

Research Article

The Role of Traceability in Ensuring Food Safety In The Indonesian Poultry Supply Chain (Study Case: PT Widodo Makmur Unggas)

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Abstract: Poultry is a major source of protein worldwide, and Indonesia is one of its largest consumers. Indonesia's poultry supply chain faces numerous issues, particularly in terms of food safety and traceability, despite its significant importance. Traceability is essential to track chicken goods from the farm to the store, where they are sold to customers. This research examines how PT Widodo Makmur Unggas Tbk (WMUU) currently tracks its products and how new technologies can enhance the safety of the food supply chain. By implementing several technologies that can operate as tracking devices, including IoT, RFID, and blockchain technology, tracking can be made easier. The results show how important it is to have a complete traceability system to maintain food safety and facilitate quick action in the event of contamination.

Keywords: Food Safety, Poultry Processing, Supply Chain Management, Traceability Systems.

I. INTRODUCTION

The poultry business is critical to meeting the world's protein needs, and in Indonesia, poultry is the most popular type of meat. As demand for chicken products increases, it is crucial to maintain a safe and open supply chain. The chicken supply chain is a single process that includes many steps, such as breeding and distribution. A lack of strong traceability is one of the biggest problems in this supply chain, as it compromises both food safety and quality.

Most of the poultry industry in Indonesia is controlled by major companies, such as PT Widodo Makmur Unggas Tbk (WMUU). Most of the people in the supply chain, meanwhile, are small-scale farmers. When there is an issue regarding food safety, this fragmentation makes it hard to follow the product's journey from farm to table. Poor traceability protocols make it hard to find out where the contamination came from, which slows down the response and raises the risk of foodborne illnesses. A significant portion of the poultry industry in Indonesia is controlled by major companies, such as PT Widodo Makmur Unggas Tbk (WMUU).

Meanwhile, most individuals in the supply chain are small-scale farmers. When there is an issue regarding food safety, this disintegration makes it hard to follow the product's journey from farm to table. Poor traceability protocols make it hard to find out where the contamination came from, which slows down the response and raises the risk of foodborne illnesses.

Traceability refers to the ability to track a product throughout all stages of manufacturing, processing, and distribution. It is an essential tool for reducing this risk. When you use a good traceability system, you ensure that food safety regulations are followed, goods are promptly recalled when necessary, and the public is confident that poultry products are safe. PT Widodo Makmur Unggas Tbk (WMUU) has made great strides in making its poultry products traceable, but there is still much to be done before it can fully utilize current technology.

This article examines how traceability aids in maintaining food safety within the Indonesian chicken supply chain. It examines the issues currently facing WMUU and assesses the potential use of the Internet of Things (IoT), Radio Frequency Identification (RFID), and blockchain technologies to improve traceability. The goal is to provide useful suggestions on how to address current issues and improve food safety practices in the industry. The poultry business is critical to meeting the world's protein needs, and in Indonesia, poultry is the most popular type of meat. As demand for chicken products increases, it is crucial to maintain a safe and open supply chain. The chicken supply chain is a single process that includes many steps, such as breeding and distribution. The lack of strong traceability is one of the biggest issues in this supply chain, as it compromises both food safety and quality.

In Indonesia, large companies such as PT Widodo Makmur Unggas Tbk (WMUU) dominate the poultry sector. However, most of the supply chain consists of small-scale farmers. When there is a question about food safety, this fragmentation makes it



difficult to trace the product's path from farm to table. Poor traceability procedures make it difficult to determine the source of contamination, which slows down the response and increases the risk of foodborne infections.

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This article examines how traceability aids in maintaining food safety within the Indonesian chicken supply chain. It examines the issues currently facing WMUU and assesses the potential use of the Internet of Things (IoT), Radio Frequency Identification (RFID), and blockchain technologies to improve traceability. The goal is to provide useful suggestions on how to address current issues and improve food safety practices in the industry.

II. LITERATURE REVIEW

A) Supply Chain Management (SCM)

Supply Chain Management (SCM) is important for making sure that things move smoothly from producers to consumers. SCM is the process of managing partnerships with customers, suppliers, and manufacturers. It focuses on coordination and communication (Chang & Chiu, 2010). SCM integrates various aspects, including demand management, sourcing, production, inventory management, and transportation, to deliver goods efficiently and safely (Pradana et al., 2022). The poultry industry's effective SCM maintains the production and delivery schedule, meeting customers' needs in a consistent and timely manner. The Internet of Things (IoT) and optimization methods make things even more efficient, which helps businesses cut costs and make more things (Jaswanth et al., 2023). SCM is a very important part of making sure that the products that chicken businesses sell are safe and of good quality. According to Windrawati et al. (2022), companies can remain competitive in a challenging market by offering customers goods that are safe and of high quality, with the ability to track them throughout the supply chain. This enables farmers to be well-informed at every step of the process, from breeding poultry to processing and selling.

B) Poultry Supply Chain

There are many steps in the poultry supply chain, such as breeding, hatching, farming, processing, and distributing the birds. At each stage, different problems arise that need to be addressed to ensure the quality, safety, and speed of the food supply chain. Farmers, slaughterhouses, and retailers need to work together to provide safe, affordable, and accessible poultry to consumers, especially as the poultry business has a major impact on global food security and economic stability. (Udoeye, 2024) In the chicken supply chain, the first step is to breed and hatch the birds. Parent stock is carefully chosen to ensure that the chicks have high quality. After chicks are hatched on farms, farmers need to track their food and health. The poultry is then slaughtered, cleaned, and packed as part of the processing. (Oloo et al. 2017) say that Hazard Analysis and Critical Control Points (HACCP) need to be followed for food safety at all stages to identify and mitigate hazards. Distribution is the process of moving the processed chicken to different places and making sure the products are in good shape as they get to the customers. Retailers need to store their products in the best possible way to avoid contamination.

C) Food Safety and Traceability

Keeping food safe is important for public health. It means taking care of risks at every step of the food production process, from handling to distributing products. Good traceability helps companies keep track of their products and ensure they are safe. The HACCP method helps identify and reduce risks in the production process (Azanaw et al., 2019). Food safety can be better managed with traceability systems in place, making the entire food supply chain transparent and accountable. Customer trust is gained when poultry farm companies provide transparency to address concerns for food safety. Traceability is a key idea in supply chain management, especially in the food and agriculture industry. It lets companies keep track of and confirm how things move through the supply chain, making sure the quality of the products and following the rules. (Guanqi & Husnain, 2022) When it comes to food safety, traceability systems help businesses identify and mitigate risks, ensuring that goods meet quality and safety standards. Blockchain technology has become an important tool for better traceability because it allows for reliable, decentralized tracking of goods from where they are made to where they are sold. Traceability is a very important part of making sure that food is safe and healthy for consumers. It helps find sources of contamination, make food safety better, and make recalls happen quickly when needed. Adding blockchain and IoT technologies together can improve tracking even more, making supply lines clearer and more efficient. (Sidarto & Hamka, 2021)

D) The HACCP system

The HACCP method is a way to keep food safe by finding and fixing possible problems throughout the whole production process. It includes finding risks, setting up critical control points (CCPs), and keeping an eye on these points to make sure they meet food safety standards. A lot of different industries, like poultry, use the method to keep Salmonella and Campylobacter

from spreading. (Goodrich-Schneider et al., 2012) Instead of relying solely on testing the finished product, the HACCP method emphasizes taking proactive steps to prevent contamination.

E) Halal Certification

Halal certification makes sure that chicken goods follow the rules for eating in Islam. This step includes making sure that the food for chickens, the way they are slaughtered, and the way they are processed all meet halal standards (Shahdan et al., 2016). In places like Indonesia, where there are a lot of Muslims, halal approval is becoming more and more important. At every step of the supply chain, from the farm to the slaughterhouse, strict checks are part of the certification process (Ikawati & Rahman, 2022). The Halal Product Assurance Agency (BPJPH) in Indonesia is in charge of making sure that poultry goods are certified as halal. To make sure that goods meet halal standards, the certification process checks that the animals were slaughtered humanely and that they were fed properly. Traceability is an important part of halal certification because it shows how the product was made, which builds trust with customers and makes sure that halal rules are followed (Saidin & Rahman, 2016).

F) Methodology

This research aims to provide insight into the importance of food traceability through the chicken supply chain in Indonesia. This research focuses on PT Widodo Makmur Unggas Tbk (WMUU). The author constructs a theoretical framework centered on issues related to food safety and traceability in poultry products. The writer employs qualitative methods to gather information from stakeholders within the poultry supply chain. The qualitative method will include interviews with business representatives, which will reveal WMUU's challenges in monitoring products and maintaining food safety. The research will review government regulations, company data, and business publications. This helps clarify the results and keeps them fit existing Indonesian poultry industry practices.

G) Data Collection Method

This research will use both primary and secondary data sources. The following list of the primary and secondary data sources used in this research:

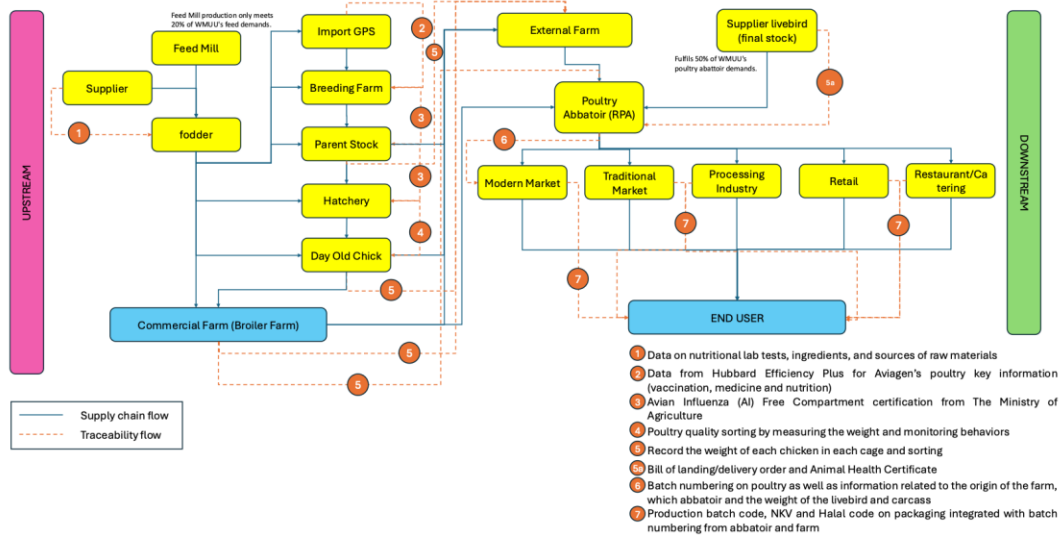
1. Interviews regarding the poultry supply chain and challenges faced by PT Widodo Makmur Unggas and gather feasible solutions for traceability and food safety practices.
2. Document analysis from reports, regulations, academic literature, and industry publications to support the primary data
3. On-site observations at poultry farms and processing facilities to assess the implementation of traceability systems and food safety practices.

III. RESULTS AND DISCUSSION

A) Traceability Practices

PT Widodo Makmur Unggas Tbk (PT WMUU) operates a vertically integrated poultry supply chain. It starts with importing Grand Parent Stock (GPS) from France and continues with breeding, hatching, and broiler-raising operations at its farms. The company produces Parent Stock (PS) for internal use and external sales, which are then transformed into Final Stock (FS) for processing at their slaughterhouse. PT WMUU utilizes a manual system that records health certificates, transit permits, and other paper-based documentation to manage poultry traceability. PT WMUU checks the documentation of health certificates and vaccines from poultry during the process of purchasing poultry from external suppliers. The company relies on manual and paper-based records throughout its supply chain to track information on its poultry products. After processing, products are stored in warehouses and managed through a Warehouse Management System (WMS). From there, they are distributed to retailers and consumers.

Figure 1: PT WMUU's Poultry Supply Chain Overview



PT Widodo Makmur Unggas' management team highlights significant challenges in ensuring effective traceability across the poultry supply chain, and their reliance on manual, paper-based systems for tracking poultry products is the primary issue. This leads to frequent data inaccuracies, such as inventory discrepancies, which result in financial losses. As PT WMUU's traceability system does not cover the entire supply chain and lacks real-time monitoring, it creates difficulty in tracking products as they move through various stages, from breeding to processing and distributing.

PT WMUU is addressing the issue by focusing on adopting a digitalized system for traceability, which may need the integration of IoT and RFID technologies to have real-time tracking of poultry products from breeding to retailing. This technological adoption will enhance the company's food safety practices, including the tracking of vaccines, medications, and chemical residues in poultry, and result in improved product quality and regulatory compliance. The transparency provided may improve customers' trust by adopting Blockchain technology, which offers immutable, accessible records of product origins and safety certifications.

The use of IoT and RFID technologies is expected to significantly enhance the operational efficiency of PT WMUU. By automating data entry and providing real-time tracking, companies can save time and money. These technologies can prevent costly mistakes, such as misplaced inventory or incorrect labeling, thereby enhancing operational efficiency. Additionally, being able to track poultry in real-time would help manage inventory more efficiently and improve decision-making by providing accurate, up-to-date data at all stages of the supply chain.

B) Feasibility of Traceability Technology

The potential technologies such as QR codes, IoT, RFID, and blockchain may be feasible to the traceability technology in the poultry supply chain, and the decision on which technology will be applied to a company will be influenced by factors such as technological infrastructure, financial considerations, regulatory requirements, and the readiness of stakeholders within the supply chain.

Assessing PT WMUU's technological infrastructure to determine the feasibility of implementing traceability technology, such as QR codes, IoT, RFID, and blockchain, is the first step to solving PT WMUU's issue with their inefficiency and human error due to the use of manual data entry and paper-based record in their poultry supply chain traceability. PT WMUU may need to upgrade its software and hardware to integrate into this technological infrastructure, which includes either RFID readers, IoT sensors, QR code scanners, or blockchain-supporting devices for the hardware, while for the software, the company will also need cloud-based platforms that can securely store and manage the traceability data to make sure the data collection and processing is effective. It will also be necessary to integrate with the existing warehouse management and financial tracking software to maintain seamless data flow and minimize problems during the transition to more advanced technologies.

Implementing traceability technology will provide PT WMUU with long-term benefits to consider, such as reduced operational inefficiencies, lower risks of foodborne illnesses, and increased consumer confidence. These benefits will require a significant initial investment, particularly for technologies such as RFID and blockchain. A cost-benefit analysis will help determine whether the proposed technologies are financially feasible for WMUU.

Table 2: Cost of Traceability Technology Solutions

QR Code & Plastic Leg Bands System				
Cost Category		Estimated Cost		Assumption
Technology Infrastructure	System Development	IDR150,000,000	IDR460,000,000	Labor cost: Development teams (front-end, back-end developers, and cloud specialists) can range from IDR 15,000,000 to IDR 30,000,000 per month, depending on their expertise. With a development team of 1-5 people , this would amount to around IDR 30,000,000 to IDR 150,000,000
	Cloud Hosting	IDR120,000,000		Cloud platform costs (e.g., AWS, Microsoft Azure, Google Cloud): IDR 5,000,000 - IDR 10,000,000 per month , depending on storage and data transfer needs. This is around IDR 60,000,000 - IDR 120,000,000 annually .
	QR Code	IDR50,000,000		Development of code generation algorithm: IDR 30,000,000 - IDR 50,000,000
	Plastic Leg Band Integration	IDR20,000,000		Software development for linking leg band information with poultry data and Integration of leg band scanning systems at various touchpoints in the supply chain (e.g., farms, processing plants)
	Mobile Scanner	IDR100,000,000		The cost for rugged mobile scanners for use in industrial environments (such as farm processing plants) typically ranges from IDR 5,000,000 to IDR 10,000,000 per scanner. This is based on common mobile barcode scanner prices from brands such as Zebra Technologies and Honeywell.
	Plastic Leg Bands Purchase	IDR20,000,000		Cost per leg band: IDR 2,000 per unit Quantity: 10,000 units for the first batch: $10,000 \times \text{IDR } 2,000 = \text{IDR } 20,000,000$
Employee Training on QR Code & Leg Band Integration		IDR200,000,000	IDR200,000,000	Training for 100 employees at IDR 2,000,000 per employee. This includes training on QR code scanning, leg band application, and using the cloud platform to track data.
TOTAL			IDR660,000,000	
Blockchain System				
Cost Category		Estimated Cost		Assumption
Technology Infrastructure	Blockchain Platform Setup	IDR120,000,000	IDR1,920,000,000	Cloud platform costs (e.g., AWS, Microsoft Azure, Google Cloud): IDR 5,000,000 - IDR 10,000,000 per month, depending on storage and data transfer needs. This is around IDR 60,000,000 - IDR 120,000,000 annually.

	Blockchain Development	IDR1,500,000,000		Blockchain developers typically cost IDR 30,000,000 - IDR 50,000,000 per month. Estimated Labor Costs: 5 developers over 6 months will total IDR 900,000,000 - IDR 1,500,000,000.
	Integrating Blockchain with Current WMS (Warehouse Management System)	IDR300,000,000		API Integration: To enable blockchain to communicate with PT WMUU's existing Warehouse Management System (WMS) and other internal systems (inventory management, health records, and product tracking). Labor Cost: The development of APIs and integration tools can cost anywhere from IDR 200,000,000 - to IDR 300,000,000, depending on system complexity.
Employee Training on Blockchain System		IDR200,000,000	IDR200,000,000	IDR 2,000,000 per employee for specialized training, which totals IDR 200,000,000 for 100 employees
TOTAL			IDR2,120,000,000	

RFID System				
Cost Category		Estimated Cost		Assumption
Technology Infrastructure	RFID System Development	IDR720,000,000	IDR1,190,000,000	Includes development of RFID system software, cloud integration, and setup of database and RFID registration. Based on development costs from IT development firms specializing in RFID systems, which charge around IDR 15,000,000 to IDR 30,000,000 per developer per month. Assuming 3-4 developers are needed for 3-6 months of development.
	RFID Tags	IDR50,000,000		Cost Per RFID Tag: The price per RFID tag typically ranges from IDR 5,000 to IDR 7,000 depending on quality and features (e.g., passive vs. active RFID tags). For 10,000 poultry items in the first year
	RFID Scanners	IDR120,000,000		For real-time scanning of RFID tags, PT WMUU will need mobile scanners at each key touchpoint (e.g., farms, processing plants, warehouses). Cost per scanner: IDR 12,000,000 per mobile scanner with prices from Zebra Technologies and Honeywell, assuming PT WMUU buys 10 devices

	System Integration	IDR300,000,000		Integration costs from WMS integration firms specializing in RFID and inventory management systems.
Employee Training on RFID System		IDR200,000,000	IDR200,000,000	IDR 2,000,000 per employee for specialized training, which totals IDR 200,000,000 for 100 employees
TOTAL			IDR1,390,000,000	

The cost of traceability technology indicates that the QR Code and Plastic Leg Bands system may be a cost-effective and quick-to-implement solution, as it addresses WMUU's immediate needs and requires a minimum budget of IDR 660,000,000. The RFID system, which costs IDR 1.39 billion, offers real-time tracking but requires a higher initial investment. The blockchain system has solid traceability and security features, but it'll cost IDR 2,120,000,000 and may be better for PT WMUU's long-term plan.

Table 2: Benefits of Traceability Technology Solutions

BENEFITS			
Benefit Category	Estimated Value Range (IDR/year)		Description
	Lower Bound	Higher Bound	
Avoided Losses from Inventory Discrepancies	IDR150,000,000	IDR200,000,000	Based on the actual financial loss incurred by PT WMUU in 2024.
Avoided Losses from Mislabeling/Packaging Errors	IDR150,000,000	IDR200,000,000	Estimated similarly to inventory losses.
Reduced Manual Data Entry & Reconciliation	IDR685,591,222	IDR685,591,222	20% labor cost saving from automation (20% of IDR 3,427,956,111)
Optimized Inventory Management (5% - 10%)	IDR1,499,149,308	IDR2,998,298,618	5%-10% savings of IDR 29,982,986,177 inventory.
Avoided Product Loss from Targeted Recalls	IDR150,000,000	IDR300,000,000	Based on recall frequency and volume.
Reduced Fines & Penalties (from recalls)	IDR100,000,000	IDR200,000,000	Based on regulatory penalty range.
Access to New Export Markets	IDR500,000,000	IDR1,000,000,000	Estimated incremental export sales.
Premium Pricing in Domestic Market (1% - 3%)	IDR548,006,057	IDR1,644,018,172	1%-3% of net sales IDR54,800,605,735.
Increased Sales Volume (1% - 3%)	IDR548,006,057	IDR1,644,018,172	1%-3% increase in IDR IDR54,800,605,735 sales volume from traceability.
Reduced Insurance Premiums	IDR74,465,516	IDR223,396,548	Estimated insurance cost savings, Based on 10% - 30% savings in IDR 744,655,162 insurance cost due to reduced risk.
Improved Supply Chain Risk Management	IDR200,000,000	IDR500,000,000	Faster response to risks reduces losses.
TOTAL	IDR4,605,218,160	IDR9,595,322,732	

Traceability technology is helpful for PT Widodo Makmur Unggas Tbk (WMUU) in terms of its finances, operations, and overall strategy. The company has the potential to save a considerable amount of financial resources annually by implementing effective inventory management strategies, reducing manual data entry, and minimizing errors that can occur due to mislabeling or incorrectly packaged items. Additionally, traceability systems will help make food safer, streamline recall processes, and reduce fines and penalties, all of which will directly impact the company's profitability. The technology also opens up new ways to get into international markets, charge higher prices, and sell more, which all lead to more money. Real-time tracking of products would also help with supply chain risk management, provide customers with more confidence, and reduce insurance costs. Traceability technology will help WMUU run its business better, make sure it follows all the rules, and make it more competitive in the market. The expected yearly benefits are expected to be somewhere between IDR 4.6 billion and IDR 9.6 billion.

C) Cost-Benefit Analysis

A common research tool that can help researchers determine if a planned project or intervention will be effective is the cost-benefit analysis, which compares the benefits to the costs. The possible costs and benefits of the project are carefully considered to help researchers determine whether the project is feasible and what effects it may have. The goal of CBA is to determine the value of benefits compared to the costs and to record these costs. According to Boardman et al. (2017), CBA is a crucial methodological tool that assesses the economic viability of a project or intervention by comparing its costs against its anticipated benefits. In this case, CBA means figuring out and quantifying the costs, like initial investments, operational costs, and ongoing maintenance costs, and considering the benefits, which can be direct financial gains (e.g., additional revenue or lower costs) or indirect benefits (e.g., improved efficiency, satisfied customers, or regulatory compliance). CBA, in this case, will calculate the most cost-effective traceability option for PT Widodo Makmur Unggas (PT WMUU) by determining the amount of funds the company can save by better managing its supply chain, reducing the costs of recalls and enhancing the company's competitiveness in the market. Cost-Benefit Ratio (CBR) calculations are often shown by dividing the total costs by the total benefits. A CBR score below 1 indicates that the benefits outweigh the costs, suggesting that the project is potentially profitable. On the other hand, a score above 1 implies that the project may not be financially feasible.

$$\text{Cost - Benefit Ratio} = \frac{\text{Expected Total Costs}}{\text{Expected Total Benefits}}$$

Fig.1 Formula for Cost-Benefit Analysis

Fig. 1 is a formula for calculating Cost-Benefit Analysis; the author learned this formula from economic and financial analysis methods used to assess the feasibility and economic viability of a project or intervention.

Table 3: Cost-Benefits Ratio of Traceability Technology Solutions

COST-BENEFIT ANALYSIS			
Benefit Category	Estimated Value (IDR)	Cost Category	Estimated Value (IDR)
Lower Bound	IDR4,605,218,160	QR Code & Plastic Leg Band	IDR660,000,000
Higher Bound	IDR9,595,322,732	Blockchain System	IDR2,120,000,000
		RFID System	IDR1,390,000,000
COST-BENEFIT RATIO			
System Type	Cost-Benefit Ratio (Lower Bound)	Cost-Benefit Ratio (Higher Bound)	
QR Code	0.14	0.07	
Blockchain	0.46	0.22	
RFID	0.30	0.14	

The Cost-Benefit analysis of traceability systems helps PT Widodo Makmur Unggas (PT WMUU) determine the cost of each alternative. The result shows that the QR Code method has the lowest CBR, which is between 0,07 and 0,14, implying that the beneficial aspects of this method are higher than the cost it will take for PT WMUU to use the method as their solution. Blockchain has the highest CBR, which is between 0.22 and 0.46 means that the cost it will take for this solution is higher than the benefits it gives. The CBR of the RFID system is between 0.15 and 0.30, which means the cost and benefit are nearly equal. PT WMUU understands the value of each technology system from the calculation given with CBA and will help them pick the best traceability solution for their business.

PT WMUU can improve traceability cost-effectively and efficiently by adopting a QR code system and plastic leg bands, as indicated by the calculation of the Cost-Benefit Analysis (CBA). The infrastructural changes needed for the QR Code system are minimal yet help the company to improve operational efficiency. Generating QR codes for each poultry batch, from farm to retail, for real-time monitoring and data entry will be easier to implement for PT WMUU without the complexity or cost of RFID or blockchain systems. This can be achieved by distinguishing batches by placing plastic leg bands on poultry, thereby building better product traceability throughout the supply chain. A cloud-based system can save breeding records and food safety compliance for stakeholders to access. QR codes reassure customers by being transparent about product origins and safety. It is straightforward to set up, requires no staff retraining, and has a minimal budget impact, making it a realistic and cost-effective first step for PT WMUU to improve traceability and compliance.

D) Discussion

This research focuses on the traceability system that helps maintain food safety in the Indonesian poultry supply chain that applies to PT Widodo Makmur Unggas Tbk (WMUU) with their current traceability system heavily relying on paper-based manual records, which causes inefficiency, data inaccuracy, and difficulty in tracking products across all stages of the supply chain. The literature widely supports the notion that traceability is crucial in ensuring food safety throughout the supply chain. Several studies (e.g., Azanaw et al., 2019; Guanqi & Husnain, 2022) emphasize that an effective traceability system helps prevent

contamination, simplifies recalls, and increases consumer confidence by ensuring compliance with safety standards, such as HACCP. This finding aligns with research, which indicates that the absence of a robust traceability system at PT WMUU increases the risk of foodborne illness due to delays in identifying sources of contamination. In the literature, traceability technologies such as IoT, RFID, and blockchain are identified as key solutions to improve traceability (Sidarto & Hamka, 2021). This was mirrored in the research findings, where it was suggested that PT WMUU adopt these technologies to enhance real-time tracking of poultry products. The research highlighted the inefficiencies of the current manual system, which is consistent with the literature's assertion that manual systems pose significant risks in terms of data accuracy and response times to contamination issues (Azanaw et al., 2019).

The research on PT WMUU's traceability system recommends improvements, such as utilizing RFID and blockchain, to enhance supply chain transparency due to their effectiveness (Jaswanth et al., 2023; Sidarto & Hamka, 2021). The QR codes and plastic leg bands with cost-benefit analysis identified this system can be a cost-effective way to get started and work towards more advanced options in the future, which is also in line with the idea that companies can grow and be efficient when they adopt traceability systems since the Blockchain and RFID system comes with high costs and complex infrastructure requirements for the systems (Azanaw et al., 2019). By putting these solutions into practice, PT WMUU can make big improvements in food safety and operational efficiency, as well as meet regulatory requirements like HACCP and halal certification.

IV. CONCLUSION

The research identifies significant issues in PT Widodo Makmur Unggas's (PT WMUU) current traceability system, including inefficiencies, data errors, and difficulties in ensuring transparency and compliance with regulations. Manual data entry and paper-based records pose challenges in tracking products after processing, thereby complicating the maintenance of traceability throughout the poultry supply chain.

The research suggests adopting automated data entry and real-time monitoring technologies, such as a cloud-based traceability system combined with QR codes and plastic leg bands, as a way to solve the primary issue of traceability in the poultry supply chain that PT WMUU faced, which will reduce human errors, improve compliance with food safety standards (HACCP, Halal, BPOM), and enhance consumer confidence by providing greater transparency.

PT WMUU is looking into Blockchain, IoT, and RFID technologies in their long-term plan for technological upgrades as they adopt QR codes and plastic leg bands as a cost-effective first step to enhance real-time tracking, improve inventory management, and ensure better product quality, as the organization gets familiar with automation, it may gradually implement IoT and RFID to help operations run more smoothly and cut down on manual labor.

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