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RFID TECHNOLOGY FOR MONITORING AND TRACEABILITY IN PORK PRODUCTION

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Abstract: Pork protein production is a very significant activity for Brazilian agribusiness. Producers are seeing the need to adapt to the demands imposed by national standards and the international market, to ensure productivity, quality, traceability and animal welfare. In this context, the development of technologies that enable the integration of these factors in favor of better and more efficient production has been gaining ground. Data collection and transmission technology through the RFID system is one possibility to meet these demands. This paper presents a proposal for monitoring and traceability of pork production using RFID technology. The proposal includes the implantation of a microchip in the animal equipped with a data reading system, in addition to a temperature sensor to monitor its health status. Based on the data collected and sent to a system, the system can analyze and identify anomalies to allow assertive decision-making, aiming at greater efficiency in the production process. Financial analysis will also be performed.
Keywords: pig farming, traceability, welfare, RFID, technology

INTRODUCTION

Pig farming is undoubtedly one of the highlights of Brazilian agribusiness. Brazilian pork production was 5.1 million tons in 2023, making Brazil the 4th largest producer and exporter in the world, with 1.2 million tons exported, representing 120 billion of the national GDP, generating 4 million direct and indirect jobs, according to data from the latest annual report of the Brazilian Animal Protein Association (ABPA, 2023). However, many importing markets, such as the European Union, require production traceability, which is the ability to identify the origin and follow the movement of a product of animal origin during the production, distribution and marketing stages, both of the raw materials and of the ingredients and inputs used (BRASIL, 2020). Traceability is necessary to identify a product from its origin, providing management of the production chain, since it aims to guarantee animal welfare, food safety, consumer confidence and regulatory compliance, and is a requirement of the Ministry of Agriculture, Livestock and Supply (M.A.P.A.).

Traceability is the first step to meet the demands of consumers around the world, who are becoming increasingly demanding regarding the quality and safety of food. Producers need traceability as a management tool, for collecting and recording zootechnical and handling data. Commercial companies want identification so that they can offer their customers quality products of known origin (DILL; VIANA, 2012). Finally, consumers are increasingly interested in the origin of the meat they consume and especially in the way these animals are raised. Transparency with consumers regarding the origin of food is necessary to give credibility to businesses (EXAME, 2017). For the agribusiness chain, subject to increasing pressure to comply with sustainability standards, traceability is synonymous with strategy, helping to meet demands for animal welfare and compliance with environmental protection standards.

To increase production and consequently their share of the global protein production market, Brazilian producers need to invest in ways to maximize production. One way to achieve this is to automate and take care of the health of the herd. In terms of health, investing in actions that prevent and anticipate the diagnosis of diseases is an advantage to be gained.

In addition to traceability being a requirement of Brazilian legislation and meat-buying markets, other requirements are causing producers to review their breeding systems, such as good management and animal welfare practices for commercial pig farms, introduced by the 2020 M.A.P.A. normative instruction (BRASIL, 2020). The regulation establishes deadlines for producers to adapt in several aspects, including the prohibition of aggressive behavior and the need for daily assessment of animals to identify possible health and welfare problems. Old practices must be left aside, and technology will gain space for producers to adapt to the recommendations.

In the process of modernizing pig farming, the adoption of new technologies has been gaining notoriety, translating into improved production rates and sustainable production. This is evident when observing the transformations and advances in facilities, health, nutrition, genetics, and welfare. There is currently talk of pig farming 4.0, referring to the fourth industrial revolution, which brings monitoring of zootechnical data through the use of technological tools, such as the internet of things and big data.

Despite Brazil's advantage in pork production due to the high health status of its herd, we still have a great lack of culture regarding disease prevention and implementation of biosafety measures, which ends up leaving animals vulnerable to the entry of new diseases. Leal et. al (2018) point out in their study three bottlenecks in pig farming today: adequate data management, disease prevention and animal welfare.

Among the systems and technologies already used in favor of animal production, some combinations can bring positive results. RFID (Radio Frequency Identification) wireless communication technology was developed for the purpose of identifying and tracking objects, animals, products and other items using radio frequency.

It is a technology that, despite having existed for a few decades (WEIS, 2007), has shown great growth in the IoT (Internet of Things) sector (ALHARBE et. al, 2013; DUROC, 2022) and takes advantage of the general trend in the technology industry towards reducing the size of electronic components. The main purpose of this system is to collect data quickly and remotely, in order to facilitate the management of the process in which it is involved, particularly in the areas of identification and security (NEUSTUPA, 2015). To this end, communication via RFID uses unique identification tags and readers, which generally have an amplifying antenna attached (ALHARBE et. al, 2013). In addition, for the processing and interpretation of data, applications and other software are required to assist the decision-maker. Thus, this work aims to conceptualize and propose a technological tool, RFID, for monitoring and traceability of pigs in Brazil, improving the management of zootechnical data, preventing and diagnosing diseases early, in addition to meeting the needs and requirements regarding animal welfare. RFID technology will be explored with a focus on the management of a pig farm, through data collection and storage, and control applications, enabling the implementation of Industry 4.0 in pig farming, through a constant monitoring system. Using the implant of a microchip, going beyond the technology currently adopted (TEKIN et. al, 2021), adding systemic functionalities and temperature sensors. Thus, it will be possible to improve strategic decision-making and facilitate the detection of anomalies, which can be caused by factors such as diseases or management failures, in order to reduce production losses.

METHODOLOGY

The following will present the proposal for monitoring and traceability technology in pig farming through the microchip implantation system and the use of RFID technology.

RFID TECHNOLOGY

The RFID; Radio-Frequency Identification, is a wireless data transmission technology that allows identification and communication between objects and readers, also known as tags and readers, respectively (ALHARBE, 2013). This technology has several technical layers, using read-write or read-only transponders, which transmit information through an induction field. In addition to requiring little or no maintenance, its lifespan is practically unlimited (DUROC, 2022). The RFID system can operate in three ways – active, passive or semi-passive, depending on its components and the compatibility between them (DUROC, 2022). Passive tags do not have their own power source; they depend on the radio frequency field emitted by the reader to operate, remaining turned off without reading or transmitting data while not in use. In active communication, on the other hand, tags have their own power source, usually batteries, to power a radio frequency transmitter, and are capable of transmitting information continuously.

Semi-passive tags – also called BAP (Battery Assisted Passive) tags – use a battery to power the tag circuit and more specific sensors, such as accelerometers and gyroscopes, for example, but transmit information in the same way as passive tags. The tag returns the received radio frequency signal through the principle of electromagnetic wave reflection, emitting its own signals back to the antenna, as shown in Figure 1.

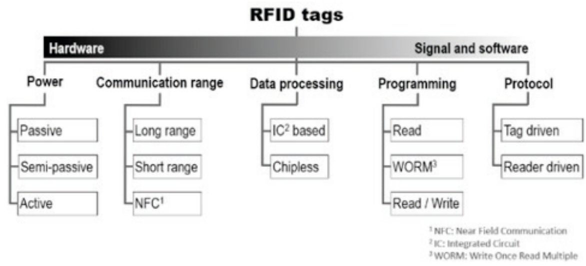

Figure 1: different types of RFID tag classification

Source: From Identification to Sensing: RFID Is One of the Key Technologies in the IoT Field (DUROC, 2022).

These radio signals can have different frequency ranges and must be compatible with the components involved in the system. In general, radio frequency ranges are usually classified as follows, according to Duroc (2022):

- Low Frequency (LF): 125-134 kHz
- High Frequency (HF): 13.56 MHz
- Ultra High Frequency (UHF): 860-960 MHz
- Extremely High Frequency (EHF): 24-30 GHz

Each operating range will be associated with a different reading distance. In an ideal environment, ignoring interference caused by air and other materials present, the operating distances and ranges can be classified according to Figure 2.

	PASSIVE			ACTIVE
FREQUENCY	LF	HF & NFC	UHF	UHF-µW
	125/134 KHz	13.56 KHz	860-915 MHz	433 MHz-5.8 GHz
READ DISTANCY	max. 50 cm	max. 1 m	max. 15 m	max. 300 m
TAGS	small, cheap, easy to produce			more expensive own battery

Figure 2: RFID tag reading distance

Source: AUCXIS – RFID Solutions.

The identification chips available on the market use low-frequency models, which are highly efficient in communicating small amounts of data over a short distance, rarely greater than 10 mm between the chip and the reader.

Therefore, for this study, we will use passive ultra-high-frequency technology in the range between 860 MHz and 960 MHz, due to the need to monitor multiple units simultaneously over a greater distance, considering standard pens in a pig finishing system. The recommendations contained in the Manual of Good Agricultural Practices in Pig Production (EMBRAPA, 2011) will be considered as standard pens, considering 1 m^2/pig (100 kg) with sheds measuring 8-12 m wide, 3-3.5 m high and variable length depending on the number of animals housed.

IMPLANT

The chip will be inserted into a biocompatible glass capsule – borosilicate (KIDO, 2011), partially coated with anti-migratory material. Thus, the implant must be placed in the most appropriate location to make the most of the sensors and minimize the possibility of interference in the reading, also reducing the possibility of rejection, allergic reactions or inflammation. The anti-migratory material will bind to the animal's tissue, in its subcutaneous tissue, fixing the capsule in place shortly after application.

One of the most innovative substances in this field is Parylene, a synthetic polymer that is already used in medicine as a coating for implants in humans, and has proven to be extremely important in maintaining the safety and durability of implants (HAO et. al, 2023). Parylene acts as a barrier protecting both the implant holder and the device itself. The material prevents the penetration of body fluids, which could cause corrosion, deterioration and even, in the worst cases, leaching of components into the bloodstream – a chemical release process that could lead to poisoning.

The substance also acts as electrical insulation, reducing interference and short circuits that can occur if the wearer comes into contact with electricity (COELHO et. al, 2023).

All these positive points are confronted by an important counterpoint: its cost. The process of deposition of this polymer is complex and requires specialized equipment, which makes it more expensive than other types of coating, even though its benefits are superior (KIM et. al, 2013). Figure 3 shows a representation of electronic boards coated with the suggested material (Parylene), and the same boards without the coating.

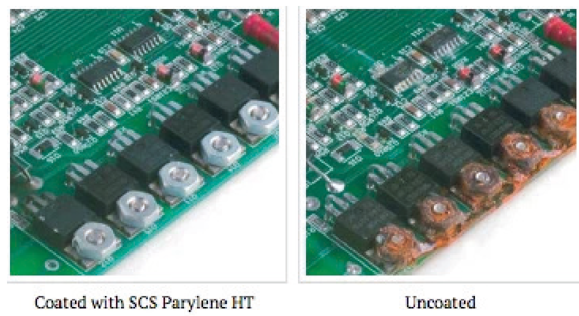

Figure 3: electronic boards with and without Parylene coating.

Source: KISCO Specialty Coating Systems, Inc.

MONITORING SYSTEM

The management interface will be developed using bootstrap, a framework that works with several markup and programming languages to create responsive websites that automatically adapt to different screen resolutions (SHAHZAD, 2017). PHP (Hypertext Preprocessor) will also be used, a scripting programming language used to create dynamic web applications, and supports a variety of databases, including MySQL (PHP Group). MySQL is an open source data storage and control database, which makes it very reliable and compatible with all common providers (OHYVER, et. al, 2019). Thus, database management can be linked to the traceability module of the Agricultural Management Platform (PGA) (BRASIL, 2015). The database of this project uses SQL (Structured Query Language) to manage and manipulate data. The system will therefore have functionality for registering new animals, monitoring information in real time, recording and updating data, scheduling scheduled readings, and generating reports manually and automatically.

The following data will be used to register each animal:

- Animal Registry Number.
- Date of registration and identification of origin.
- Name of animal, size, sex, breed or lineage, color.
- Age (real or presumed).
- Data on animal health, reading history (microchip sensors), vaccinations, reproductive status, feed conversion, weight.
- Individual records of states, such as designation pen, transfer, change of breeding phases, slaughter.
- Individual records of occurrences.

To manufacture the chip, components already on the market will be required. A temperature sensor associated with the RFID chip with a transponder consisting of a unique identification code, antenna and capacitors to maintain its operation for a period after activation, as shown in Figure 4.

Chip readings will be performed periodically, either manually or automatically, at intervals defined by the manager. Data will be collected using RFID antennas associated with an integrated reader, programmed in proprietary software from the device manufacturer. The reading system will have a maximum RF power of 26 dBm, will support the ISO 18000-6C and 18000-6B protocols, and will operate in the 902 to 907 MHz and 915.1 to 928 MHz bands, with a reading distance of approximately 6 meters – with a reduced final range due to environmental interference and the subcutaneous position of the implants (MURAMATSU; KODAMA, 2023). The antennas will be positioned every 4 meters, installed at a maximum height of 3 meters, with their faces facing the animal enclosure.

The infrastructure will follow the communication via network cables to the computer that manages the server. The data will be automatically entered directly into the logical database, which will be integrated with the databases of the Ministry of Agriculture and Livestock (MAPA) via network protocols, meeting all the requirements of the normative instruction that establishes the PGA (BRASIL, 2015). In this system, measurement standards will be defined according to veterinary parameters. These standards will serve as internal benchmarking for comparison with the readings taken, and any changes can be handled quickly and in a targeted manner. Figure 5 represents a basic diagram of the project's structure and operation.

The assessment of changes in body temperature has long been the subject of study due to its correlation with diseases. According to Adams (1990): "Hippocrates discovered that when a part of the body is hotter or colder than the rest, it is an indication that disease is present in that part". Small thermogenic changes in specific tissues may reflect diseases or changes in physiological function. These changes can be regulated by measurements and non-drug treatments (SCOLARI, 2011). Sensitivity of reading temperature patterns refers to the amount of temperature difference that can be detected and is measured in degrees Celsius. Sensors with moderate sensitivity can detect temperature differences in the order of 0.1ºC and those with good

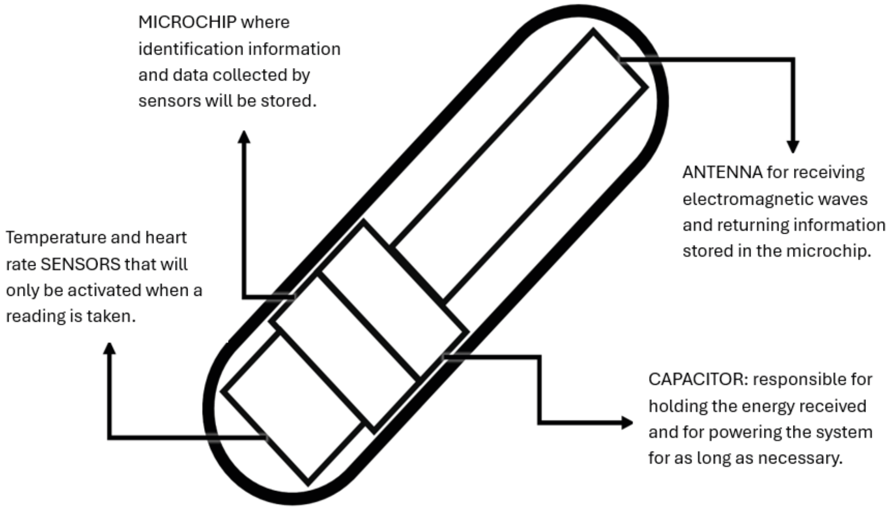

Figure 4: Basic schematic of the implant structure

Source: Authors

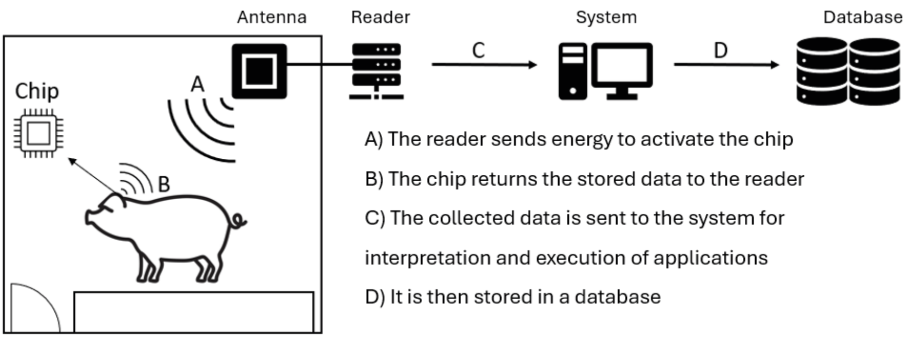

Figure 5: Basic diagram of how the project works

Source: Authors

sensitivity can detect up to four times smaller or 0.025ºC. Thermometry, associated with other techniques, such as clinical examination, has the potential to be an auxiliary tool in the diagnosis and prognosis of several changes. Among them, a well-being assessment can be carried out so that correct control of the environment can be carried out. Despite being homeothermic animals, pigs do not have a well-developed thermoregulatory system. One well-studied explanation for this is the fact that they do not have functional sweat glands (BERTON, 2013). Thus, thermal comfort and body temperature fluctuations are well studied and evaluated in order to maintain the best health and management standards.

DISCUSSION

The proposal presented in this study meets national and international requirements (BRAZIL, 2020; BRAZIL, 2015; FARM ANIMAL WELFARE COUNCIL, 2009) regarding both monitoring and traceability of the herd, but mainly in terms of promoting welfare.

The demand for clean, healthy and safe products is growing rapidly in the global market, especially with regard to food of animal origin. Thus, the need arises for producers to have technological instruments that assist in production management, inspection, and collection of zootechnical data from birth to slaughter to obtain quality, food safety, efficiency and effectiveness in production (DILL, VIANA, 2012). Technology is already a reality in modern pig farming, and has been undergoing adjustments and improvements.

To ensure traceability in swine production, there are several systems that have been studied and proposed that can be applied, such as traditional, electronic, biometric and even those that use laboratory tests, such as DNA analysis. These are chosen by producers according to their accessibility, cost and practicality of operation. In traditional systems, numbered plastic earrings, ear tags and tattoos are easily read by humans and are a relatively inexpensive technology (PEREIRA, 2000). Ear tags, which despite being a limited system, as they allow individual control of up to 1,599 animals, are also a painful and difficult process to apply, not compatible with animal welfare standards. The tattoo may fade over time, making it difficult to see. Plastic earrings may fall off or be removed by other animals; reading errors and impurities may be fixed in the bar code/numbers, making reading difficult or impossible (DILL, VIANA, 2012).

Electronic systems include earrings, rings, collars with transponders, and subcutaneous transponders. Identification by subcutaneous transponder is fast and accurate, including during the slaughter stage (INDUSTRIAL PIG FARMING, 2022). Earrings and collars with chips are used by some producers, but they still represent many errors, mainly because they are easily removed by the animals themselves out of curiosity, and during the slaughter stage they are easily removed, losing traceability if another method or control is not applied. The only disadvantage of subcutaneous chips is reports of migration and loss of reading (DILL, VIANA, 2012). In our system, with the use of Parylene, the implant becomes anti-migratory and the collected data is not lost. After standardizing the chip application site, there will also be no problems in terms of food safety, since the implant is considered a foreign body.

Biometric systems are performed by reading the retina or scanning the iris. The blood vessels in the retina are unique to each animal and stable throughout its life. In the iris, their designs are unique to each animal and stable over time, but it is not known when they stabilize (INDUSTRIAL PIG FARMING, 2022). Unfortunately, this method has the disadvantage of taking a long time to obtain a reading of the animal's retina/iris and of frequently needing to control the animal, in addition to the high cost (DILL, VIANA, 2012).

As is already the case in precision livestock farming, pork production needs to consider a digital management system that continuously measures the production, reproduction, health, and well-being of the animals in the herd through the use of information technology tools (TEKIN et. al, 2021). In conventional production, decisions are based on assessments, judgments and experience of producers, veterinarians and farm workers. The growing demand for production and the high number of animals in herds make this type of monitoring difficult without the use of technology. One person is not capable of monitoring an animal 24 hours a day. Using technological tools helps in the collection and analysis of data and makes decision-making more assertive.

CONCLUSION

Meat production needs to combine animal welfare, ethics, traceability and sustainability requirements to become competitive and efficient, and this becomes much easier and more reliable when real data is obtained and analyzed using information technology. Monitoring through the implanted chip and data collected via RFID system allows producers to have quick access to indicators that are essential for managing and conducting their business, in addition to meeting the requirements of regulatory agencies and the consumer market. This is the proposal of our application, which still requires further studies, especially in terms of cost analysis and economic viability, but which will be the next steps to be explored.

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