World Journal of Biology Pharmacy and Health Sciences
eISSN: 2582-5542
Cross Ref DOI: 10.30574/wjbphs
Journal homepage: https://wjbphs.com/

(RESEARCH ARTICLE)

Check for updates

Effect of Breed and Different Storage Temperatures on the Productivity of Boar Semen

Ni Kadek Siska Padmara Dewi [1], Luh Gde Sumardani [2], Ni Wayan Siti [2,*] and Ni Wayan Ayu Ningsih [2]

[1] *Master's Program, Faculty of Animal Husbandry, Udayana University, Denpasar, Bali Indonesia.*
[2] *Faculty of Animal Husbandry, Udayana University, Denpasar, Bali, Indonesia.*

World Journal of Biology Pharmacy and Health Sciences, 2026, 25(01), 184-191

Publication history: Received on 11 December 2025; revised on 17 January 2026; accepted on 20 January 2026

Article DOI: https://doi.org/10.30574/wjbphs.2026.25.1.0046

Abstract

This study aimed to evaluate the productivity of boar semen from different breeds and the effect of storage temperature on semen quality during the storage period. Fresh semen was collected from Landrace, Yorkshire, and Duroc boars and stored under two temperature conditions, namely refrigerator temperature (±15–20°C) and room temperature. The observed parameters included semen volume, sperm motility, sperm viability, and sperm abnormality. The study was arranged in a factorial experimental design, and the resulting data were evaluated through analysis of variance to identify treatment effects and their interactions. The results showed that breed differences had a significant effect on boar semen quality. Landrace and Yorkshire breeds exhibited higher sperm motility and sperm viability compared to Duroc, while sperm abnormality tended to be lower. Storage temperature significantly affected semen quality, where storage at refrigerator temperature was able to maintain sperm motility and sperm viability and suppress the increase in sperm abnormality compared to room temperature storage. A decline in semen quality occurred with increasing storage time, particularly under room temperature conditions. An interaction between breed and storage temperature was observed on several semen quality parameters, especially sperm abnormality, indicating different responses of each breed to storage conditions. It can be concluded that boar semen productivity is influenced by breed differences and storage temperature, and storage at refrigerator temperature is recommended to maintain semen quality in supporting the implementation of artificial insemination in pigs.

Keywords: Pigs; Breed; Semen quality; Storage temperature; Productivity

1. Introduction

The livestock industry is an important component of the global economy, providing animal-based protein for communities. One livestock commodity with strong potential to support animal protein supply is pork, due to its high reproductive performance. Data reported by the Directorate General of Livestock and Animal Health under the Indonesian Ministry of Agriculture indicate that, in 2024 the pig population in Indonesia reached 4,115,030, while in 2018–2023 the population was recorded at 7,622,724, indicating a sharp decline. This condition is associated with traditional farming practices without proper housing and a lack of understanding of artificial insemination (AI) technology, which is one of the key factors for productive success. Pig productivity can be increased through the application of artificial insemination, supported by the availability of boars with superior genetic quality. Semen from boars can be used to inseminate 10–20 sows [1].

Artificial insemination is a reproductive technology that involves inserting semen into the genital tract of healthy female animals using an insemination device so that the animals become pregnant [2]. Artificial insemination is a technology that can improve the genetic quality of pigs in a cost-effective, simple, and rapid manner. The semen used in AI is greatly

* Corresponding author: Ni Wayan Siti

influenced by several factors, including the source of pig semen (boar), semen collection techniques, diluents, storage duration, and storage temperature of liquid semen. Pig semen can survive at temperatures up to 20°C but cannot survive long during in vitro storage. Based on this, preservation efforts are carried out to maintain semen quality for a relatively long period [3]. Pig semen has its own characteristics compared to other domestic animals: large semen volume and high sensitivity to cold shock, with the viability of spermatozoa decreasing dramatically when exposed to temperatures below 15°C [4]. Research on pig semen productivity in various breeds and storage temperatures has been extensively conducted in Indonesia. One relevant study is that by [5], which states that diluted lontar fruit water and moringa leaf extract antioxidants can maintain the quality of Landrace pig semen at storage temperatures of 5°C, 15°C, and 22°C.

Based on this background, this study examines the productivity of boar semen in various breeds with different storage temperatures, as well as analyzes the relationship between breed and storage temperature on boar semen productivity to support the development of Artificial Insemination (AI) technology and the sustainability of the pig population in the future

Based on this background, this study examines the productivity of boar semen in various breeds with different storage temperatures, as well as analyzes the relationship between breed and storage temperature on boar semen productivity to support the development of Artificial Insemination (AI) technology and the sustainability of the pig population in the future.

2. Materials and methods

2.1. Materials

The pigs used in this study were three male pigs of different breeds (Table 1) that were healthy and exhibited good semen quality. The animals were fed a diet containing 18% protein and metabolizable energy (3,824.16 kcal/kg), consisting of rice bran, corn bran, pollard, wheat, concentrate 152, minerals, lysine, and Starbio, with a total feed intake of 2.5 kg/animal/day.

Table 1 Name, breed, age, source, and body weight of boar pigs with different breeds

Name and Breed of Boar	Age of Boar	Source of Boar	Body Weight (Kg)
LW Melaya 01	4 Years	Jembrana	234 Kg
LR Batukarang	7 Years	Gianyar	230 Kg
DR Chapoh 02	7 Years	Gianyar	205 Kg

Note: Age and body weight as of September 2025

2.2. Metode

2.2.1 Sample Collection

Semen collection is carried out through several systematic stages. The first stage is the preparation of tools and materials, where all equipment such as semen collection tubes, thermometers, and sterile gloves is prepared and sterilized in advance. The males to be used are also selected based on their health and readiness for collection. Next, the boars are placed in clean and comfortable pens and given time to adapt in order to reduce stress. Before collection, the boars are stimulated using female stimulants or dummies to increase libido and facilitate the ejaculation process. The ejaculation process in boars takes a relatively long time, ranging from 3 to 20 minutes for one complete ejaculation. It begins with the movement of the penis for several minutes, followed by the release of the penis for several minutes and the release of pre-sperm fluid that appears clear, slightly sticky, and contains various gelatinous substances resembling jelly. After releasing semen, the boar becomes calm and the volume of semen increases dramatically. After collection is complete, the semen is evaluated macroscopically and microscopically.

2.2.2 Research Design Structure

Using a Completely Randomized Design (CRD) with a factorial split-time arrangement, breed (B) was set as the first factor, including Landrace, Duroc, and Yorkshire, while storage temperature (S) served as the second factor, comprising 15–20°C (refrigerated) and 20–22°C (room conditions). The design consisted of six treatment combinations (3×2), each replicated five times, yielding a total of 30 experimental units. Semen collection was carried out at three-day intervals,

followed by semen warming at 35–37°C for 3–5 minutes after storage. Microscopic evaluation of semen quality was conducted 24 hours post storage.

2.2.3 Parameters Evaluated

The variables observed were fresh semen and liquid semen productivity.

Macroscopic observations of fresh semen included

- Volume (mL)

Semen volume was determined by reading the scale on the semen collection tube.

- Color

Abnormalities in semen color were identified, such as reddish coloration due to blood contamination or discoloration from fecal contamination. Pig semen is generally milky white.

- Odor

Normal pig semen has a characteristic seminal odor.

- pH

Semen acidity (pH) was measured using indicator paper by placing a drop of semen onto the paper.

- Consistency (viscosity)

If semen flows slowly along the tube wall, the consistency is high (high viscosity). Conversely, rapid flow indicates low consistency (low viscosity).

Microscopic observations included

- Spermatozoa concentration (10^6 cells/mL)

Sperm concentration, defined as the number of spermatozoa per milliliter of semen, is an important semen quality parameter used to estimate the number of females that can be inseminated using the semen.

- Spermatozoa motility (%)

Mass movement was assessed by observing the tendency of spermatozoa to move collectively in the same direction, forming thick and fast-moving waves (+++), thin and fast-moving waves or thick and slow moving waves (++), thin and slow moving waves (+), or showing no movement (0).

- Spermatozoa viability (%)

The proportion of live spermatozoa was observed microscopically. Live spermatozoa do not absorb eosin stain, whereas dead spermatozoa absorb the dye.

- Spermatozoa abnormalities (%)

Using eosin staining, spermatozoa were examined under a microscope at 450× magnification, with a total of 200 spermatozoa evaluated.

Observation of liquid semen after storage was carried out every 24 hours

Microscopic observations included:

- Spermatozoa motility (%)

The percentage of spermatozoa moving progressively within the field of view was assessed. The evaluation was performed by assigning a score from 0 to 100 percent in 5% increments.

- Spermatozoa viability (%)

Viability was determined using differential eosin–negrosin staining under a microscope. Live spermatozoa exhibited white heads, whereas dead spermatozoa showed dark-red staining.

- Abnormalities

Sperm abnormalities were identified by examining 200 sperm cells at 10×40 magnification using differential staining, enabling the detection of structural abnormalities in the sperm head or tail.

2.2.4 Data Processing and Analysis

The collected data were evaluated through an analysis of variance, and any detected significant treatment differences ($P < 0.05$) were evaluated using Duncan's multiple range test [6].

3. Experimental Findings

3.1. Evaluation of Fresh Semen

The results of fresh semen evaluation are preliminary semen tests that serve as the basis for determining suitability for further processing.

Table 2 Fresh Semen Productivity in Boars

Spermatozoa Characteristics	Mean Value ± Standard Deviation (SD)			Standard*
	B1	B2	B3	
Volume	320,00±88,32	404,00±74,03	220,00±24,49	200-250
Color	Milky white	Milky white	Milky white	Milky white
Consistency	Thin consistency	Thin consistency	Thin consistency	Thin consistency
Odor	Characteristic seminal odor	Characteristic seminal odor	Characteristic seminal odor	Characteristic seminal odor
pH	7.52±0.13	7.60±0.16	7.62±0.18	7.40±0.2
Concentration ($\times 10^6$cells/mL)	167.60±36.67	183.40±36.85	142.80±40.44	200-300
Motility (%)	70.00±0.00	71.00±2.24	71.00±2.24	≥ 60
Viability (%)	74.90±3.09	75.50±2.74	73.90±2.63	≥ 80
Abnormalities (%)	16.10±2.61	14.90±4.64	13.60±2.72	≤ 20

Notes: * [7]: B1: Yorkshire; B2: Landrace; B3: Duroc

The characteristics of fresh boar semen used in this study show that its general quality is still acceptable for use in storage at different temperatures. Macroscopic parameters such as color, viscosity, and aroma indicate normal conditions, namely milky white in color, low in viscosity, and with a characteristic fresh seminal odor. These characteristics are in accordance with the report by [8] which states that pig semen with a normal macroscopic appearance generally comes from healthy males exhibiting normal accessory glands, and that the pH value of the semen is within the physiological range that supports spermatozoa activity, namely 7.58±0.15.

The volume of fresh semen obtained in this study was 314.67±100.13 mL, which is above the general standard range for boar semen, which is 200–250 mL. However, other studies report that the average volume of Landrace boar semen is around 137 mL. This difference may occur due to individual variations in males, maintenance conditions, collection frequency, and the age of males, which affect semen secretion [9].

The spermatozoa concentration obtained was 164.60±39.22×10^6 cells/mL, which is lower than the ideal standard of 200–300×10^6 cells/mL, but it can still be used in the semen dosage preparation process because the concentration standard can be adjusted by regulating the dilution volume [10].

This relatively low concentration may indicate that although the ejaculate volume is high, the spermatozoa count per milliliter is not very dense. This condition may be caused by a high proportion of seminal fluid or physiological variations between breeds. According to [11]. low concentration can occur when collection is conducted at close intervals or when the male is in a certain environmental adaptation condition that affects reproductive hormone levels.

The initial motility of spermatozoa in this study was 70.67±1.76%, exceeding the minimum standard of ≥60%, which indicates good motility and meets the minimum requirement for semen storage. This value shows that spermatozoa in fresh ejaculate still have good motility. These results are consistent with the study by [12], which also reported initial sperm motility in pigs above 60%. High motility in fresh semen is important because it will be a determining factor in the ability of spermatozoa to survive during the storage process at various temperatures.

The viability of fresh semen spermatozoa was 74.77±2.70%, which is slightly lower than the standard of ≥80%. This indicates that the proportion of live spermatozoa is still relatively high but does not fall within the optimal category. Lower viability may be influenced by genetic factors, the age of the male, environmental stress, or nutritional conditions. Research by [8] indicates that sperm viability below the standard is often observed in males with intensive reproductive activity or suboptimal management conditions.

Spermatozoa abnormalities were recorded at 14.87±3.37% and remained below the normal limit (≤20%), indicating that the majority of spermatozoa were in a normal morphological condition. This value indicates that the spermatogenesis process in the three boar breeds is within a normal physiological range. [9] reported that sperm abnormalities in Landrace pigs ranged from 12–18%, indicating that the results of this study are consistent with the anatomical and physiological conditions of healthy boars.

Overall, the characteristics of fresh semen in this study indicate that the semen has sufficient basic quality for storage treatment. Initial motility and viability are in favorable condition, while slightly lower concentrations remain an important factor to consider during storage. These conditions of fresh semen provide an initial indication of how spermatozoa are likely to respond when stored at different temperatures. According to [12], semen with moderate to good initial quality is still able to maintain its quality well when stored at a temperature of 15–17°C.

3.2. Percentage of Boar Semen Motility at Different Breeds and Storage Temperatures

Table 3 Percentage of Boar Semen Motility at Different Breeds and Storage Temperatures

Parameter (%)	Breed	Refrigerated (15°-20°C)	Room Temperature (20°-22°C)	Mean
Motility	B1	70.00 ± 3.54[a]	65.00 ± 3.54[b]	67.50 ± 4.25
	B2	71.00 ± 2.24[a]	67.00 ± 2.74[b]	69.00 ± 3.16
	B3	65.00 ± 0.00[b]	61.00 ± 2.24[b]	63.00 ± 2.58

Values marked with different superscripts in a row represent significant differences (P < 0.05)

In the results of semen motility observations between breeds (Table 3), it can be seen that breed has a significant effect on the ability of sperm to maintain progressive motility during storage (P < 0.05). The Yorkshire (B1) and Landrace (B2) breeds showed higher motility values than Duroc (B3) at both refrigerated temperatures (15–20°C) and room temperature (20–22°C). This finding is consistent with reports that genetic differences between breeds affect sperm quality, particularly membrane stability and mitochondrial activity [13]. Landrace and Yorkshire are generally known to have superior reproductive performance, including more stable post-storage motility. In all breeds, motility at refrigerated temperatures was consistently higher than at room temperature. Storage at lower temperatures slows spermatozoa metabolism, reduces free radical production, and helps maintain plasma membrane integrity so that sperm motility can be sustained for a longer period [14]. Conversely, at room temperature, metabolic activity increases, causing spermatozoa energy reserves to decline more rapidly, resulting in lower motility. This is evident in the Duroc breed (B3), which showed the greatest decrease in motility when stored at room temperature (61.00±2.24%), indicating that Duroc is more sensitive to temperature fluctuations than the other two breeds. When viewed based on overall averages, the Landrace and Yorkshire breeds still have higher motility performance than Duroc in both temperature conditions. These findings indicate that these two breeds are more adaptive to the short-term semen

storage process and are more suitable for use in artificial insemination programs that require stable semen quality during transportation and distribution.

3.3. Percentage of Boar Spermatozoa Viability at Different Breeds and Storage Temperatures

Table 4 Percentage of Boar Spermatozoa Viability at Different Breeds and Storage Temperatures

Parameter (%)	Breed	Refrigerated (15°-20°C)	Room Temperature (20°-22°C)	Mean
Spermatozoa Viability	B1	71.40 ± 4.16[a]	70.10 ± 3.29[a]	70.75 ± 3.60
	B2	72.00 ± 2.74[a]	68.40 ± 3.21[a]	70.20 ± 3.39
	B3	70.30 ± 5.04[a]	68.40 ± 3.21[a]	69.35 ± 4.11

Values marked with different superscripts in a row represent significant differences (P < 0.05)

The results showed that the viability of boar semen from the three breeds tested (Yorkshire, Landrace, and Duroc) remained within an average range of approximately 69–71% when stored at refrigerated temperatures (15–20°C). The differences between breeds were not statistically significant (P > 0.05), indicating that genetic factors did not affect spermatozoa viability under these storage conditions, so semen from different breeds could be handled with a uniform storage protocol without the risk of reducing the proportion of live sperm[15].

A storage temperature in the range of 15–20°C is likely the main factor in maintaining spermatozoa viability. This temperature allows sperm cell metabolism to remain active without triggering cold-shock damage, so membrane viability is preserved even though motility may decline. This principle is consistent with research on liquid pig semen, which shows that storage at the optimal temperature range (around 17–25°C) is able to maintain spermatozoa viability and motility better than storage at cold temperatures (5–10°C), which leads to decreases in viability and motility due to cell damage [16. 17].

Extenders also play an important role in maintaining semen viability during storage. [11] Reported that Landrace boar semen using commercial extenders showed that with extenders and storage at 18°C, viability could be maintained for up to 72 hours of storage. Similarly, extenders using natural ingredients such as palm fruit water and egg yolk have been reported to maintain spermatozoa viability during short-term storage, provided that the storage protocol is applied correctly [18]. These findings confirm that the effectiveness of semen storage is influenced not only by temperature and breed, but also by the quality and composition of the extender. Although semen viability in this study was stable, it is important to note that viability alone does not guarantee successful fertilization. Other parameters such as progressive motility, sperm concentration, and abnormalities remain important in determining semen fertility[19]. Various studies show that although viability can be maintained, motility and other functional parameters can decline if storage is prolonged or the diluent is inadequate[20]. Therefore, semen evaluation before insemination must be conducted comprehensively, not only based on viability.

Thus, storing liquid pig semen at a refrigerated temperature of 15–20°C with an appropriate diluent can be regarded as a viable short-term method. Semen from various breeds maintains adequate spermatozoa viability. However, to ensure optimal artificial insemination quality, careful semen management and thorough assessment of semen parameters prior to use are required.

3.4. Percentage of Boar Semen Abnormalities at Different Breeds and Storage Temperatures

Table 5 Percentage of boar semen abnormalities at different breeds and storage temperatures

Parameter (%)	Breed	Refrigerated (15°-20°C)	Room Temperature (20°-22°C)	Mean
Abnormalities	B1	12.10 ± 354[a]	13.60 ± 2.70[a]	11.95 ± 4.82
	B2	11.90 ± 2.66[a]	14.20 ± 2.59[a]	13.05 ± 2.27
	B3	13.00 ± 4.18[a]	14.20 ± 4.80[a]	13.60 ± 4.29

Values marked with different superscripts in a row represent significant differences (P < 0.05)

The relatively low percentage of sperm abnormalities across all treatments indicates that storage at temperatures ranging from 15–22°C does not exert a significant negative effect on pig sperm morphology [21]. This finding is

consistent with the study by[19], which reported that short-term storage of liquid semen at standard refrigerated temperatures can preserve sperm morphology, particularly when handling and dilution procedures are properly applied.

The effect of breed on semen abnormalities also appears minimal, supporting the findings of [15] that genetic differences among breeds do not always exert a significant influence on sperm morphological quality during short-term cold storage. These findings are relevant in the context of liquid semen management at artificial insemination centers, as semen from different breeds can be stored and utilized under uniform conditions without an increased risk of sperm abnormalities.

Extenders also contribute to maintaining sperm morphology during storage. The use of appropriate extenders can protect the plasma membrane and reduce cell deformation resulting from oxidative stress or osmotic changes during storage [12]. Additionally, studies on boar semen using natural extenders based on coconut water and egg yolk have demonstrated stable sperm morphology during 24–48 hours of storage, with a low incidence of abnormalities [18].

Although the abnormality level is relatively low, a comprehensive evaluation of other semen parameters, such as motility, concentration, and viability, is still necessary, as the combined influence of these factors determines fertilization success in artificial insemination [20, 22]. This finding confirms that semen from the three breeds remains suitable for short-term use, although proper semen handling continues to be a key factor in maintaining sperm morphology and fertilization potential.

Overall, short-term storage of semen at refrigerated or room temperatures (15–22°C) did not result in a significant increase in abnormalities, and the different breeds exhibited comparable abnormality values. These results provide a scientific basis for liquid semen management in pig farms or artificial insemination centers in Indonesia, particularly in ensuring that sperm morphology remains optimal during storage and distribution.

4. Conclusion

Semen from Landrace, Yorkshire, and Duroc breeds is of sufficient quality for artificial insemination, with motility, viability, and abnormality rates remaining within acceptable standards. Refrigerated storage temperature (15–20°C) has been shown to be more optimal in maintaining sperm motility, while breed does not significantly influence semen quality. The percentage of abnormal cells remains low and is not influenced by differences in temperature or breed during short-term storage.

Compliance with ethical standards

Acknowledgments

The author gratefully acknowledges the Dean of the Faculty of Animal Science, Udayana University, for providing academic support and institutional assistance throughout the implementation of this study

Disclosure of conflict of interest

The author declares that there are no financial or personal relationships that may have affected the conduct or interpretation of this study.

Statement of ethical approval

The use of three male pigs in this study was approved by the Animal Ethics Committee, Faculty of Veterinary Medicine, Udayana University.

References

[1] Manurung, C. P. (2024). Effectiveness of Gentamicin Administration on the Semen Quality of Landrace Boars.

[2] Directorate General of Livestock and Animal Health. (2012). Guidelines for the Optimization of Artificial Insemination (AI) in 2012. Directorate General of Livestock and Animal Health, Ministry of Agriculture, Jakarta, Indonesia..

[3] Tosi, W. A., Foeh, N. D. F. K., and Gaina, C. D. (2021Effect of Adding Chicken Egg Yolk to Palm Fruit Water–Based Natural Extender on the Quality of Landrace Boar Semen at Preservation Temperature 5 C. Jurnal Veteriner Nusantara, 4(1), 14-14.

[4] Bebas, W., & Gorda, W. (2019). Addition of Bovine Serum Albumin to Beltsville Thawing Solution Can Preserve the Quality of Boar Semen Stored at 15°C . Jurnal Veteriner Jurnal Veteriner. 20(3), 330-336.

[5] Aplugi, M., Gaina, C., and Foeh, N. D. F. K. (2020). Quality of Landrace Boar Spermatozoa Supplemented with Moringa (Moringa oleifera Lam.) Leaf Extract as an Antioxidant at Different Storage Temperatures. Jurnal Veteriner Nusantara, 3(2), 156-160.

[6] Steel, R.G.D. dan J.H. Torrie. 1993. Principles and Statistical Procedures. PT. Gramedia. Pustaka Utama, Jakarta.

[7] Johnson, L. A., K. F. Weitze, P. Fiser & W. M. C. Maxwell. 2000. Storage of boar semen. J Anim. Sci. 62:143-172

[8] Sitohang, E. R., Warmadewi, D. A., and Ardika, I. N. (2025). Selection of Boars from Different Breeds Based on Libido and Semen Quality in UPTD BIBDPTHHPT. Jurnal Peternakan Tropika, 13(2), 58-75.

[9] Kaka, A. (2020). Characteristics and Fertility Potential of Landrace Crossbred Boar Spermatozoa. (Indonesian Journal of Animal Science), 22(3), 277-283.

[10] Pramono, H., Sutanto, A., & Lestari, U. (2020). Spermatozoa Concentration and Boar Semen Motility at Different Dilution Levels Jurnal Sain Peternakan Indonesia, 15(1), 45–53.

[11] Ernawati, S., Salundik, L., & Arifiantini, R. (2016). Study on the Quality of Liquid Boar Semen Using Commercial Extenders. ournal of Animal Science and Technology, 39(3), 101–108.

[12] Butta, C. A., Gaina, C. D., & Foeh, N. D. (2021 Motility and Viability of Boar Spermatozoa in Coconut Water–Village Chicken Egg Yolk Extender. Jurnal Veteriner Nusantara, 4(1), 3-3

[13] Sugiarto, A., Yendraliza, & Wibowo, B. (2021). Effect of Sire Breed Differences on Fresh and Stored Semen Quality. Jurnal Peternakan Nusantara, 7(2), 120–128

[14] Wahyuni, N., Arimbawa, I. M., & Tresna, I. G. (2018). Stability of Boar Spermatozoa Motility During Storage at Different Temperatures. Jurnal Veteriner, 19(1), 95–103.

[15] Ma, D., Gaina, R., & Foeh, H. (2022). Effect of Breed on the Quality of Chilled Liquid Boar Semen. Jurnal Veteriner Nasional, 14(4), 201–209.

[16] Kuster, C., Müller, T., & Fischer, J. (2022). Storage temperature effects on boar semen viability and fertilizing capacity. Frontiers in Veterinary Science, 9, 953021.

[17] Sumardani, N. G., Tuty, L. Y., & Siagian, P. H. (2008). Viability of Boar Spermatozoa in Modified Beltsville Thawing Solution (BTS) under Different Storage Conditions. Media Peternakan, 31(2).

[18] Djawapatty, R., Belli, A., & Hine, P. (2024). Effectiveness of Natural Extenders in Maintaining Boar Spermatozoa Viability During Storage. Jurnal Ilmu Peternakan Indonesia, 15(1), 12–21.

[19] Suryadi, A., Salundik, L., & Arifiantini, R. (2016). Relationship Between Boar Semen Viability and Motility and Their Fertilization Ability. Jurnal Ilmu dan Teknologi Peternakan, 8(1), 55–63.

[20] Li, J., Zhu, J., et al. (2023). Post-thaw storage temperature influenced boar sperm quality and survival. Animals, 14(1), 87.

[21] Parera, R., & Lenda, H. (2023). Storage of Liquid Boar Semen and the Effect of Temperature on Spermatozoa Morphology. Jurnal Peternakan Tropis, 11(1), 34–42.

[22] Sumardani, R., Tuty, I., & Siagian, L. (2008). Evaluation of the Quality of Liquid Landrace Boar Semen Using Local Extenders. Jurnal Peternakan Tropis, 6(2), 34–42.