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TECHNOLOGY AS A TOOL TO ENSURE BIOSAFETY IN AGRIBUSINESS

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Abstract: The spread of pathogens among pig and poultry farms can be the result of biosecurity failures, becoming a very serious problem for the entire Brazilian agribusiness chain. Among the biosecurity measures implemented, controlling access by people and vehicles is essential to prevent the spread of agents such as the avian influenza virus. Combining technology with this control is a promising tool, such as the development of an electronic gate system to control access by people and vehicles. The proposal consists of a facial and/or digital recognition system associated with the registration of people in a database (full name, social security number, occupation, etc.), where all registrations and records communicate with a cloud database to correlate data between all farms. When an individual does not comply with the predetermined sanitary vacuum, the system blocks entry to the farm, thus preventing them from carrying pathogens from one farm to another.

Keywords: Biosecurity, standards, technology, pigs, poultry.

INTRODUCTION

Brazilian agribusiness represents a significant portion of the national GDP, reaching 29.5% by the end of 2025, according to data published in the report by the Center for Advanced Studies in Applied Economics (Cepea) at Esalq/USP (CEPEA, 2025).

According to data from the Brazilian Animal Protein Association (ABPA, 2025), the poultry and pork sector in Brazil achieved record production and export levels in 2024. Chicken meat production was estimated at 15 million tons, while exports re-

ached 5.294 million tons, generating record revenues of US$ 9.928 billion. ABPA also projected record pork production for 2024, with exports growing by 9.8%.

Brazil's prominent position is only possible thanks to the sum of continuous efforts and advances achieved through hard work to develop an increasingly better herd. Improvements in genetics, nutrition, management, and health. However, in the first half of 2025, this status was shaken by the identification and confirmation of an outbreak of an important disease, controlled and monitored worldwide: Avian Influenza.

In Brazil, the identification of a case of Highly Pathogenic Avian Influenza (HPAI) in a breeding farm in the city of Montenegro (RS) in May 2025 led to significant financial losses and trade restrictions for Brazilian poultry farming. The outbreak on the commercial farm, the first of its kind in the country, triggered immediate embargoes by important trading partners. The farm in Montenegro was severely affected, with the death of more than 7,000 birds and the culling of the remaining 17,000 to contain the virus. Replacing the flock represents a high cost for producers, which is still being estimated in the middle of the year (MAPA, 2025).

In addition, several countries and economic blocs, such as China, the European Union, Canada, and Mexico, suspended imports of chicken meat from Brazil, impacting about 33% of Brazilian exports. China alone, the main buyer, accounts for about 11% of sales. The restrictions resulted in estimated losses of up to R$ 1.5 billion per month, according to the Brazilian Animal Protein Association (ABPA, 2025).

Thanks to the rapid response to tackle and manage the crisis, brilliantly conducted by the supervisory bodies, in just over a month, the problem was completely overcome and producers were able to resume their activities, including exports returning to normal. By the end of the year, the sector will be fully recovered, and according to forecasts, 2025 will end with further progress and growth.

A failure in biosecurity likely led to this enormous loss. After an investigation by the Official Veterinary Service (SVO) of the State of Rio Grande do Sul, it became clear that stricter measures are needed to control the access of pathogens, such as the Avian Influenza virus, which probably entered the farm through an employee, visitor, or vehicle. Therefore, stricter measures are needed to control access to properties.

The term biosecurity can be defined as the set of rules and procedures that aim to reduce the risks of introducing certain infectious pathogens into the system, as well as reducing the incidence of pathogens already present in the production system (ADAPAR, 2022). On poultry and pig farms, biosecurity aims to prevent the entry of diseases such as avian influenza and swine fever, reducing mortality and avoiding production and economic losses, making production more efficient and stable.

In view of what has happened and the need for continuous improvement and reinforcement in biosecurity, especially with regard to access control on properties, this study aims to review the effectiveness of the main biosecurity measures currently adopted in commercial poultry and swine farms and propose the construction of a computerized system that controls and monitors all types of access, from people to vehicles, in

order to comply with health standards and minimize the risk of pathogen transmission.

METHODOLOGY

To develop this work, the main technical guidelines published by official bodies on the subject of biosecurity applied to poultry and pig farming over the last 20 years were reviewed in order to systematically review the subject. After this review, it was time to verify where technology comes in as a tool already in use and how it can be improved to enhance the efficiency of actions already in practice.

RESULTS

Biosafety standards in animal husbandry are defined as a set of measures and procedures designed to prevent the entry and spread of infectious agents (viruses, bacteria, fungi, and parasites) into the herd, protecting animal health, public health, and the well-being of workers. This concept is well understood and applies in accordance with the standards already proposed by various regulatory bodies. Among these standards, we can highlight the following:

3.1 Control of access to the property: Restricting access by strangers, vehicles, and animals to the production unit is an essential measure to reduce the risk of introducing pathogens into the production system. To this end, it is recommended to install fences, gates, and adequate signage, in addition to registering and conducting health checks on visitors (FAO, 2008; WOAH, 2022).

3.2 Hygiene and disinfection: The adoption of strict hygiene and disinfection practices contributes significantly to disease prevention. Footbaths and wheelbaths with appropriate disinfectants should be used, and facilities, equipment, and vehicles should be cleaned periodically. Hand hygiene, changing clothes, and wearing footwear exclusively for animal handling are also recommended measures (EMBRAPA, 2020; CRMV-SP, 2024).

3.3 Animal health management: Proper health management includes vaccination programs, internal and external parasite control, and daily monitoring of animal health. These actions allow for early identification of diseases and reduce the spread of infectious agents in the herd (WOAH, 2022; EMBRAPA, 2020).

3.4 Quarantine and isolation: Newly acquired animals must undergo a period of quarantine before being introduced into the herd to prevent the introduction of diseases. Similarly, sick or clinically suspected animals should be immediately isolated in specific facilities for sanitary separation (FAO, 2008; WOAH, 2022).

3.5 Feed and water control: The use of feed from known sources and properly stored is essential to prevent contamination. The water supplied to animals must be potable and subject to periodic quality controls, reducing risks to animal health and the safety of animal products (EMBRAPA, 2020; FAO, 2008).

3.6 Proper waste disposal: The correct management of animal production waste, such as manure, carcasses, and contaminating materials, is essential to prevent the spread of pathogens and negative environmental impacts. Practices such as composting, incineration, or burial should be adopted, in accordance with current health and environmental legislation (EMBRAPA, 2020; CRMV-SP, 2024.).

3.7 Pest and vector control: The presence of pests and vectors can facilitate the transmission of diseases among animals. Thus, it is necessary to implement continuous programs for the control of rodents, insects, and synanthropic birds, in addition to eliminating breeding sites, such as feed residues and standing water (FAO, 2008; WOAH, 2022).

3.8 Staff training: Continuous training of workers is a fundamental component of biosecurity. Employees must be trained in good sanitary practices, the correct use of personal protective equipment, and the risks of zoonoses, ensuring greater safety in the workplace (CRMV-SP, 2024; EMBRAPA, 2020).

3.9 Traceability and records: Keeping records of health, treatments, vaccinations, and animal movements is essential for traceability and decision-making in health emergencies. These records contribute to epidemiological surveillance and disease outbreak control (WOAH, 2022; EMBRAPA, 2020).

Based on what is already known and applied, the use of technology has become a key ally in improving biosecurity management on commercial poultry and pig farms, contributing to disease prevention, infection control, and animal welfare. Table 1 shows the main applications of technology that are already used in biosecurity in animal production.

DISCUSSION

Controlling access to rural livestock properties is essential to prevent the introduction of pathogens into the breeding system. To this end, the measures known and used today are the installation of fences, gates, and adequate signage, in addition to the registration and health control of people (employees and visitors). On many properties, this registration is still carried out by manual annotation in books, which is a rudimentary and unreliable practice.

After evaluating all biosafety requirements related to access control, this study proposes the use of technology to implement an electronic gate system to control access by people (employees, service providers, and visitors) and vehicles, thereby minimizing the possibility of biological risks entering and spreading.

The proposed technology consists of a facial and/or digital recognition system associated with the registration of people in a database (full name, social security number, occupation, etc.). All registrations and records communicate with a cloud database to correlate data between all farms. All farms that have the technology implemented will receive a biosafety certification that will increase the reliability and credibility of their activity, thus adding more value to the business as a whole.

In accordance with health legislation, necessary sanitary downtime periods will be stipulated and suggested as safe for people and vehicles to travel between farms. If an individual does not respect the predetermined sanitary downtime, the system blocks entry to the farm, thus preventing individuals from carrying pathogens from one farm to another.

The proposal can also be integrated with ERP or agricultural management systems for better data collection and management, providing greater efficiency for the entire activity.

Real-time monitoring **Environmental sensors**: Temperature, humidity, ammonia, and gas concentration sensors installed in poultry and swine facilities allow for real-time monitoring and adjustment of environmental conditions, preventing outbreaks of respiratory diseases and promoting animal comfort. These sensors ensure that the environment is always in ideal conditions for animal health and to avoid stress that can predispose them to disease (FAO, 2008). **Remote disease monitoring**: Animal health monitoring software, connected to wearable devices or biometric sensors, can identify early signs of disease, such as fever, changes in behavior, or decreased feed intake. This allows for rapid intervention, preventing the spread of disease and minimizing the use of antibiotics (WOAH, 2022).
Data management and traceability **Digital traceability systems**: The digitization of recording processes, such as animal movements, vaccinations, and medical treatments, facilitates herd traceability, a crucial element for biosecurity. Specific software allows all stages of production to be monitored, creating complete and accessible histories for future analysis, which is essential in the event of outbreaks (WOAH, 2022, Dall'Stella et al., 2023). **Blockchain for traceability**: Some farms are using blockchain to ensure the transparency and traceability of pork and poultry, allowing consumers and health authorities to track the entire production chain, from birth to slaughter, ensuring that biosecurity standards are being followed (CRMV-SP, 2024, Colezea et al., 2018).
Automation of health management **Automated cleaning and disinfection systems**: Automation technologies such as robots for cleaning and disinfecting facilities help reduce workers' exposure to pathogens and improve the efficiency of hygiene routines. These systems are programmed to perform disinfection tasks accurately, using effective disinfectants without leaving any areas at risk (Gontijo & Holliday, 2022). **Automated feed and medication distribution**: Automated feeding systems, connected to feed consumption sensors, allow for personalized distribution of feed and medication based on each animal's needs. This reduces waste of resources and avoids direct contact between workers and animals, minimizing the risk of cross-contamination (Brown-Brandl, et al. 2013).
Artificial Intelligence (AI) for early diagnosis and outbreak prediction **AI and machine learning**: Artificial intelligence can analyze large volumes of data related to animal health and behavior (such as variations in feed consumption, weight, and clinical signs) to identify patterns that indicate the onset of outbreaks. In addition, algorithms can predict the spread of disease and recommend corrective actions, such as quarantining specific groups of animals, before an outbreak spreads (Nascimento, 2025). **Image and video analysis**: The use of video surveillance cameras combined with AI can visually identify signs of disease in poultry and swine, such as changes in posture, breathing, or behavior. This monitoring can be integrated with automatic alerts for farm managers, promoting a rapid response and minimizing the spread of disease (Nascimento, 2025).
Use of drones for farm inspection **Aerial inspection and monitoring of facilities**: Drones equipped with cameras and sensors can be used to perform visual inspections of facilities, monitoring the health of the environment, the condition of fences, and ventilation systems. In addition, they can be used to check the overall condition of hard-to-reach farms, helping to ensure that biosecurity standards, such as access control, are being followed (Agronegócio AZ, 2025).

Telemetry and IoT **Internet of Things (IoT)**: IoT enables connected devices (such as waterers, feeders, ventilation systems) to communicate with each other and with the control center, ensuring that animals always receive optimal feeding, watering, and ventilation conditions. These systems can be programmed to send alerts when they detect faults, helping to prevent situations that could lead to disease outbreaks (Baracho & Tolon, 2024).
Virtual training and simulators **Online training and capacity building**: Digital platforms can be used to train farm workers in good health management and biosecurity practices, including the correct use of protective equipment, medication management, and response to disease outbreaks. Virtual reality (VR) simulators can also be used to create management scenarios, allowing workers to practice responding to biosecurity emergencies without risk to animals (Matozo et al., 2023).

Table 1 – Technology applied in animal production

FINAL CONSIDERATIONS

Animal protein production is an activity of paramount importance for Brazilian agribusiness. Given the risk and losses involved when a disease spreads, it is essential to adopt more rigorous measures to avoid situations such as the one that occurred in the municipality of Montenegro (RS) in May 2025. Therefore, using technological advances to complement existing biosecurity efforts is a viable and promising alternative for the sector.

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