial vagina, according to the standard operating procedures of the Lembang Artificial Insemination Centre. The buck breeds used were Etawah Grade and Anglo-Nubian, aged 3–4 years. Each breed consisted of two males, and semen was collected five times from each individual. Fresh semen was transported to the laboratory and stored at 32°C for evaluation.

Evaluation of Fresh Semen Quality

Fresh semen is evaluated for semen volume, sperm motility, and sperm concentration. Semen volume is measured by reading the number on the tube according to the amount of semen collected (Arifiantini, 2012). Fresh semen samples are analyzed for sperm motility using a portable Computer Assisted Semen Analysis (CASA) system (AndroScope, Minitube, Germany). 10 µL of fresh semen is mixed with 490 µL of Tris buffer, then 2.9 µL of the mixture is placed in a Leja that has been warmed on a heating table. Observations are made in four different fields of view to obtain the average sperm motility value.

Sperm concentration was calculated using a Photometer SDM 6 (Minitube, Germany) by

placing the semen into a cuvette containing 0.9% physiological NaCl in a ratio of 1:500. The cuvette was then covered with parafilm and homogenized by carefully inverting the cuvette three times. The cuvette was then placed in the photometer channel, which had been turned on and warm-up for 10 minutes. The sperm concentration measurement procedure began by pressing the “measure” button, after which the results were displayed.

Evaluation of Frozen Semen Production Potential

The semen production potential was evaluated to assess the ability of males to produce semen straws in each ejaculation. The data used consisted of primary data, namely the results of direct observations of five ejaculations per male individual during the study period, as well as secondary data on semen production at the Lembang AI Center in 2024. Semen production potential was calculated using the following formula:

Frozen semen production potential (straws) = (semen volume × sperm motility × sperm concentration) / (50 × 10⁶).

Statistical Analysis

The research results are presented in tables as averages ± Standard Error of the Mean (SEM). The effect of breed on the potential for frozen semen production was analyzed using a linear mixed model (LMM). In the model, breed was included as a fixed effect, and individual bucks were treated as random effects, with ejaculations nested within individuals to account for repeated measurements. When significant effects were detected, pairwise comparisons were performed using appropriate adjustments. Statistical analyses were conducted using SPSS version 30 (IBM Corp., Armonk, NY, USA), and significance was declared at P<0.05.

RESULTS AND DISCUSSION

Fresh Semen Characteristics

The fresh semen samples analyzed in this study exhibited good quality and met the minimum standards for processing into frozen semen. The semen volume of Etawah Grade and Anglo-Nubian bucks was 2.60 ± 0.06 mL and

2.97 ± 0.06 mL, respectively. Progressive sperm motility reached 76.54 ± 1.01% in the Etawah Grade and 74.05 ± 0.60% in the Anglo-Nubian breed, both exceeding the minimum requirement for semen processing. Sperm concentration was recorded at 2326.93 ± 34.29 × 10⁶/mL and

2397.25 ± 15.27 × 10⁶/mL, respectively. These results indicate that both breeds possess adequate initial semen quality to support frozen semen production.

These values are comparable to those reported in previous studies on goat semen, where semen volume typically ranges from 2.30 to 2.60 mL Mokoagow *et al.* (2021) and sperm motility exceeds 70% BSN (2023). Sperm concentration has been reported in several studies

at approximately 2770 × 10⁶/mL in local goats. Such variations are influenced by breed, age, nutritional status, and environmental conditions Daoed *et al.* (2024), which are known to affect testicular function and spermatogenesis. The relatively high sperm concentration and motility observed in this study indicate that both Etawah Grade and Anglo-Nubian breeds possess good reproductive potential and are suitable for frozen semen production.

Table 1. Semen production potential in individual buck

Variable	Krastala	Adanu	Andromeda	Andriano	P-value
Production potential	87.86 ± 2.78 ^b	95.40 ± 2.54 ^b	122.45 ± 2.07 ^a	89.07 ± 2.74 ^b	< 0.01

Note: Means in the same row with different superscript differ significantly (P<0.05).

Table 2. Semen production potential in Etawah Grade and Anglo-Nubian breeds

Production potential	Etawah Grade	Anglo-Nubian	P-value
Per ejaculate	91.63 ± 1.92 ^b	105.76 ± 2.54 ^a	< 0.01
Per annually	7,330.4	8,460.8	-

Note: Means in the same row with different superscript differ significantly (P<0.05). Annual semen production potential is calculated by multiplying the average production per ejaculation by the ejaculation frequency (twice per week) and the duration of the production period (40 weeks per year).

Frozen Semen Production Potential in Individuals and Breeds

The analysis results showed significant differences (P<0.01) in frozen semen production potential between individuals (Table 1) and very significant differences (P<0.01) between the Etawah Grade and Anglo-Nubian breeds (Table 2). The highest potential for frozen semen production was observed in the individual Andromeda (122.45 ± 2.07 straws), which was significantly higher than in buck names Krastala (87.86 ± 2.78 straws), Adanu (95.40 ± 2.54 straws), and Andriano (89.07 ± 2.74 straws).

The results of the comparison between breeds showed that the Anglo-Nubian had a higher semen production potential (105.76 ± 2.54 per ejaculation or 8,460.8 straws annually) than the Etawah Grade (91.63 ± 1.92 per ejaculation or 7,330.4 straws annually). This difference indicates that breed plays a significant role in determining semen production capacity, particularly through its influence on sperm output per ejaculation. This difference is likely related to body condition score (BCS) and testicular development, which are positively correlated with sperm output per ejaculation. In the present study, the higher production potential observed in Anglo-Nubian bucks may be attributed to their

larger body size and better testicular development compared to Etawah Grade.

Previous studies have reported that breed significantly affects semen characteristics, including semen volume, sperm concentration, and total sperm output, thereby influencing the number of straws that can be produced per ejaculation (Barbas *et al.*, 2024). The larger body size of Anglo-Nubian bucks, as the BCS has been reported to be positively correlated with semen volume, sperm concentration per ejaculation, and testicular weight (Ouchene-Khelifi dan Ouchene, 2021).

Increased testicular weight reflects enhanced spermatogenic capacity, which directly contributes to higher total sperm production per ejaculate, ultimately increasing frozen semen production potential. In this context, sperm concentration plays a critical role, as higher sperm concentrations increase the number of frozen semen straws that can be produced from a single ejaculation (Arifiantini *et al.*, 2020). This is consistent with the findings of the present study, where Anglo-Nubian breed exhibited slightly higher sperm concentration compared to Etawah Grade breed, contributing to their greater production potential. In addition, genetic factors play a key role in regulating semen quality traits, including sperm motility and fertility potential,

by altering gene expression and metabolic pathways (Jia *et al.*, 2026).

Despite the higher production potential in Anglo-Nubian, Etawah Grade breed exhibited relatively better sperm motility, suggesting differences in sperm functional quality. This finding highlights a possible trade-off between sperm quantity and sperm quality between breeds. Sperm motility is a complex trait regulated by mitochondrial activity and energy metabolism, particularly through metabolites involved in ATP production (Yuan *et al.*, 2023). The higher sperm motility observed in Etawah Grade bucks may indicate more efficient energy metabolism and mitochondrial function compared to Anglo-Nubian bucks. Variations in seminal plasma composition and metabolomic profiles across breeds may explain differences in sperm motility and function. Furthermore, seminal plasma components have been shown to influence sperm resilience during cryopreservation, where inappropriate composition can reduce post-thaw sperm quality (Esteve *et al.*, 2025).

The discrepancy between higher production potential and lower sperm motility in Anglo-Nubian breed suggests that a greater number of sperm cells does not necessarily correspond to better functional quality. The freezing–thawing process induces oxidative stress, membrane damage, and reduced sperm motility, which may disproportionately affect certain breeds depending on their intrinsic sperm

characteristics (Oktanella *et al.*, 2024). Therefore, although the Anglo-Nubian breed produces more straws per ejaculation, the functional competence of sperm must still be carefully considered in AI programs.

In addition to genetic and physiological factors, external factors such as microbiota and environmental conditions may also influence semen quality. Recent studies have shown that variations in semen microbiota are associated with changes in sperm motility, kinematics, and overall fertility potential (Mocé *et al.*, 2022). This suggests that differences in microbial composition between individuals and breeds may partly explain the variability observed in semen characteristics in the present study.

However, the results of this study indicate that a higher semen production potential does not necessarily reflect superior functional sperm quality. This is clearly demonstrated in the present study, where the Anglo-Nubian breed showed higher production potential but lower sperm motility than the Etawah Grade breed. These differences suggest breed-related physiological variations that influence the ability of sperm to maintain functional integrity. Previous studies have similarly reported significant breed effects on semen characteristics, including sperm motility and oxidative status Sukmawati *et al.* (2014), as well as interactions between breed and extender type affecting sperm motility in frozen semen without altering plasma membrane integrity (Sukirman *et al.*, 2019).

CONCLUSION

Individual and breed variations significantly affect frozen semen production potential. Anglo-Nubian bucks exhibit higher production capacity, whereas Etawah Grade

bucks tend to have better sperm quality variables. These differences should be considered in designing efficient breeding and semen production programs.

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