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Optimizing poultry production using RFID-based monitoring systems: A review article

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Abstract
The poultry industry has witnessed rapid growth driven by rising global demand for affordable animal protein. However, this expansion brings challenges such as maintaining animal welfare, improving production efficiency, managing disease outbreaks, and ensuring product traceability. Traditional monitoring methods are often labour-intensive and prone to errors, limiting timely decision-making in intensive poultry farming systems. Radio-Frequency Identification (RFID) technology offers a promising solution by enabling automated, real-time data capture on individual bird behavior, health, and movement. This review highlights the multifaceted role of RFID-based monitoring systems in optimizing poultry production. Beyond basic identification, RFID facilitates detailed tracking of laying patterns, feeding and drinking behavior, and locomotion, providing critical insights into welfare and productivity. Expanded applications include vaccine administration monitoring to ensure efficacy, supply chain and cold chain management to maintain product quality, and enhanced traceability from hatchery to market. Furthermore, RFID systems contribute to antibiotic usage reduction by supporting early disease detection and precise health management, promoting sustainable poultry farming. The technology also aids in selecting and managing disease-resistant flocks, aligning with global efforts to combat antimicrobial resistance. Challenges such as tag durability, data integration, and system costs are discussed alongside emerging trends integrating RFID with IoT and AI for advanced analytics. Overall, RFID-based monitoring presents a transformative opportunity to enhance poultry health, welfare, and operational efficiency, paving the way for smarter, more sustainable production systems.

Keywords: RFID, traceability, vaccine efficacy, cold chain management, antibiotic reduction, egg tracking; supply chain management, disease resistance, smart farming

1. Introduction
The poultry industry has experienced significant intensification over recent decades to meet the increasing global demand for affordable protein sources. This intensification, however, presents several challenges including maintaining animal welfare in high-density housing, managing health issues, minimizing product recalls, and addressing the growing concern of Antimicrobial Resistance (AMR) due to excessive antibiotic use. Ensuring the welfare and health of poultry flocks while maximizing productivity requires accurate, continuous monitoring systems that can provide real-time insights into individual bird behavior and environmental conditions.
Radio-Frequency Identification (RFID) technology has evolved substantially from its initial use in inventory management to a critical tool in precision livestock farming. In poultry production, RFID facilitates automatic, non-invasive identification and tracking of individual birds, enabling detailed data collection on feeding, drinking, movement, and laying behaviors. This technological advancement not only enhances operational efficiency but also improves traceability and transparency throughout the supply chain, from producer to consumer.
This review article aims to provide a comprehensive overview of RFID applications in poultry farming, focusing on its multi-domain role in optimizing production. We explore RFID's capabilities in vaccine administration and efficacy monitoring, supply chain and cold chain management, egg production tracking, antibiotic usage reduction, and disease resistance monitoring.

By synthesizing current research and practical implementations, this review highlights how RFID-based monitoring systems contribute to sustainable, smart poultry farming, addressing both industry challenges and consumer demands.

2. RFID Technology Overview

Radio-Frequency Identification (RFID) technology has become fundamental in poultry production for tracking and monitoring individual birds efficiently. According to Chien and Chen (2018) [2], low-frequency (LF) RFID tags are widely applied in laying hen monitoring within nest boxes due to their short read range and robustness against interference from metals and liquids commonly found in poultry environments. These tags enable precise individual identification, essential for accurate egg production tracking.

But, demonstrated the advantages of ultra-high frequency (UHF) RFID in broiler houses, where longer read ranges facilitate monitoring of feed and water intake in group-housed birds. This approach allowed detailed analysis of feeding behavior, helping optimize nutrition and health management.

High-frequency (HF) RFID systems have also been used effectively in poultry for tracking movement and activity patterns within housing systems. As described by Pereira *et al*. (2019), HF RFID supports welfare assessment by monitoring bird mobility and space use.

The RFID tags vary as passive, active, or semi-passive types depending on their power sources and read capabilities. Passive tags, powered by the reader's signal, are most commonly used due to their light weight and cost-effectiveness. Active tags, which have internal batteries, provide longer read ranges but are less frequently used in poultry farming because of their size and cost.

A RFID system comprises tags attached to poultry (leg or wing bands), fixed readers placed at feeders, drinkers, or nest boxes, and antennas that enable communication. The data collected is processed and stored in backend cloud systems. As noted by Gonzalez *et al*. (2020), integration of RFID with Internet of Things (IoT) platforms allows real-time monitoring and smart decision-making, increasing farm efficiency and welfare management.

Each RFID frequency band has trade-offs: LF offers reliability and interference resistance with limited read range; HF provides moderate range and memory; UHF delivers long read distances suitable for large-scale operations but can be affected by environmental factors such as dust and moisture. This was studied by Kim *et al*. (2021), who emphasized the importance of antenna positioning and system calibration for maximizing read accuracy in commercial poultry operations.

Overall, RFID technology provides a powerful, adaptable tool for poultry producers to improve traceability, welfare, health monitoring, and production efficiency through precise, automated data collection.

3. Applications in Poultry Farming

3.1 Production Parameters

3.1.1 Body Weight and Growth Performance

RFID-enabled automatic feeders and weighing systems allow precise monitoring of body weight gain relative to feed intake. Perelman *et al*. (2021) [13] demonstrated that abnormal feeding behaviors correlated with reduced growth performance, enabling early detection of underperforming birds.

3.1.2 Carcass Traits

Carcass yield and quality can be indirectly predicted through feed intake and weight gain monitored by RFID. Van der Sluis *et al*. (2020) [17] confirmed that locomotion and feeding data collected via RFID systems could be correlated with carcass characteristics.

3.1.3 Feed Intake and Feed Efficiency

Tracked over 600 broilers and found that birds with regular feeding interval exhibited better weight gain and feed conversion ratios (FCR). Their study revealed a 10-15% improvement in FCR when feeding data was used to tailor a nutritional strategies. Perelman *et al*, (2021) [13] demonstrated that abnormalities in feeding frequency and duration detected by RFID feeders served as early biomarkers for disease outbreaks such as Avian influenza and Newcastle. Early detection allowed for targeted treatments reduced the flock mortality by approximately 30% and lowered the use of antibiotics by 20%.

Monitor feeder access through RFID and found the dominant birds accessed feeders more frequently, sometimes led to suboptimal nutrition for lower ranking birds. This insight has prompted design improvements and feeding system to ensure equitable access.

3.1.4 Water Intake

Water consumption monitoring using RFID equipped drinkers has also been showed to be a vital welfare indicator Santos *et al*., (2020) documented a 25% reduction in water intake during heat stress condition, which corresponded with increased incidences of dehydration and heatstroke. These real time alerts enable the farmers to implement cooling measures from promptly and to reduce mortality rates by up to 18 %.

3.1.5 Egg Production and Quality

The use of low frequency (LF) RFID in smart nest boxes allows for precise industrial level monitoring of egg laying patterns. Chein and Chen (2018) [2] demonstrated that integrating RFID with automated nest boxes enabled detection of temporal laying patterns with 98% accuracy. This system significantly reduced labor and human error associated with manual egg collection and recording.

Reported that RFID system enabled real time identification of hens with declining production facilitated. Timely management decision such as nutritional adjustment or health interventions. This study across several commercial layer forms showeded 12-15% increasing overall flock egg production and a 7% decrease in egg breakage rates due to better management.

Utilised RFID data combined with environmental sensors to correlate egg production with light exposure and the temperature revealed that hens laid eggs more consistently when environmental conditions that were optimized.

Wang *et al*, (2020) [19] integrated RFID system with egg quality sensors capable of measuring parameters like egg weight, shell strength and internal characteristics. Their research revealed strong correlations between hen activity and laying behaviors recorded through RFID and egg quality outcomes.

3.1.6 Nutritional Management

Perelman *et al*. (2021) [13] demonstrated that feed intake data from RFID allowed nutritionists to adjust dietary formulations dynamically, particularly under stress conditions. This supports sustainable nutrient utilization and cost reduction.

3.2 Welfare Monitoring

3.2.1 Comfort and Stress Assessment

Marchewka *et al*, (2021) [10] used RFID to monitor movement ranges in free range laying hens and found that individuals with restricted spatial movement exhibited significantly elevated corticosterone levels a physiological stress marker. These stressed hens produced eggs with measurable decline in shell thickness (up to 12 % thinner) and egg weight (approximately 8% reduction) demonstrating a direct link between welfare and productivity. RFID tracking enabled the identification of spatial avoidance behaviors possibly related to social stress or environmental discomfort, offering opportunities to adjust the housing conditions to promote both welfare and egg quality.

Dawkins *et al*, (2019) [3] employed RFID activity tracking to quantify hen interactions with enrichment devices in large commercial houses. Their research showeded hens in enriched environment demonstrated significantly increased voluntary movement .By using RFID data they revealed birds in enriched environment showeded 40% higher usage of perches and 35% increased dust bathing compared to barren environments. These activity patterns correlated with reduced feather pecking and lower corticosterone concentration, suggesting lower stress levels. The precision of RFID allowed researchers to pinpoint periods of high enrichment use, informing better management strategies to enhance welfare sustainably.

3.2.2 Behavioural Monitoring

RFID was used to map individual hen movement patterns. Hens exhibiting reduced daily activity were more proneto disease such as coccidiosis and footpad dermatitis. Specifically, low mobility birds consume 20-25% less feed and had a 15% reduction in egg production compared to more active counterparts.

Similarly, Liu *et al*, (2022) [18] track a locomotion in broilers and discovered that birds with loco motor activity below the flock average by 30% had a 2.8 fold increased risk of leg deformities and related mortality. This data supports RFID's role in selective breeding and early intervention. It demonstrated the utility of RFID based activity mapping to detect early signs of lameness in commercial broiler flocks. They equipped the birds with RFID tags and continuously monitored their movements and they observed that birds exhibiting a 30% or greater reduction in daily locomotion within the first three weeks were highly likely to develop clinical lameness symptoms later in the production cycle.

3.3 Health Monitoring

3.3.1 Disease Detection

Smith *et al*. (2020) [15] reported that respiratory infection such as Infectious bronchitis and Mycoplasma gallisepticum infections caused measurable changes in feeding and movement patterns well before clinical symptoms were observable. Using RFID data, infected birds showeded a 30% reduction in feeding visits and irregular movement trajectories up to 72 hours prior to cough or nasal discharge appearance. This early detection allowed a farmer to isolate affected individuals and implement targeted treatment promptly, leading to a 25% reduction in flock wise antibiotic use.

3.3.2 Vaccine Efficacy

Martinez *et al*. (2021) [4] RFID tags combined with temperature and activity sensors allowed for detailed tracking of individual bird responses following vaccination. Then study on broilers vaccinated against Newcastle diseases virus demonstrated that subtle fluctuations in activity levels and body temperature detected by RFID linked wearable sensors served as early biomarkers of the immune response.

3.3.3 Antimicrobial Resistance (AMR)

The value of RFID in antibiotic reduction is amplified when integrated with automated health management platforms. Reported the development of an RFID based decision support system that analyzes behavioral and environmental sensor data to recommend precise antibiotic treatments or alternative interventions such as probiotics and vaccines.

Demonstrated that farms implementing RFID based health surveillance had significantly lower residue detection rates during routine product testing, enhancing market access and consumer trust.

3.3.4 Breeding and Genetic Selection

Gonzalez *et al*. (2021) [4] demonstrated that RFID could be used to monitor traits related to disease resistance and feed efficiency, enhancing genetic selection programmes.

The continuous, detailed dataset generated by RFID enabled egg tracking and the quality assessment creates a powerful feedback loop for improving genetic selection and nutrition strategies. By monitoring individual hen productivity along side egg quality, producers, and breeders can select superior birds that consistently produce high quality eggs under commercial condition. Furthermore, RFID data facilitates dynamic nutrition adjustment tailored to individual or subgroup needs within the flock. For instance, Wang *et al*, (2020) [19] demonstrated that birds with reduced laying frequency with good equality responded well to diet formulations enriched in specific amino acids and minerals, improving both production and egg characteristics.

3.3.5 Biosecurity and Access Control

Jensen and Soresen (2019) [6] implemented RFID-based entry systems at poultry farms facilities to regulate and monitor human and equipment access to sensitive areas such as poultry houses and feed storage. Each authorised individual or piece of equipment was equipped with RFID tags, and readers installed at entry points logged all movements in and out of the premises.

3.3.6 Disease Outbreak Management

Jorgesen *et al*. (2022) [7] combined RFID data with environmental parameters temperature, humidity and physiological sensors measuring heart rate and respiratory rate in vaccinated laying hens. They found the deviation from baseline activity and vital signs correlated strongly with vaccine induced the stress and early infection markers. In the study prolong elevated respiratory rate with decreased RFID monitored activity were diagnose early in birds suffered with Infectious coryza enabled pre-emptive treatment and reduced mortality by 20%.

Nguyen *et al*, (2021) used RFID monitoring to compare responses to different vaccine formulations and administration routes in activity and feed intake compared to intramuscular injection groups, suggested lower vaccine induced stress and faster recovery.

3.4 Supply Chain Management

3.4.1 Cold Chain Monitoring

Nguyen and Tran (2019) [12] emphasized RFID'S critical role in identifying cold chain disruptions during refrigerated poultry shipments. Their research employed RFID enabled data loggers that the recorded temperature fluctuations with minute level granularity inside transport containers. They found the even short-term spike above recommended temperatures often missed by manual checks and accurately captured and provided objective evidence of coldchain breaches. This information facilitated swift response such as rerouting shipments, adjusting refrigeration settings, or rejecting compromised batches before they reached retail outlets. The ability to pinpoint where and when temperature excursions occur improves accountability among stakeholders and reduces the risk of food borne illness caused by microbial proliferation.

Li and Chen (2022) [19] utilized RFID data to optimize refrigeration cycles in poultry cold storage facilities. By analyzing real time temperature profiles and product movement, they proposed dynamic cooling schedules that reduce unnecessary energy use during low demand periods while ensuring product safety. Their model demonstrated a potential 18% reduction in electricity consumption, contributing to lower greenhouse gas emissions and cost savings for producers and distributors.

3.4.2 Traceability

According to Zhao *et al*, (2020) [19] RFID tagging of poultry products begins at the farm, where individual batches or packages are assigned unique RFID tags embedded with data on flock origin, vaccination status, and processing details. This creates a digital pedigree that travels with the product throughout the supply chain. This approach resulted in a 15% reduction in product loss due to temperature abuse and enhanced compliance with food safety standards such as HACCP and ISO22000. Described RFID enabled Block chain integration, where product history ranging from farm conditions to processing and logistics is immutably recorded and accessible to consumers via QR codes linked to RFID tags. This traceability empowers consumers to verify product authenticity, ethical sourcing and freshness, building trust and supporting premium pricing for high quality poultry products.

Singh *et al*, (2020) [8] showed that transparency enabled by RFID traceability positively influences purchasing decisions and willingness to pay premium for ethically produced poultry products.

4. Challenges and Limitations

Despite demonstrated advantages, RFID technology in poultry production, several challenges and Limitations hinder its widespread adoption, especially among small scale producers and in varying operational practices.

The cost of RFID system remains a major barrier to adoption, particularly for small holder farmers according to Kumar *et al*, (2020) [8] expenses related to purchasing tags, readers, antennas and integrating environmental sensors can be substantial.

The performance of RFID systems can be compromised in wet, metallic or densely packed environments typical in poultry processing and storage facilities. Nguyen and Transport (2019) [12] reported that water and metal surfaces cause signal interference and reduce tag traceability, especially for HHF RFID systems.

The massive volume of data generated by RFID and integrated sensor network possess significant challenges in data storage, cloud uptime reliability, and real time analytics capabilities. Smith *et al*, (2020) [15] highlighted that effective data management requires sophisticated software platforms and skilled person eel to translate raw data into actionable insights. Farms without access to robust IT infrastructure or data science expertise may struggle to fully utilize RFID generated information.

The absence of universal RFID and cold chain management standards across regions and industries limits interoperability and data sharing between producers, processors and retailers. Gonzalez *et al*, (2021) [4] emphasized that varying frequency regulations, tag formats and data protocols complicate integration efforts in multinational supply chain. This fragmentation can undermine traceability goals and consumer confidence in product authenticity.

5. Future Prospects

The future of RFID in poultry production lies in greater accessibility and integration. Low-cost tags and smartphone-based readers (Tang *et al*., 2022) [16] are expected to encourage adoption by small-scale farmers. Artificial Intelligence (AI) and machine learning will enable predictive disease and welfare modelling from RFID data (Banhazi *et al*., 2019) [1]. Blockchain integration will further secure transparency and traceability (Li & Chen, 2019) [9]. Adoption in organic and free-range systems will also provide consumers with verified welfare credentials (Guo *et al*., 2021) [5].

6. Conclusion

RFID technology has emerged as a cornerstone in modern poultry production offering comprehensive benefits that span behavior monitoring, health management, vaccine efficacy evaluation and supply chain traceability. According to Chien and Chen (2018) [2] RFID enabled smart nest boxes facilitates precise egg production tracking, optimizing flock productivity and welfare. The work of Martinez *et al*, (2021) [4] demonstrated RFID's capacity to improve vaccine response monitoring by integrating physiological sensors, which aids in timely immunological assessments and reduces disease incidence. Zhao *et al*, (2020) [19] ensures product quality and safety from farm to fork, whole Smith *et al*, (2020) [15] highlight RFID's pivotal role in early disease detection that supports judicious antibiotic use, mitigating antimicrobial resistance risks. Despite these advantageous, and challenges such as high implementation cost, technical barriers in complex farm environments, and the need for advanced data analytics infrastructure remain significant as discussed by Kumar *et al*, (2020) [8]. More over the lack of global standardization complicated seamless data exchange along international poultry supply chains limiting broader adaptation Gonzalez *et al*, (2021) [4]. Looking forward, emerging technologies such as AI driven analytics and Blockchain integration promise to revolutionize RFID applications, offering predictive disease modelling and tamper-proof traceability systems that foster transparency and consumer confidence, as anticipated by Nguyen *et al*, (2021).

In conclusion while technical and economic challenges must be addressed, RFID technology when integrated with IOT, AI and Blockchain has the potential to fundamentally transform poultry farming into a smart, sustainable and welfare centric industry. These advancement will enhance the production efficiency, diseases resistance, product quality and market transparency, aligning poultry farming with future global food security and ethical standards.

Conflict of Interest

Not available

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Reference

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