# REPRODUCTION TECHNOLOGIES IN PIG FARMING: ARTIFICIAL INSEMINATION - LITERATURE REVIEW

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## ABSTRACT

This summary addresses the use of reproduction technologies in swine farming, with an emphasis on artificial insemination (AI). Brazilian swine farming has been growing significantly and seeks new technologies to achieve high productive indices sustainably and competitively. Pigs present favorable characteristics such as high prolificacy, fertility, rapid growth, feed efficiency, and carcass yield, which has led to intensive development of the activity with advanced genetic selection. AI is widely employed to disseminate genetic material among different regions and farms. Several AI techniques are used in modern swine farming: intrauterine insemination (IUI) allows semen deposition in the uterine region, reducing costs; fixed-time insemination (FTAI) synchronizes estrus in various females, facilitating management and increasing efficiency; deep intrauterine insemination (DIUI) deposits semen in the uterine horns, obtaining better results; and cervical insemination (CI), a traditional technique widely used, although it may be more time-consuming and present higher reflux rates. The success of AI is related to knowledge of the reproductive cycle of sows, proper nutrition, and genetic and environmental factors. Semen quality is essential, requiring collection by trained professionals and evaluation of sperm motility and morphology. Although it is a consolidated technique, there are issues to be further explored to optimize its application, defining the exact moment for insemination, reducing reflux, and adopting effective protocols. AI is an essential tool for the growth of Brazilian swine farming, but it requires continuous studies to maximize its efficiency and results, considering the farm's production goal and the size of the enterprise to achieve high reproductive and productive indices.

**Keywords:** Intensive pig farming; Artificial insemination; Reproductive efficiency; Productivity.

# TECNOLOGIAS DE REPRODUÇÃO NA SUINOCULTURA: INSEMINAÇÃO ARTIFICIAL – REVISÃO DE LITERATURA

## RESUMO

Este resumo aborda o uso de tecnologias de reprodução na suinocultura, com ênfase na inseminação artificial (IA). A suinocultura brasileira vem crescendo significativamente e busca novas tecnologias para alcançar altos índices produtivos de maneira sustentável e competitiva. Os suínos apresentam características favoráveis, como alta prolificidade, fertilidade, rápido crescimento, eficiência alimentar e rendimento de carcaça, o que levou ao desenvolvimento intensivo da atividade com seleção genética avançada. A IA é amplamente empregada para disseminar material genético entre diferentes regiões e granjas. Diversas técnicas de IA são

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utilizadas na suinocultura moderna: a inseminação intrauterina (IAIU) permite a deposição do sêmen na região uterina, reduzindo custos; a inseminação em tempo fixo (IATF) sincroniza o estro em várias fêmeas, facilitando o manejo e aumentando a eficiência; a inseminação intrauterina profunda (IAUP) deposita o sêmen nos cornos uterinos, obtendo melhores resultados; e a inseminação cervical (IAC), técnica tradicional amplamente utilizada, embora possa ser mais demorada e apresentar maiores taxas de refluxo. O sucesso da IA estar relacionado ao conhecimento do ciclo reprodutivo das matrizes, à nutrição adequada e aos fatores genéticos e ambientais. A qualidade do sêmen é essencial, exigindo coleta por profissionais treinados e avaliação da motilidade e morfologia dos espermatozoides. Apesar de ser uma técnica consolidada, há questões a serem aprofundadas para otimizar sua aplicação, definindo o momento exato para a realização da inseminação, a redução do refluxo e adoção de protocolos eficazes. A IA é uma ferramenta essencial para o crescimento da suinocultura brasileira, mas requer estudos contínuos para maximizar sua eficiência e resultados, considerando o objetivo produtivo da granja e o tamanho do empreendimento para alcançar altos índices reprodutivos e produtivos.

**Palavras-chave**: Suinocultura intensiva; Inseminação artificial; Eficiência reprodutiva; Produtividade.

## TECNOLOGÍAS DE REPRODUCCIÓN EN LA PORCICULTURA: INSEMINACIÓN ARTIFICIAL - REVISIÓN DE LITERATURA

### RESUMEN

Este resumen aborda el uso de tecnologías de reproducción en la producción porcina, con énfasis en la inseminación artificial (IA). La producción porcina brasileña ha crecido significativamente y busca nuevas tecnologías para alcanzar altos índices de productividad de manera sostenible y competitiva. Los cerdos presentan características favorables, como alta prolificidad, fertilidad, rápido crecimiento, eficiencia alimentaria y rendimiento de la canal, lo que ha llevado al desarrollo intensivo de la actividad con selección genética avanzada. La IA se utiliza ampliamente para difundir material genético entre diferentes regiones y granjas. Diversas técnicas de IA son utilizadas en la producción porcina moderna: la inseminación intrauterina (IAIU) permite la deposición del semen en la región uterina, reduciendo costos; la inseminación a tiempo fijo (IATF) sincroniza el estro en varias hembras, facilitando el manejo y aumentando la eficiencia; la inseminación intrauterina profunda (IAUP) deposita el semen en los cuernos uterinos, obteniendo mejores resultados; y la inseminación cervical (IAC), técnica tradicional ampliamente utilizada, aunque puede ser más demorada y presentar mayores tasas de reflujo. El éxito de la IA está relacionado con el conocimiento del ciclo reproductivo de las hembras, la nutrición adecuada y los factores genéticos y ambientales. La calidad del semen es esencial, requiriendo la recolección por profesionales capacitados y la evaluación de la motilidad y morfología de los espermatozoides. A pesar de ser una técnica consolidada, hay aspectos que deben ser profundizados para optimizar su aplicación, como la definición precisa del momento de la inseminación, la reducción del reflujo y la adopción de protocolos eficaces. La IA es una herramienta esencial para el crecimiento de la producción porcina brasileña, pero requiere estudios continuos para maximizar su eficiencia y resultados, considerando el objetivo productivo de la granja y el tamaño del emprendimiento para alcanzar altos índices reproductivos y productivos.

**Palabras clave:** Suinocultura intensiva; Inseminación artificial; Eficiencia reproductiva; Produtividade.

## INTRODUCTION

The Brazilian swine sector has experienced remarkable growth over the years, reaching increasingly higher levels of development. According to a recent report from the Brazilian Association of Animal Proteins [1], in 2022, the housing of breeding sows reached a historical milestone with 2,067.749 million animals housed, surpassing the numbers from 2016, which were 2,067.704 million. These data evidence a continuous increase in development opportunities for the sector and a growing demand for pork products in the market.

The notable growth of the Brazilian swine sector is evidenced by its significant production numbers. In 2012, pork production in the country totaled 3.488 million tons, while in 2022, it reached the mark of 4.983 million tons, representing an impressive increase of 42.89% over a decade. This substantial growth opens doors to greater market opportunities, drives demand for labor, and reinforces the increasing appreciation of pork products by the population. The sector appears promising and continuously developing, consolidating the importance of swine farming for the Brazilian economy.

This growth is also driven by solid investments in cutting-edge technologies, encompassing different areas, such as environmental technology, which provides a higher quality of life for the animals by creating suitable environments to meet their specific needs. Additionally, advances in nutrition technology have been fundamental in achieving an ideal nutritional balance, maximizing the genetic potential of the animals, and ensuring their health and productivity [2].

However, it is in reproductive technologies that investments become especially crucial. These innovations ensure not only an increase in the number of live-born animals but also contribute to these animals reaching productive age with the lowest possible rate of losses. This focus on reproductive efficiency has played a vital role in the continuous expansion of the swine sector. As a result of this commitment to technology and innovation, Brazilian swine farming remains competitive in the global market, earning international recognition. By following this path, the sector not only meets the growing demands for high-quality pork products but also promotes a sustainable and responsible approach, driving the country's economic growth. The future vision based on the strategic application of technologies promises to further elevate the productivity and efficiency of the sector, solidifying it as one of the pillars of the Brazilian economy [3].

In modern swine farming, artificial insemination is a widely used technique to optimize reproductive performance, eliminating the need for direct use of the male. The main techniques employed are intrauterine insemination (IAIU), timed artificial insemination (IATF), and deep intrauterine insemination (IAUP). Intrauterine insemination (IAIU) involves the use of a catheter that slides through the traditional pipette, allowing the semen to be deposited directly inside the uterus, passing through the cervix. Timed artificial insemination (IATF) requires the synchronization of sows through hormones so that insemination can be performed at a specific time during the reproductive cycle [4].

On the other hand, deep intrauterine insemination (IAUP) is similar to IAIU, but the semen is deposited in a deeper position in the uterine horns. These techniques have proven to be effective and are fundamental to driving the productivity and efficiency of the swine sector, contributing to its continuous development [5].

The objective of this review is to analyze and highlight the effectiveness of the application of artificial insemination methods in swine farming, presenting a comprehensive approach to the advantages and disadvantages associated with this reproductive technique.

## MATERIALS AND METHODS

This review was conducted through a literature search based on different publications found in databases. The search for articles was performed in the following electronic literary research databases: Web of Science and Google Scholar, using both associated and non-associated search terms, in both plural and singular forms, in both English and Portuguese. Some of the search terms used were: "Suinocultura" AND "Tecnologia" AND "Inseminação" in Portuguese, and "swine farming" AND "Technology" AND "Insemination" in English.

After analyzing the files in both scientific databases, Web of Science and Google Scholar, articles that did not fit the theme or did not meet the inclusion criteria were excluded, along with any duplicate articles.

## DEVELOPMENT

## SWINE REPRODUCTION

The reproductive cycle of female pigs is regulated by the hypothalamus, which stimulates the pituitary gland to release gonadotropins. The reproductive period is characterized by the maturation of the hypothalamus-pituitary-gonadal axis in female pigs. Reproductive maturity in gilts is reached between five and nine months, with gonadotropin-releasing hormone (GnRH) responsible for triggering this process [6].

The estrous cycle of female pigs is divided into two distinct phases: the follicular phase and the luteal phase. The follicular phase begins with the regression of the corpus luteum and extends until ovulation. The luteal phase begins after ovulation and continues until the complete regression of the corpus luteum, characterized by the presence of this corpus luteum and the predominance of the hormone progesterone, as described by Bortalozzo et al. [7].

The peak of luteinizing hormone (LH) triggers ovulation, promoting functional and structural changes in the follicular wall that lead to the development of intra-follicular pressure and the process of ovulation. After the peak of LH, the formation of the hemorrhagic body occurs, where the wall of the ovulated follicle collapses and is invaded by lymph and blood, promoting the formation of the corpus luteum under the influence of angiogenic and myogenic factors [8].

Progesterone is a crucial hormone in the estrous cycle of female pigs, playing a crucial role in maintaining the uterus in suitable conditions for conception. It performs various important functions, such as stimulating the proliferation of endometrial cells, promoting relaxation of the myometrium, and regulating the estrous cycle. Additionally, progesterone induces the differentiation of the endometrial stroma, stimulates glandular secretion, and promotes the release of proteins in endometrial cells, contributing significantly to the process of embryonic development [4].

This correlation is important because progesterone is the predominant hormone in the luteal phase of the estrous cycle of female pigs. During this phase, characterized by the presence of the corpus luteum and the predominance of progesterone, the uterus prepares to receive the embryo and provides ideal conditions for embryonic development. Thus, progesterone plays an essential role in maintaining pregnancy and reproductive success in female pigs.

Reproduction in pig farming is also influenced by crucial factors such as genetics and nutrition, playing decisive roles in achieving productive success through balance with their physiology [9]. From the moment of selection of potential breeders, proper nutrition directly impacts the development of the reproductive organs of these animals. Careful weight control is a fundamental aspect of the nutrition of a sow, avoiding problems such as the early onset of reproductive life and difficulties during farrowing. It is recommended that animals reach a weight of 115 to 120 kg at the age of 180 to 190 days.

By carefully considering factors such as genetics and nutrition, it is possible to optimize the reproductive performance of female pigs, ensuring a more efficient and successful production in pig farming. The harmonious interaction between these elements is essential to maximize the productivity and reproductive health of the animals, contributing to the sustainable growth of the sector.

In this context, the nutritional status of female pigs deserves daily attention. Well-nourished females have better conditions for the survival of embryos, resulting in a higher number of piglets per litter. On the other hand, undernourished females may suffer abortions and give birth to weak litters. Undernutrition can also lead to embryonic losses due to increased gestational heat and result in loss of appetite in later stages, such as lactation [11]. The careful observation of these factors is essential to ensure healthy and productive reproduction, promoting the continuous success of pig farming.

## ARTIFICIAL INSEMINATION

With the increasing demand for animal protein production, methods aimed at increasing the reproductive rate have been explored in modern pig farming. In this context, artificial insemination has stood out due to its genetic updating and the guarantee of fertilization without the direct need for male breeders. Additionally, its affordable cost compared to the natural mating process and management of male breeders is another attractive incentive for its use [12].

In 1995, data on the initial use of artificial insemination were recorded in the Southern region of Brazil [13]. Its introduction into Brazilian herds occurred gradually as its efficiency was proven by positive responses, such as an increase in the birth rate of up to 80%. Consequently, this technique rapidly spread throughout the sector, becoming one of the most widely used in reproduction. Artificial insemination allowed for wider dissemination of semen from genetically superior males, resulting in higher productivity and economically desirable traits [14].

The process of artificial insemination is highly dependent on the preceding procedures. Semen collection should be conducted by properly trained professionals, and donor males should be carefully selected, ensuring they do not present genetic problems and possess economically desirable traits. Additionally, laboratory techniques such as motility and morphology evaluation are used as indicators of the quality of the inseminating dose and should be thoroughly assessed at the time of insemination [15]. These critical steps ensure the effectiveness and success of artificial insemination in pig farming.

To ensure satisfactory semen collection in pig farming, the facilities must have a pre-collection room, collection room, and laboratory. In the laboratory, it is essential to have a microscope to evaluate sperm quality and count, as well as an incubator at 15 to 17°C for semen preservation and a water bath to keep materials warm [16].

It is crucial to accurately define the amount of semen to be used, avoiding overestimation, which can result in a measured concentration higher than the actual concentration of the ejaculate, affecting the number of sperm in the inseminating dose and influencing pregnancy quality, as an inadequate amount of sperm will be present at the time of ovulation. Careful attention to these steps is crucial for the success of artificial insemination in pig farming. The addition of excessive extender is also an overestimation practice to be avoided, as it may reduce the amount of seminal plasma in the dose, negatively impacting the LH peak in the female, final oocyte maturation, and the timing of ovulation. These factors, in turn, can lead to a decrease in fertility, increase the return rate to estrus, and reduce the number of farrows or piglets [17].

Artificial insemination is prepared after detecting estrus, and it is recommended in nulliparous and primiparous sows between 24 and 28 hours before ovulation. In nulliparous sows, ovulation occurs approximately 30 hours after the onset of estrus, while in multiparous

sows, it occurs at approximately 39 hours. Regarding the number of doses to be used, there are conflicts regarding this information. Studies have shown that, in multiparous sows, one inseminating dose per day was equivalent to protocols with intervals of 8-16 hours. For nulliparous sows, different experiments have shown that insemination at 12, 24, and 30 hours did not present significant differences in pregnancy rate and number of embryos [16].

Artificial insemination should be performed following a protocol to ensure a lower reflux rate, avoid pipette contamination, and prevent injuries during the process. After cleaning the sow's vulvar region, the pipette should be unwrapped and lubricated with semen or appropriate lubricating gel.

Then, the pipette is inserted in the dorsocranial direction with anti-clockwise movements until it fixes in the cervix, and the semen vial is attached to the end of the pipette, gently pressing for the transport and absorption of sêmen. After insemination, the pipette should be removed at a 45-degree angle with clockwise movements, and the male should stay with the female for another 5 minutes to improve fertility rates [18].

## CERVICAL ARTIFICIAL INSEMINATION

Traditional artificial insemination (IAT) or cervical insemination (IAC) is widely used in pig farms due to its simple application, which includes disinfection of the vulva, use of a traditional pipette, lubrication, insertion, and attachment of the semen vial [19]. However, because it demands time for execution, IAT has been improved over the years to reduce the time spent and increase its efficiency, with the development of new pipettes, belts, and methods of female stimulation [20].

Traditional artificial insemination (IAT) is a constantly evolving technique in pig farming, aiming to increase reproductive rates. Different insemination protocols have been developed from the traditional method, including post-cervical insemination, fixed-time insemination, intrauterine insemination, and deep intrauterine insemination [21]. Since its introduction in 1975, the use of artificial insemination has increased significantly, from 2% in 1975 to 27% in 2000, and currently, it is estimated that 95% of herds worldwide use IAT. This method is adopted to reduce the need for male breeders, take advantage of genetic improvement, and accelerate the reproductive process [22].

The protocol for traditional artificial insemination (IAT) consists of the cervical deposition of semen doses containing two to four billion sperm, using doses of 80 to 100 ml, stored at a temperature of 15º to 18º Celsius [23]. Although IAT presents pregnancy rates above 80%, it has some disadvantages, such as the time it takes, which can reach up to 5 minutes per female.

Stimulation techniques are used to reduce this time, but still, compared to other insemination protocols, its execution time is longer. Additionally, IAT can result in a significant loss due to reflux, especially in primiparous sows, where a high reflux rate is observed [18]. Despite the disadvantages, IAT continues to be a widely used technique in pig farming, contributing to the advancement of reproductive rates in pig production.

## POST-CERVICAL ARTIFICIAL INSEMINATIONS

Post-cervical artificial insemination (IAPC) is a technique developed to enhance reproductive outcomes, representing an evolution compared to traditional artificial insemination. In this more advanced method, the semen is deposited directly into the uterine body, allowing a reduction in the concentration of sperm used. Doses of 26 to 30 ml are employed, with sperm concentration ranging from 1.5x10^9 to 3x10^9 billion sperm [21].

Post-cervical artificial insemination (IAPC) offers the advantage of reducing the amount of sperm used, going from approximately 3 billion, commonly used in traditional artificial insemination, to around 1.2 billion. This reduction allows the use of male breeders to be around 40%, resulting in lower costs, a higher number of available doses, and the possibility of covering a greater number of sows with semen from the same male [22].

Comparative studies between traditional artificial insemination (IAT) and post-cervical artificial insemination (IAPC) conducted by Araujo et al. [24] found that sows inseminated by IAPC showed a higher pregnancy rate, possibly due to the lower reflux rate provided by this protocol. Additionally, Oliveira et al. [25], in their comparison between IAT and IAPC, observed that the direct deposition of semen into the uterine body provides better birth rates, as there is a lower barrier and lower energy expenditure for sperm to reach the oocytes.

In their comparative study, Alvarenga et al. [27] found that different amounts of seminal fluid in post-cervical artificial insemination (IAPC) achieve a farrowing rate of 91.70% when using doses of 30 ml (1.5 billion sperm), with no significant difference compared to doses of 60 ml (2 billion sperm). This result allows the replication of the same collection and covers a larger number of females, making IAPC an advantageous option to optimize reproductive efficiency in pig farming.

Despite improving reproductive rates, post-cervical artificial insemination presents a significant disadvantage regarding its use in nulliparous sows, which represent a group with a higher percentage of farrowing, around 16 to 18%. This is due to the characteristics preceding their reproductive period and also because this technique demands a higher investment in labor [28].

## FIXED-TIME ARTIFICIAL INSEMINATION

Fixed-time Artificial Insemination (FTAI) is a growing practice in the swine industry, allowing the insemination of a large number of females through hormonal synchronization. This technique simplifies estrus detection, reducing the number of required inseminations and demanding less labor, resulting in more efficient execution of reproductive management [28].

The technique of Fixed-time Artificial Insemination (FTAI) is widely used in replacement gilts, as it requires prior synchronization of estrus, unlike weaned sows, which can be physiologically synchronized or through the ovulation inducer.

The pursuit of consolidation and greater adoption of FTAI is a growing trend, as well-developed protocols make it the most used technique when aiming for high results and reproductive performance. Among the advantages of FTAI, we highlight the reduction in the number of inseminations per female, a decrease in maintaining breeding males, optimization of labor use, precise planning of the necessary semen doses per breeding group, scheduling of artificial insemination, farrowing, and piglet care actions, as well as a reduction in the variability of the gestational period of females and the age of piglets at weaning [5].

Fixed-time Artificial Insemination (FTAI) can be defined by two distinct protocols: one that depends on estrus detection for its execution and another that is performed entirely blindly [29]. The use of gonadotropins in the induction and synchronization of ovulation in swine is a facilitating practice in reproductive management. In the case of pigs, equine chorionic gonadotropin (eCG) acts on the receptors of follicle-stimulating hormone (FSH) and luteinizing hormone (LH), stimulating follicular growth, ovulation, and estrus in gilts, as well as promoting the return of ovarian activity after weaning. In turn, induction with chorionic gonadotropin (hCG) performs functions similar to LH, inducing ovulation, luteinization of granulosa cells, maintaining the functional life of the corpus luteum, and increasing progesterone secretion from luteinized cells [8].

Gonadotropin-releasing hormone (GnRH) can be classified into two groups: natural and synthetic analogs. Synthetic analogs such as buserelin, goserelin, and triptorelin are used to induce ovulation in female pigs. These drugs act at the hypothalamic level, stimulating the endogenous release of luteinizing hormone (LH) by the pituitary gland, resulting from estrogen production by growing follicles in the ovary [28].

The use of Fixed-time Artificial Insemination (FTAI) is not yet widely consolidated in the swine industry, and strategies need to be adopted to make its use viable, such as hormonal induction [18]. One of the main challenges of FTAI is the reduction in farrowing rate when the protocol is not adequately followed. In this regard, it is essential to consider factors such as genetics, nutrition, and individual observations of the animals to adjust the most appropriate induction protocol for each farm. If problems are observed in conducting FTAI, traditional artificial insemination can be an alternative to be considered [29].

## INTRAUTERINE ARTIFICIAL INSEMINATION

Intrauterine Artificial Insemination (IAIU) presents a distinct approach where semen is directly deposited into the uterine body through a catheter, resulting in a higher pregnancy rate [22]. This methodology allows for reducing the number of sperm and extenders per dose, making the process more cost-effective. With IAIU, the collected semen can be divided into up to five doses since a large number of sperm per inseminating dose is not necessary. Comparative studies between FTAI and IAIU indicate that both techniques achieve similar results, but IAIU offers the advantage of reducing the costs associated with insemination [30].

Within an artificial insemination protocol, the exact timing of the procedure is the determining factor for its success. Sperm deposited in the uterus has a viability of 16 to 24 hours, while oocytes remain viable for 4 to 8 hours. Therefore, the key to the success of artificial insemination is to perform it 24 hours before ovulation [8].

The technique of Intrauterine Artificial Insemination (IAIU) presents some disadvantages to be considered. One of them is related to problems in the cervical canal, characterized by the presence of cervical rings, which can cause difficulties in the passage of instruments used in the process. Most of these devices, such as the spiral pipette and the 15 to 20 cm catheter, do not consider the individual characteristics of the females, resulting in injuries when handled by inexperienced or untrained staff [22]. Additionally, another disadvantage of IAIU is its limited use in nulliparous and multiparous females, as the forced introduction of the catheter can cause injuries and bleeding, affecting reproductive performance, and increasing the reflux rate. These problems occur due to the incomplete development of the reproductive tract in nulliparous and some multiparous females [4].

The study conducted by Schroeder et al. [31] demonstrated that the passage of the catheter through the cervix of female pigs presents less resistance as the reproductive system develops. It was observed that females in the 2nd, 3rd, 4th, and 5th estrus had passage rates of 44%, 65%, 66%, and 60%, respectively. Furthermore, the weight of the sows also exerts a significant influence on the passage rate, with sows weighing 140 kg and 150 kg showing a passage rate of 70%.

## INTRAUTERINE DEEP ARTIFICIAL INSEMINATION

Deep Intrauterine Artificial Insemination (IAIUP) is characterized by depositing semen deeply in the caudal part of the uterine horns. This technique allows the use of a smaller number of sperm per insemination, as well as the use of cryopreserved or sexed semen [22]. Comparative studies conducted by Carvaca et al. [32] demonstrated that IAIUP presents better results in terms of the number of live-born piglets compared to other insemination techniques.

This is attributed to the reduction of obstacles that the sperm faces until reaching the fertilization site, providing higher reproductive efficiency. IAIUP emerges as a promising alternative to improve the birth rates in pig farming, showing a technique that can significantly contribute to the improvement of reproductive management.

IAIUP can be performed using the Firflex probe, which allows semen deposition in one of the uterine horns without the need for surgery or animal anesthesia. The procedure is carried out by introducing the artificial insemination catheter similar to cervical insemination, followed by attaching the Firflex probe through the catheter. With the help of a syringe, the semen dose is introduced with a bit of air, and then 1.5 ml of diluent is used to push the remaining dose [17]. This technique offers a less invasive and more practical alternative for performing intrauterine insemination in pigs, contributing to the optimization of reproductive management in pig farming.

IAIUP presents several advantages, such as reduced semen reflux, the need for a smaller number of viable sperm, the possibility of using frozen semen, and sexed sperm. However, it is important to note that this technique also has some disadvantages, such as a higher cost associated with the price of the catheter and the need for specialized and trained labor for its execution [12]. Despite the limitations, IAIUP represents a promising option to enhance reproductive efficiency in pig farming, especially when measures are implemented to overcome the challenges pointed out.

IAIUP has demonstrated its efficiency in tests, where the use of only 20 million sperm can achieve results similar to techniques that use the deposition of 200 million or even 1 billion sperm [21]. However, to ensure the success of IAIUP, it is essential that the person performing the procedure is properly trained, as deep catheter introduction requires skill and injuries during the process can cause reproductive losses [29].

## CONCLUSION

Through the techniques of traditional artificial insemination, fixed-time artificial insemination, and deep intrauterine artificial insemination, swine husbandry has made significant advances in terms of reproductive efficiency. Each of these approaches has specific advantages and disadvantages, but all have contributed to increased pregnancy rates and improved reproductive management in swine production. With the proper application of these techniques and adequate training of the professionals involved, the swine industry can continue to evolve to meet the growing demand for animal protein.

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