

An Overview of Performance and Influencing Factors of Frozen Semen Producers in Indonesia

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ABSTRAK

Arifiantini RI, Gusman KT, Agil M, Susilawati T, Karja NWK, Said S, Mahendra HC. 2025. Gambaran umum kinerja dan faktor-faktor yang memengaruhi produsen semen beku di Indonesia. *JITV* 30(3):132-139. DOI:<http://dx.doi.org/10.14334/jitv.v30i3.3521>.

Di Indonesia, terdapat 21 produsen semen beku, semua produsen tersebut mempunyai rumpun pejantan, jenis pengencer dan target produksi berbeda. Penelitian ini dilakukan dengan tujuan untuk menganalisis faktor-faktor yang memengaruhi kinerja produsen semen beku tersebut. Metode survei dilakukan dengan menggunakan kuesioner (melalui formulir Google) yang diisi oleh 21 petugas laboratorium produsen semen beku di Indonesia. Data yang terkumpul dianalisis secara deskriptif dan disajikan dalam bentuk angka dan persentase. Hasil penelitian menunjukkan bahwa kinerja para produsen bervariasi, dengan jumlah petugas laboratorium berkisar antara satu hingga lebih dari lima orang, dan didominasi oleh laki-laki dan perempuan (76,19%). Latar belakang pendidikan petugas laboratorium sebagian besar adalah sarjana peternakan (54,29%), jumlah sapi jantan yang dimiliki bervariasi mulai kurang dari 10 ekor hingga lebih dari 200 ekor (90,48% dan 9,52%). Sapi jantan yang dipelihara sebagian besar adalah sapi eksotik dan sapi lokal (76,19%). Pengencer yang paling banyak digunakan adalah pengencer buatan sendiri (71,43%) dan pengenceran semen sebagian besar dilakukan dalam satu tahap (57,14%). Konsentrasi sperma semen segar diukur oleh seluruh produsen, menggunakan fotometer (SDM atau accucell); kalibrasi internal dilakukan oleh 71,43% produsen. Evaluasi kualitas semen beku sebagian besar difokuskan pada motilitas sperma pasca-thawing (100%), dan hanya 61,90% produsen yang menghitung konsentrasi sperma. Penilaian tambahan, yang meliputi viabilitas dan morfologi sperma, hanya dilakukan oleh 52,38% produsen, dan hanya 4,76% produsen yang menilai integritas membran plasma sperma. Proporsi sampel semen beku yang melebihi, memenuhi, atau tidak memenuhi SNI masing-masing adalah 80,95%; 14,29%; dan 4,76%.

Kata Kunci: Balai Inseminasi Buatan, Produsen Semen Beku, Profil Produsen Semen Beku, Semen Beku

ABSTRACT

Arifiantini RI, Gusman KT, Agil M, Susilawati T, Karja NWK, Said S, Mahendra HC, 2025. An overview of performance and influencing factors of frozen semen producers in Indonesia. *JITV* 30(3):132-139. DOI:<http://dx.doi.org/10.14334/jitv.v30i3.3521>.

In Indonesia, there are 21 frozen semen producers, each with a different stud herd, diluent type, and production target. The present study was conducted to evaluate the performance of these producers. A survey method was employed, utilising a questionnaire (via Google Forms) completed by 21 laboratory personnel from frozen semen producers in Indonesia. The collected data were analysed descriptively and presented as numbers and percentages. The study revealed that producers' performance varied, with the number of laboratory workers ranging from 1 to more than 5, and that men and women (76.19%) were the dominant group. The laboratory personnel's educational backgrounds were predominantly in animal science (54.29%), while the number of bulls owned ranged from less than 10 to more than 200 (90.48% and 9.52%, respectively). The bulls kept were primarily exotic and local cattle (76.19% of the total). The most commonly used diluents were homemade (71.43%), and semen dilution was predominantly performed in a single step. The sperm concentration of fresh semen was measured by 100% of producers using a photometer (SDM or AccuCell); however, internal calibration was performed by 71.43% of producers. Moreover, the evaluation of frozen semen quality focused predominantly on post-thaw motility (100%), with only 61.90% of producers calculating sperm concentration. Furthermore, supplementary assessments, including sperm viability and morphology, were conducted in only 52.38% of cases, with only 4.76% of producers assessing sperm plasma membrane integrity. The proportions of frozen semen samples that exceeded, met, or did not meet the SNI were 80.95%, 14.29%, and 4.76%, respectively.

Key Words: Artificial Insemination Centers, Frozen Semen, Frozen Semen Producers, Frozen Semen Producer Performance

INTRODUCTION

According to Livestock Statistics 2023, the cattle population in Indonesia in 2022 consisted of 17,602,538 beef cattle and 507,075 dairy cattle (Kementerian Pertanian 2023). The ratio of male to female cattle, as determined by the 2017 Livestock Business Household Cost Structure Survey (BPS 2017), is 36.86%: 63.14%. Total of 63.14% of cattle in the above category, 41.61% were mature females aged between two and over eight years, with a productive age of 38.05% or 6,881,652.94 heads.

Cattle breeding primarily uses artificial insemination, though some farmers still use natural mating. Assuming mating with artificial insemination at 60% and service per conception at two, the requirement for frozen semen in Indonesia is 8,257,983 straw units, which producers of frozen semen supply. According to the Regulation of the Minister of Agriculture (MOA) of the Republic of Indonesia Number 10/2016, the following entities are eligible to be frozen semen producers: Nasional Artificial Insemination Centers (NAICs), Regional Artificial Insemination Centers (RAICs), breeders, livestock companies, government, provincial or district/city governments, and universities.

In Indonesia, the production of frozen semen is currently overseen by various entities, including NAICs such as Singosari and Lembang AICs, 18 RAICs distributed across multiple provinces, and one Artificial Insemination Laboratory affiliated with universities, such as the Teaching Farm Airlangga. Regulation by MOA No. 10/2016 serves as a guideline for each frozen semen producer in producing and distributing its products and is outlined in each producer's standard operating procedure (SOP). Frozen semen producers generally follow similar SOPs; however, production targets, operational implementation, and application within each AIC distinguish producers.

The quality of frozen semen is influenced by various factors, including the male breed (Morrell et al. 2018), the freezing method employed (Zhang et al. 2024), the equipment used (Lieberman et al. 2016), the diluent (Sukirman et al. 2019; Zhang et al. 2024), and human resources (Pertiwi & Soesanto 2022). The variation is also influenced by the handling practices of frozen semen, its transportation and storage facilities, and the proximity of the region/district to the National Artificial Insemination Centre (Engidawork 2018).

The present study aimed to evaluate the laboratory human resources, identify the number and breeds of cattle, evaluate the equipment used, the type of semen diluents and dilution techniques, and the quality examination of frozen semen by frozen semen producers in Indonesia.

MATERIALS AND METHODS

Time and place of research

The research was conducted from September 2023 to November 2024 at two institutions: the Central Java RAIC in Ungaran, Central Java, and the School of Veterinary Medicine and Biomedical Sciences, IPB University.

Research procedures

A survey was conducted to collect data on the performance of frozen semen producers. The survey method involved administering a questionnaire (Google Form) to laboratory personnel at frozen semen producers in Indonesia. The participating institutions included Singosari and Lembang NAIC, RAIC of Aceh, North Sumatra, Tuah Sakato, West Sumatra, Riau, Jambi, Bengkulu, South Sumatra, Lampung, Ciamis, Central Java, Blora, Yogyakarta, Banyumulek, West Nusa Tenggara, Baturiti Bali, South Kalimantan, South Sulawesi, Central Sulawesi, Southeast Sulawesi, and Teaching Farm Airlangga. The following questions were included in the survey: a) Number, composition, and education of laboratory personnel. b) Breeds and number of males used. c) Equipment used for quality testing of fresh and frozen semen. d) Diluent and dilution technique used. e) Quality testing of frozen semen performed by producers.

Data analysis

The data were analysed descriptively and presented as numbers and percentages of 21 frozen semen producers in Indonesia.

RESULTS AND DISCUSSION

Human resources

The findings indicated a variation in the number of laboratory staff among frozen semen producers. Some producers employed a single laboratory personnel member (4.76%), while 71.43% had 2-4 laboratory personnel, and 23.81% had 5 or more. Those with five or more staff were national producers with ambitious production goals. The gender composition of the laboratory staff was predominantly mixed, with 76.19% being both male and female, 14.29% female, and 9.52% male. Most personnel held a Bachelor of Animal Sciences degree, followed by qualifications as Veterinarians, High School Diplomas, Bachelor of Chemical Sciences, and Paramedic Diplomas (Table 1).

Table 1. Human resources at the Laboratory of frozen semen producers in Indonesia

Variable	Criteria (Number)	Producers	Percentage (%)
Laboratory personal	1	1	4.76
	2	4	19.05
	3	6	28.57
	4	5	23.81
	5	1	4.76
	>5	4	19.05
Gender of Laboratory personnel	All female	3	14.29
	All male	2	9.52
	Female dan male	16	76.19
Educational Background of Laboratory personnel	Highschool graduate	4	11.43
	Paramedic Diploma	1	2.86
	Bachelor of Animal Husbandry	19	54.29
	Bachelor of Chemical Sciences	2	5.71
	Veterinarian	9	25.71
Total		21 (100%)	

The production of frozen semen involves a wide range of human resources, including administrators, animal nurses, veterinarians, feed quality supervisors (WASTUKAN), semen quality supervisors (WASBITNAK), bull masters, and laboratory personnel. The combined efforts of these professionals are essential in ensuring the quality of frozen semen (Pertwi & Soesanto, 2022). This research focused on laboratory personnel who are responsible for preparing diluents, evaluating the quality of fresh semen, processing frozen semen, and assessing the quality of the final product. Furthermore, laboratory personnel meticulously document all data related to processes and operations in the frozen semen production laboratory. According to Regulation MOA No. 10/2016, human resources must meet competency standards and/or have expertise in their respective areas.

Human resources play a crucial role in meeting an organization's goals and objectives, significantly impacting the efficiency and overall performance of its systems. Having an adequate number of personnel with the right educational qualifications and skills is essential for determining the quality of frozen semen. Maintaining consistent quality and quantity of frozen semen is vital for producers. The production of frozen semen is a multifaceted process that begins with preparing diluents, assessing fresh semen, diluting, packaging in straws, equilibrating, freezing, storing the straws, and evaluating the frozen semen. This production process, which includes several stages, necessitates the involvement of multiple laboratory staff,

ideally 2–3 for regional producers and a minimum of four for national producers.

The number and breed of cattle owned by frozen semen producers

The quantity and type of cattle owned by frozen semen producers showed variation, with ownership ranging from fewer than 10 to 50 bulls (90.48%) to more than 200 bulls (9.52%). The quantity and type of cattle owned by producers of frozen semen are linked to their production goals. These producers must evaluate the production capabilities of each breed and individual animal, as there are variations in frozen semen production potential among different breeds and individuals (Indriastuti et al. 2020; Shopian et al. 2025). Notably, some regional producers of frozen semen exclusively maintain domestic breeds (14.29%), a strategy implemented by the RAIC to preserve the genetic purity of domestic breeds in Indonesia and protect the genetic potential of cattle to develop superior breeding stock. In contrast, 9.52% of frozen semen producers solely keep exotic bulls in their herds. A large majority of frozen semen producers (76.19%) typically use a combination of domestic and exotic bulls. The production targets for frozen semen were broad, spanning from 20,000 to 3 million straws annually (Table 2). This table lists the number and breed of bulls, along with their respective production goals.

To ensure the production of high-quality frozen semen that aligns with the Indonesian National Standard

Table 2. The number and breed of cattle and the frozen semen production target of frozen semen producers in Indonesia

Variable	Criteria (bull head)	Number of Producers	Percentage (%)
Number of Bulls	<10	6	28.57
	10 – 20	9	42.86
	20 – 50	4	19.05
	50 – 100	0	0.00
	100 – 200	0	0.00
	>200	2	9.52
Breed of Bulls	Only Exotic	2	9.52
	Only local cattle	3	14.29
	Exotic & local cattle	16	76.19

Table 3. Potential frozen semen production from various breeds of cattle

Breeds	Production Potential		Source
	Straw/year	Straw/ejaculate	
Exotic cattle			
Limousin	45.520*	569	Jakaria et al. (2018)
Simmental	29.920*	374	Isnaini et al. (2019)
	14.640	183	Baharun et al. (2021)
Angus	13.920*	174	Jakaria et al. (2018)
Domestic Cattle			
Aceh	11.399	285	Sophian et al. (2025)
Bali	21.640	270	Iskandar et al. (2022)
Brahman	36.560*	457	Jakaria et al. (2018)
FH	19.840*	248	Jakaria et al. (2018)
Madura	7.980	99	Komariah et al. (2020)
Ongole	26.720*	334	Isnaini et al. (2019)
Pasundan	13.400	167	Santoso et al. (2021)

*= The result of multiplying 80×number of straws/ejaculates

(SNI) for frozen bovine semen (4869-1:2021), frozen semen producers must own bulls of exceptional quality; this not only supports the success of artificial insemination (AI) in the field but also enhances the quality of local cattle in the areas where frozen semen is produced (Iskandar et al. 2022). The annual production target, measured in straws, reflects a producer's capacity to produce frozen semen, with a significant relationship between this target and the number and breed of bulls each producer owns. Prominent national frozen semen producers aim to exceed 3 million straws per year, made possible by a sufficient variety of bulls from different breeds. Conversely, regional producers have a more limited selection of bulls and breeds, resulting in lower production targets. As outlined in the Roadmap of Indonesian Superior Bulls 2018-2022, a bull is considered productive if it yields at least 7,500 straws of

frozen semen annually for local cattle and 12,500 straws for exotic cattle.

The capacity of a bull to produce semen that can be effectively frozen is known as its potential for generating frozen semen. This potential can be evaluated for each ejaculate or over a year, typically based on 40 weeks of production annually or 80 semen collections, with two collections per week. The production of frozen semen from bulls is contingent upon the amount of motile sperm in the ejaculate (Santoso et al. 2021). There are significant variations in the ability to produce frozen semen among different cattle breeds (Sophian et al. 2025) and individual bulls (Indriastuti et al. 2020). The feasibility of producing frozen semen is influenced by both the volume of semen and the sperm concentration in each sample. While variations in sperm concentration do not impact the quality of frozen semen, these factors

do affect the number of straws produced (Arifiantini 2017). Table 3 summarizes the potential of different cattle breeds to produce frozen semen for artificial insemination, based on previous studies.

Semen diluents are used in the frozen semen producer.

The study found that 71.43% of frozen semen producers utilized homemade diluents, with Tris-egg yolk and skimmed milk-egg yolk being the most common. In contrast, the other producers chose to use commercial diluents. The quality of frozen semen can differ significantly depending on the type of diluent and the dilution methods used. Nevertheless, using appropriate and effective diluents and techniques can make the production process more economical, leading to a lower cost per straw for breeders. The choice of commercial diluents by frozen semen producers is mainly influenced by the ease of preparation, established quality, and the need to produce in small quantities (Riwu et al. 2023). However, the use of commercial diluents is restricted by their non-local production, which can be affected by supply chain issues, potentially halting the production of frozen semen. Therefore, to ensure continuous production, producers need an alternative in-house supply of diluents. Table 4 lists the types of semen diluents used by frozen semen producers in Indonesia.

Dilution techniques

The results showed that 57.41% of frozen semen producers used a one-step dilution technique and 42.86% used a two-step dilution technique. The filling process was performed at 5 °C. Furthermore, the results indicated that 61.90% of producers conducted the packaging process at room temperature, whereas 38.10%

performed it at 5°C. The semen dilution techniques employed by frozen semen producers in Indonesia are listed in Table 5.

The method of dilution used to produce frozen semen has been shown to affect semen quality significantly (Zhang et al. 2024). Techniques that are compatible with the process have been found to produce semen of notably higher quality (Dias et al. 2018). This study revealed that 57.41% of frozen semen producers used a one-step dilution method, while 42.86% used a two-step dilution method. When employing the one-step dilution method, the semen is packaged at room temperature (20–22°C). Then it undergoes an equilibration process, during which the temperature is adjusted to 5°C for 4 hours before freezing.

The diluents employed in the two-step dilution technique included those both with and without cryoprotectants. The initial diluent, constituting 50% of the required volume, was introduced at room temperature and subsequently stored at 5°C. In contrast, the second diluent, which contained glycerol, was maintained at this temperature and added 1 hour after the initial dilution. The filling process was conducted at 5°C, and the equilibration period was measured from the moment the semen was combined with the first diluent. The data indicated that 61.90% of producers conducted the packaging process at room temperature, while 38.10% preferred 5°C. The two-step dilution method is exclusively utilized by frozen semen producers who employ a cooling top (cooling cabinet) for equilibration, such as the NAIC. Producers engaged in smaller-scale frozen semen production primarily utilize refrigerators set between 4 and 5°C.

Arif et al. (2020) found that a one-step dilution method produced higher-quality frozen semen than two- or three-step dilution methods. The process involving two or three dilutions causes changes in temperature and osmotic pressure when the cooling. The countainer is

Table 4. Types of semen diluents used by frozen semen producers in Indonesia

Type of Semen Diluents	Number of Producers	Percentage (%)
Commercial diluents	6	28.57
Egg yolk-skimmed milk	6	28.57
Tris-egg yolk	9	42.86

Table 5: Dilution techniques of frozen semen producers in Indonesia

Variables	Criteria	Producers	Percentage (%)
Dilution techniques	One-step dilution	12	57.14
	Two-step dilution	9	42.86
Dilution, filling, and sealing temperature	Room temperature	13	61.90
	5°C	8	38.10

opened and closed during the addition of diluent and the packing of the straw. These fluctuations in temperature and osmotic pressure place stress on sperm, leading to molecular alterations, DNA damage, changes in the plasma membrane, and increased reactive oxygen species (ROS). As a result, the motility and quality of the frozen semen are adversely affected.

Semen freezing equipment used in frozen semen producers

The equipment available to producers for creating frozen semen is generally adequate for the purpose. Both national and regional producers possess phase-contrast microscopes with monitors, automatic straw packaging and printing machines, and equilibration devices, such as a cooling cabinet or refrigerators. The freezing equipment at RAICs includes automatic machines and traditional tools, such as temperature-controlled Styrofoam boxes.

In addition to a microscope, a crucial tool for semen evaluation is a sperm concentration meter, as it is essential for calculating semen dilution. Sperm concentration refers to the number of sperm per milliliter of semen. An incorrect sperm evaluation can affect the sperm count in the straws. Importantly, all frozen semen producers in Indonesia utilize computer-based counters, such as the Photometer SDM 5 or SDM 6 (95.24%) and AccuCell (4.76%). These devices require calibration internally every two weeks. The results of this study

indicated that only 71.43% of producers followed the internal calibration procedure, while the remaining producers did not comply with the protocol (Table 6).

Semen quality testing by the producer

The findings showed that all producers (100%) evaluated sperm motility, while only 61.90% checked sperm concentration. The quality of frozen semen produced was 4.76% not meeting SNI standards, 80.95% meeting SNI standards, and 14.29% surpassing the SNI standard (Table 7). Further analysis revealed that 52.38% of the studies included evaluations of sperm viability and morphology, and 4.76% concentrated on the integrity of the sperm plasma membrane. The National Standardization Agency (BSN) has established a standard for frozen bovine semen quality, as detailed in SNI 4869.1:2021, which requires post-thaw motility of over 40% and a minimum concentration of 25 million sperm/0.25 ml per straw.

The quality of frozen semen produced by producers must meet SNI standards. The study's findings indicated that although all producers conducted sperm motility tests, only 61.90% performed sperm concentration assessments. Recalculating the sperm concentration in a straw is vital to ensure the cell count aligns with the specified criteria. This step also evaluates the staff's competence in calculating the concentration of sperm in fresh semen and determining the correct amount of diluent

Table 6: Equipment for evaluation of sperm concentration

Variables	Criteria	Producers	Percentage (%)
Sperm Concentration Tools	Photometer SDM/Accucell	21	100
Calibration	Internal	15	71.43
	External	6	28.57

Table 7: The quality examination of frozen semen produced by frozen semen producers in Indonesia

Variable	Producers	Percentage (%)
Quality Examination		
Sperm motility	21	100
Sperm concentration	13	61.90
Sperm viability	11	52.38
Sperm morphology	11	52.38
Sperm plasma membrane integrity	1	4.76
Frozen semen quality		
Below the Indonesian national standard	1	4.76
Compliant with Indonesian national standards	17	80.95
Exceeding the Indonesian national standard SNI	3	14.29

to use. As shown in Table 7, while most centers adhere to the SNI standards for frozen semen quality, some even exceed these criteria, and some centers do not meet the required standards. It is essential to conduct a thorough evaluation of these producers to enhance their quality. The findings reveal that 52.38% of producers have implemented tests for sperm viability and morphology, whereas only 4.76% have examined the integrity of the sperm's plasma membrane.

To assess sperm viability and morphology, producers of frozen semen use eosin-nigrosine or 2% eosin staining methods, and the hypo-osmotic swelling technique to evaluate the integrity of the sperm plasma membrane. Those producers who did not perform these additional tests cited difficulties in acquiring raw materials and a lack of knowledge about the procedures and benefits of these examinations.

According to the Director General of Animal Husbandry and Animal Health Decree Number 9471/KPTS/HK.160/F/09/2023, additional tests for frozen semen quality are mandated to be gradually implemented over the next five years. Producers of frozen semen must understand these quality assessments, as they influence sperm fertility and the effectiveness of artificial insemination (AI). Evaluating sperm motility, along with viability and plasma membrane integrity, is particularly important because it ensures sperm remain viable and motile while also protecting the cytoplasm and DNA integrity within the cells (Arif et al. 2022; Ugur et al. 2019).

According to the analysis, there is significant diversity among frozen semen producers, which can be linked to several factors, including human resources, the number and breeds of bulls, production goals, types of semen diluents and dilution methods, equipment used, and the quality testing of frozen semen. Support and oversight are necessary from various entities, including the Livestock Service Office, universities, and research centers focused on semen quality in Indonesia. The involvement of professional certification bodies or animal product certification organizations is essential. Furthermore, producers should enhance their laboratory personnel's skills to ensure that the frozen semen produced meets the required standards for artificial insemination.

CONCLUSION

The findings concluded that frozen semen producers differed in the number and gender of their laboratory personnel, as well as in the number and types of local and exotic bulls used. These producers typically use homemade diluents in a single-step process. Their equipment was generally comprehensive. All producers conducted quality tests on frozen semen for post-thaw motility, although only a few recalculated the sperm

concentration in the straws. Additional assessments, such as sperm viability and morphology, were conducted by 52.38% of producers, while 4.76% tested sperm plasma membrane integrity. Most producers met or exceeded the SNI standards, but 4.76% failed to meet the SNI criteria.

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