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Enhancing layer farm MSMEs productivity through egg grading machines and stainless cage mats

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ABSTRACT

Poultry and egg farming SMEs must be empowered to enhance egg and chicken production through the development of egg-sorting equipment and tools aimed at reducing egg defects. This initiative seeks to improve the performance of micro, small, and medium enterprises (MSMEs) in the poultry sector. The implementation of sorting tools significantly alleviates the operational burden on livestock in MSMEs by accelerating the sorting process, which in turn facilitates faster product shipments. Over the long term, this can lead to a decrease in the number of sorting employees required and helps minimize egg breakage during harvesting. Moreover, the introduction of curved stainless steel cage bottoms significantly enhances egg production capacity. This innovation leads to an average reduction of 54 percent in the number of defective eggs during harvesting. Furthermore, sorting time sees an impressive average decrease of 28 percent. Currently, the average sorting time for an egg is 31.42 seconds, but with the implementation of the Automatic Egg Sorter Tool, this time is reduced to 22.6 seconds per egg, reflecting a marked improvement in efficiency.

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1. INTRODUCTION

Digitalization in micro, small, and medium enterprises (MSMEs) extends beyond marketing, such as the implementation of e-commerce; it also fosters digital transformation, builds cohesive business teams, and optimizes production systems (Ulas, 2019, Teng et al., 2022). One sector within MSMEs that requires digital transformation is the Layer Farm sector. A prominent player in the Cilongok area is Anto Farm. Anto Farm has established a supply chain network for poultry and eggs, which is structured as illustrated in Figure 1.

Anto Farm is a prominent micro, small, and medium enterprise (MSME) located in the Cilongok Banyumas region, specializing in layer farming and male chicken cultivation. The farm effectively serves the markets of Banyumas, Purbalingga, and Cilacap, providing access to fresh poultry products. By adopting a direct sales approach, Anto Farm connects directly with consumers, bypassing traditional intermediaries in the egg supply chain. This strategy not only makes eggs more affordable for customers but also supports the livelihoods of local farmers. Covering an area of 2,000 square meters, Anto Farm

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houses a robust population of 8,000 laying hens and 5,500 male chickens, producing approximately 150 kilograms of eggs daily. In addition to its role as an independent breeder, Anto Farm serves as a coordinator, working diligently to empower fellow breeders in the Cilongok region of Banyumas. This collaboration focuses on meeting the regional demand for eggs and male chickens through a cooperative system that fosters community engagement and strengthens local agricultural practices. Through these efforts, Anto Farm contributes not only to its own growth but also to the sustainability and resilience of the local farming ecosystem.

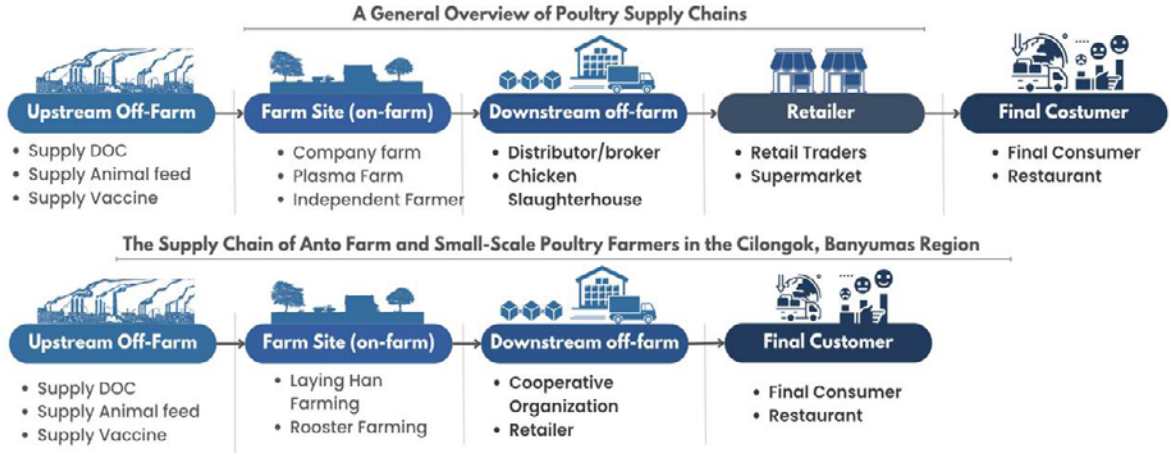

Figure 1. Poultry supply chain

Anto Farm employs a total of 14 staff members, consisting of 5 stable employees and 9 warehouse employees, each with specific roles. The farm has 5 cage employees responsible for egg harvesting tasks, which include counting eggs, cleaning drums, mixing feed, and feeding the poultry. In the warehouse, the 9 employees are organized into distinct roles: 5 are egg sorters, 2 handle egg and chicken deliveries, 1 manages bookkeeping, and another is responsible for weighing and packaging the eggs before they are sent to the suppliers. Each day, Anto Farm typically harvests between 150 to 200 kg of eggs. It is estimated that approximately 13-20 percent of total egg production suffers from natural cracks, breakage, or damage during the harvesting process. Preliminary observations indicate that these defects primarily occur due to collisions between the eggs and the edge of the cage floor immediately after the chickens lay them (Gutawa et al., 2023). Figure 2 is an overview of the current condition of the cage base at Anto Farm.

Currently, egg sorting at Anto Farm UMKM relies on visual inspection, depending solely on the instincts of the employees. This practice often leads to inaccuracies in identifying egg quality (Aristianto et al., 2020). Each employee has an average sorting rate of 18 eggs every 10 minutes, which means that sorting 150 kilograms of eggs (approximately 2,700 eggs) takes about 1,500 minutes, or roughly 25 hours. With a team of five individuals handling the task, each person is required to sort for 5 hours per day. This not only results in high levels of fatigue but also contributes to delays in delivery (Harnsoongnoen & Jaroensuk, 2021). Figure 2 illustrate the current conditions at Anto Farm.

Due to several operational challenges faced by Anto Farm, particularly in the MSME production process, specific research objectives were established: (1) To reduce the time spent on manual egg sorting, which currently lacks precision (Atwa et al., 2024); and (2) To minimize the occurrence of egg breakage shortly after the chickens lay their eggs in the coop (Mertens et al., 2011). In response to these

identified issues, the following solutions have been implemented at Anto Farm: (1) The development of an automatic egg sorting tool capable of selecting eggs based on size and weight; and (2) The creation of egg storage containers made from stainless steel, featuring curved edges for added protection.

Figure 2. Existing egg sorting condition

The overarching goal of this service initiative is to enhance the capabilities of Poultry and Egg Farmer Partners by increasing both egg and chicken production through the introduction of egg sorting equipment and tools designed to mitigate egg defects (Mertens et al., 2011; Patel et al., 1998). Specifically, we aim to boost egg production capacity by reducing the incidence of defective eggs at harvest and during transit. Our success indicators include achieving a reduction in the number of defective eggs at harvest to less than 5 percent and alleviating the operational burdens on livestock MSMEs by expediting sorting times. This will facilitate prompt delivery, streamline workforce operations, and minimize losses due to broken eggs during transport. The presence of an automatic egg sorter is expected to enhance farm performance and reduce operational costs (Alikhanov et al., 2017; Hernando et al., 2024; Nasiri et al., 2020). This initiative is focused on empowering MSMEs through the application of Appropriate Technology, with a tool implementation period of eight months.

2. METHODS

The procedures established to support the implementation of the proposed methods are organized as activity plans, detailed in the community service implementation schedule for the program, as illustrated in Figure 3. The implementation comprises the following stages: (1) Partner Situation and Condition Analysis Phase: This stage includes conducting field surveys, gathering data, identifying

challenges, and facilitating Focus Group Discussions (FGDs) with partners; (2) Appropriate Technology Manufacturing (TTG) Phase: This phase is centered on producing technologies such as Automatic Egg Sorting Tools and Stainless-Steel Cage Bases; (3) Training Phase: This stage involves conducting training sessions on the use and maintenance of the TTG, as well as educating participants on the benefits and optimization of these tools; (4) PKM Evaluation Stage: The final stage evaluates the overall effectiveness of the program. These stages collectively ensure a comprehensive approach to achieving the program's objectives.

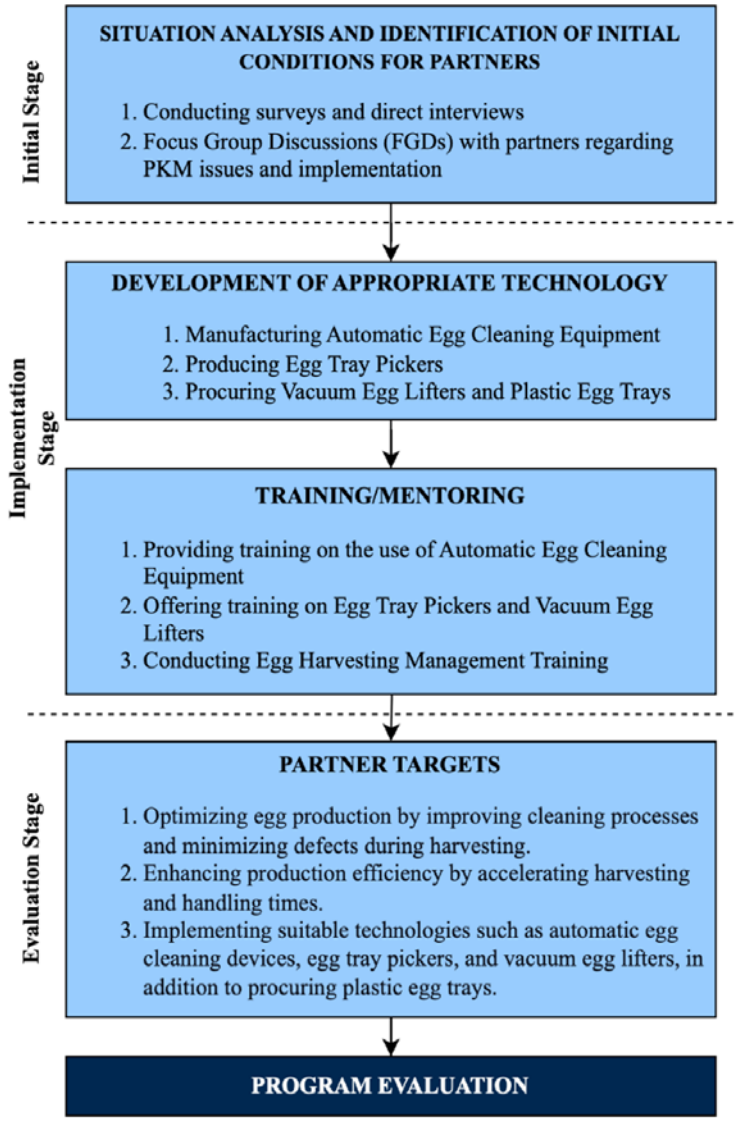

Figure 3. Community empowerment programs implementation mechanism

Implementation Mechanism

The implementation mechanism for Community Empowerment Programs is structured into three main stages: the Initial Stage, the Implementation Stage, and the Evaluation Stage.

Initial stage

The initial stage involves analyzing the partner's current situation and conditions. This phase includes making initial observations to directly assess the partner's state. Additionally, direct surveys and interviews are conducted to gather more detailed information about the existing partners. The final stage consists of facilitating a focus group discussion (FGD) with partners and similar breeders to identify the most pressing issues faced by the partner. Together, they will agree on the problems to address and outline the steps for implementation.

Implementation stage

This phase consists of two main components: the development of suitable technology and the Training and Mentoring phase. The process of creating appropriate technology starts with design, followed by manufacturing, development, and testing. Once the equipment has successfully passed testing, training and support for its use will be provided.

The evaluation stage

The evaluation stage involves assessing whether the tool can be utilized in alignment with the initial objectives. During this phase, observations are made to determine if the established targets can be achieved. Additionally, the evaluation activities are conducted by the team, focusing on identifying any obstacles and challenges that may arise in the field. When such issues are encountered, an evaluation is performed to find solutions that ensure activities proceed as planned. Furthermore, this stage includes evaluations from the institutional LPPM.

SMEs Participation

Partner participation in the PKM MSME Livestock Program in Kalisari Village, Cilongok District, Banyumas Regency is as follows: (1) Anto Farm, along with other chicken farming MSMEs in Cilongok, plays a vital role in supporting the program and is a beneficiary of its initiatives. In addition, this MSME will provide tools and materials during the trial phase. Anto Farm is also a pilot project for MSMEs focusing on the use of appropriate technology, which can subsequently be implemented more broadly for similar MSMEs in the Cilongok area; (2) The Village Head (Lurah) has the authority to grant permission for the implementation of Community Empowerment Program (PKM) activities in Kalisari Village, Cilongok, Banyumas; (3) The Poultry Farming Group Center serves as an informant on livestock issues in the areas of Banyumas, Purbalingga, Cilacap, and Kebumen.

Evaluation of Program Implementation

The evaluation of the implementation of the community service program and its sustainability takes place after the completion of the activities. This involves engagement with partners, including the LPPM of Telkom Institute of Technology Purwokerto. The evaluation process includes gathering feedback from partners to assess the level of technology adoption, conducted through Usability Testing. Ongoing monitoring continues even after the PKM activities conclude, focusing on the practicality and usage of the implemented technology as well as its effectiveness. This approach aims to facilitate broader implementation of the tools in the future and their potential for commercialization. The community service initiative spanned eight months and was conducted in Kalisari Village, Cilongok District, Banyumas Regency.

3. RESULTS AND DISCUSSION

Product and Technological Inovation

The Anto Farm ITTP PKM Team has developed three types of innovative technological equipment: 1) Automatic Egg Sorting Tool, 2) Stainless Curved Cage Base, and 3) Weight Loss Detection Sensor.

Automatic egg sortir/grading machine

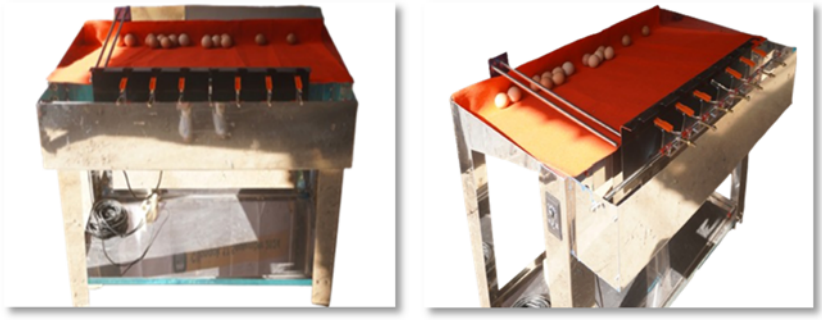

Figure 3. Egg grading machine

This innovative sorting tool utilizes the principle of magnetic attraction to effectively classify eggs based on their weight (Mertens et al., 2011; Patel et al., 1998). At the heart of the design is a static magnet mounted on the egg carrier block, which is strategically paired with another static magnet located at the edge of the machine. These magnets are intentionally spaced apart, creating a controlled environment where the gravitational pull acts on the eggs. As a result, heavier eggs descend first due to the greater force exerted on them, followed by the lighter ones. This method not only ensures a reliable sorting process but also enhances efficiency in handling the eggs. Figure 4 is an initial design concept for an automated egg sorting mechanism that embodies these principles.

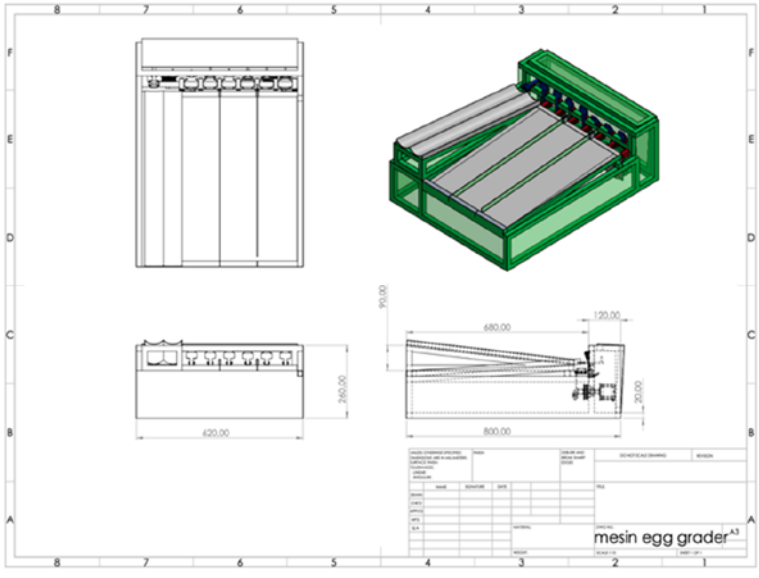

Figure 4. Blueprint egg grading machine

Stainless curved cage mats

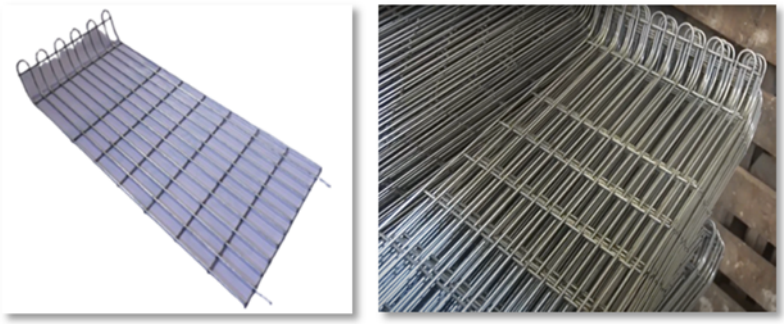

Figure 5. Stainless egg mats

A cage with a curved base offers the advantage of effectively holding the eggs by directing the force to the oval corner at the end of the drum's bottom. In contrast to traditional drums that still utilize bamboo and have egg holders with a 90-degree angle, this design often results in eggs, particularly those from chickens with thin shells or approaching the cull stage, colliding with the tip of the drum (Harlita & Solikhah, 2022).

Relevance of the Aplication of the Product Innovation

Relevance of egg grading implementation

Figure 6. Egg grading implementation

The egg sorting process at Anto Farm UMKM currently relies on visual inspection, depending solely on the instincts of the employees. This method frequently results in errors when assessing egg quality (Dandung et al., 2023) Additionally, each employee averages a sorting speed of 18 eggs every 10 minutes. Consequently, sorting 150 kilograms of eggs (approximately 2,700 eggs) takes around 1,500 minutes, or about 25 hours, which is divided among five workers, resulting in each person sorting for about five hours daily. This extended workload leads to significant fatigue, which can diminish concentration and precision in the sorting process (Mujiono et al., 2023). At Anto Farm UMKM, egg sorting is performed entirely by hand without the aid of any tools, relying solely on the employees' instincts. Eggs are sorted based on their color and size, subsequently categorized into Grade A, Grade B, and Grade C.

Relevance of stainless curve caged base implementation

The 1:10 egg breaking problem refers to an occurrence in which, for every 10 eggs produced, one egg breaks. This phenomenon is attributed to the design of the cage, which features a 90-degree angle. With a slope of 15 degrees, when a chicken lays an egg, it often strikes the corner of the bamboo cage's base, leading to cracks and ultimately resulting in the egg breaking.

Figure 7. Condition after installing the stainless mats

Stainless steel cage bases, which feature curved edges, offer enhanced durability and sterility while being resistant to rust. Bedding made from stainless steel minimizes the risk of rusting and is easier to clean, as chicken droppings do not adhere easily to its surface (Rahadi, 2012).

Impact and Usefullness Tools

Based on the results of initial observations conducted over 2-5 days after implementation, the outcomes for each tool implementation are described.

Result of egg grading implementation

The implementation of sorting tools typically reduces the operational burden for livestock MSMEs by streamlining the sorting process, thereby enabling quicker shipment of goods. This increased efficiency may lead to a decrease in the number of sorting employees needed over time, as well as a reduction in the incidence of broken eggs during the harvesting process. The experimentation involved a single crate of eggs weighing 15 kg, containing a total of 240 eggs. This study began with Experiment 1, which utilized a single crate of 30 eggs, and concluded with Experiment 5, which also focused on one crate of eggs. Below is a comparison of the results obtained before and after the introduction of the egg sorter.

Table 1. Egg grading implementation result

Number of Eggs	Existing Sorting Time (min)	Improvement Sorting Time (min)	Amount Decreased (%)
30	15	12	0.20
60	28	18	0.36
100	51	42	0.18
150	90	54	0.40
240	130	97	0.25

The data presented in the table indicates a notable reduction in sorting time when comparing the existing sorting method to the improved process. The average percentage decrease in sorting time is 28 percent, which is quite impressive, especially considering that the machine has only undergone initial testing. The average sorting time for one egg with the existing method is 31.42 seconds, while the Automatic Egg Sorter Tool achieves an average sorting time of 22.6 seconds per egg. This is further confirmed by (Alikhanov et al., 2017; Hernando et al., 2024; Mertens et al., 2011; Nasiri et al., 2020) in previous research, demonstrating that an automatic egg sorter can significantly decrease sorting time, and enhancing operational efficiency.

Result of curved stainless egg mats implementation

The implementation of curved stainless steel cage Mats significantly increases egg production capacity by reducing the number of defective eggs at harvest (Banjarat et al., 2019; Kurttila, 2021). Observations were carried out in one flock of cages consisting of approximately 150 chickens.

Table 2. Curved stainless egg mats implemetation result

Observation Date	Average Daily Egg Defect/ Flock (pcs)	The Amount of Defect after Improvement (pcs)	Amount Decreased (%)
15-Sep-24	7	4	0.43
16-Sep-24	7	1	0.86
17-Sep-24	7	5	0.29
18-Sep-24	7	4	0.43
19-Sep-24	7	3	0.71

The data presented indicates a notable decrease in the percentage of defective eggs, averaging a reduction of 54 percent. Previously, the average defect rate using traditional Egg Pads was 7 eggs per flock per day. However, after implementing the stainless-steel base and monitoring it over a period of 5 days, the average defect rate dropped to 3 eggs per flock per day. Stainless steel cage mats prove to be particularly effective for managing eggs from older laying hens, those over 90 weeks of age. This is significant because, as a laying hen ages, its eggshells become thinner. Consequently, when an egg with a thin shell contacts the edge of the bamboo cage base, which has a 90-degree angle housing tip, it is much more susceptible to breaking.

4. CONCLUSION AND RECOMMENDATIONS

The implementation of appropriate technology, including an automatic egg sorting machine and stainless cage mats, has proven effective in improving productivity and reducing operational inefficiencies in layer farm MSMEs. These innovations contribute to better egg quality, reduced labor intensity, and enhanced sustainability for the partner enterprise. This integration of technology not only streamlines the sorting process, ensuring higher efficiency and reduced labor hours but also enhances the overall welfare of the hens. The use of stainless cage mats offers unparalleled durability and hygiene, which are critical in maintaining a healthy environment for optimal egg production. By adopting these innovations, layer farm MSMEs can maximize their output and contribute to the growing demand for quality eggs in the market. The implementation of curved stainless steel cage bottoms significantly enhances egg production capacity by decreasing the number of defective eggs at harvest. Notably, there is an average

reduction of 54 percent in the percentage of defective eggs. Furthermore, the average reduction in sorting percentage is 28 percent, which is quite impressive considering that this is the first test of the machine. Currently, the average sorting time for one egg stands at 31.42 seconds. In contrast, the average sorting time using the Automatic Egg Sorter Tool is reduced to 22.6 seconds per egg.

The implementation of suitable technology, particularly within the Layer Farm MSME sector, can be further refined and expanded to encompass MSMEs facing similar challenges. The sustainability of automatic egg sorting equipment technology can be enhanced by incorporating more advanced weight sensor detection devices, along with mechanisms to assess the condition of the eggs.

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