

Application of Lean Manufacturing for Waste Reduction in the Chicken Cut-Up Production Process: A Case Study

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ABSTRACT

PT XYZ, an integrated poultry processing company and part of the chicken processing industry, faces production challenges such as bottlenecks, overtime, and product rejects that hinder efficiency. This study applies Lean Manufacturing using Value Stream Mapping (VSM), Waste Assessment Model (WAM), and Value Stream Analysis Tool (VALSAT) to the cut-up chicken production process, the company's flagship product. This research aims to identify the types of waste in the cut-up chicken production process and determine the critical waste. Additionally, the study aims to categorize activities into value-added, non-value-added, and necessary non-value-added, analyze the root causes of critical waste, and design improvement proposals through the creation of Future State Value Stream Mapping (FSVSM) and calculate lead time reduction in the production process. The methods used in this study combine VSM analysis to map material and information flows in the production process, WAM to identify and measure the severity of waste, and VALSAT to analyze value-added and non-value-added activities. Data was collected through observation, interviews, and questionnaires completed by five employees knowledgeable about the overall production process. The implementation of the FSVSM design successfully reduced lead time in the production process. In Future State 1, lead time decreased by 2583 seconds, increasing the Process Cycle Efficiency (PCE) by 23.02% to 83.45%. Meanwhile, Future State 2 showed a reduction of lead time by 882.68 seconds, with a 6.29% increase in PCE, reaching 66.72%. These improvements accelerated the production flow, increased efficiency, reduced waste, resolved bottlenecks, eliminated overtime, and minimized product rejects.

Keywords: Lean Manufacture; Value Stream Mapping (VSM); Waste Assessment Model (WAM); Value Stream Analysis Tool (VALSAT); cut-up chicken

INTRODUCTION

Production is an activity that transforms inputs into outputs, encompassing all activities or operations that produce goods or services, as well as other supporting or enabling activities to generate those products, whether goods or services. The production process is one of the factors of production within a company in producing a product. In increasingly fierce industrial competition, companies are required to further optimize resources up to product quality to increase productivity. Therefore, efforts must be made for a production process that can provide a full contribution to productive activities related to value addition and strives

to avoid or minimize waste (Budiartami & Wijaya 2019; Silambi & Indiyanto 2024).

Manufacturing companies categorize production process activities based on their impact: Value Added (VA), Non-Value Added (NVA), and Necessary Non-Value Added (NNVA). VA activities are those that, from the customer's perspective, provide added value to a product or service, making customers willing to pay for them. NVA activities are those that do not add value to a product or service in the customer's eyes. NNVA activities do not add value to the product or service from the customer's perspective, but they are required by existing procedures or operating systems (Nurdiansyah et al. 2022; Erlina et al. 2025).

NVA activities are considered waste that companies aim to eliminate, as they consume resources like energy, human capital, and time, reducing production efficiency. These activities can result in higher costs, delays, and lead to inefficiencies in the production process, which would reduce output and profitability. Based on their types, waste is categorized into several forms: overproduction, waiting, transportation, inventory, motion, defects, over-processing, and underutilized talent (Lestari & Susandi 2019; Dara et al. 2024).

Lean manufacturing is a systematic approach to optimize a system by reducing waste through a series of improvement activities. Lean manufacturing considers all resource expenditures to gain economic value for the customer. Value Stream Mapping (VSM) is a visual method for mapping a product's production path, encompassing material and information flow at each workstation. This method aims to illustrate the value stream from the beginning to the end of the process. VSM is used to analyze the current state and design a more efficient future state to improve overall process performance (Syaher et al. 2024; Kumar et al. 2022).

Many methods can be used to identify waste, one of which is the Waste Assessment Model (WAM). WAM is a model designed to simplify and facilitate finding the root causes of waste, enabling the identification of the most critical waste. WAM includes several tools, among them the Waste Relationship Matrix (WRM) & the Waste Assessment Questionnaire (WAQ). This model offers advantages such as a simple matrix and a comprehensive questionnaire, which can contribute to achieving accurate results in identifying relationships between waste types and their root causes (Jufrijal 2022; Hidayatullah & Widjajati 2024).

VALSAT (Value Stream Analysis Tools) is a tool used for in-depth analysis of the value stream within production or service processes, with the primary goal of identifying and eliminating waste to improve efficiency, quality, and productivity. The method incorporates several matrices, including Process Activity Mapping (PAM), Supply Chain Response Matrix (SCRM), Decision Point Analysis (DPA), Product Variety Funnel (PVF), Quality Filter Mapping (QFM), Demand Amplification Mapping (DAM), and Physical Structure (PS). By using VALSAT, organizations can gain a detailed understanding of existing value stream mapping, identify processes that add value, and address the root causes of waste (Ariska & Aryanny, 2023; Triana et al. 2024).

Root Cause Analysis (RCA) is a systematic method for identifying the underlying causes of a problem or failure. Its objective is to uncover the fundamental reasons why a problem occurred, enabling effective corrective actions and preventing similar issues from recurring in the

future. One RCA method is the fishbone diagram, which aims to identify and categorize potential causes that can lead to a problem, and ultimately, find its root cause (Irawati et al. 2019).

PT XYZ is a unit in Maros operating under one of Indonesia's largest integrated poultry processing companies. As part of the national food supply chain, PT XYZ plays a strategic role as a producer of various quality chicken products to meet market demand. Interviews and observations at PT XYZ revealed several issues that could hinder the company's production efficiency. Identified problems include bottlenecks at several process stages due to the accumulation of work-in-process in the clean area, excessive overtime hours caused by forecasting results leading to daily production orders exceeding actual production capacity to consistently meet market demand, and rejected products such as bruising, residual feathers, miscuts, and breakages in work-in-process.



FIGURE 1. Work-In-Process On The Production Floor



FIGURE 2. Rejected Cut-Up Chicken Products

If analyzed based on lean manufacturing, these problems are related to the concept of 7 wastes, with the exception of overproduction waste. This is because the company implements a make-to-stock production system based on demand forecasting by PPIC and utilizes overtime to meet projected market demand. The relationships with other wastes can be explained as follows.

1. **Waiting:** Bottlenecks cause production activities to halt or wait, leading to ineffective use of working time.

2. Defects: The presence of rejected goods is a form of waste that directly impacts company profits.
3. Processing: Rejected products can lead to additional, unnecessary processes.
4. Motion: Frequent overtime hours indicate an inefficient workflow, requiring workers to perform more movements or tasks than necessary.
5. Inventory: Bottlenecks can cause the accumulation of materials at certain points, potentially worsening the overall workflow.
6. Transport: Bottlenecks can affect the distribution or flow of materials, creating unnecessary additional transportation steps.

These problems indicate inefficiencies in the production process. Thus, the researcher suggests that several types of waste are occurring on PT XYZ's production floor. This paper will begin by identifying activities that add value to the product, while simultaneously reducing activities that potentially lead to waste. Therefore, one scientific approach that can be applied is Lean Manufacturing, which aims to identify and reduce waste and improve the efficiency of the production process.

METHODOLOGY

RESEARCH OBJECT

The Cut Up category in the broiler chicken production process shows a dominant role, with a total volume of 3,962,963 units throughout the year 2024, surpassing other categories such as Whole Chicken, Boneless, and Parting. Of the total output, the Cut Up 9 R MCD variant contributes the highest production, amounting to 498,080 units. The high production volume of this variant indicates its strategic role in the company's operational system, making it important to study further. Therefore, Cut Up 9 R MCD was chosen as the research object due to its highest production volume, which signifies that this product is the company's flagship product. The main goal of this research is to evaluate the production process in order to identify any waste that may hinder efficiency. Based on these findings, improvements will be proposed, expected to reduce or eliminate waste, thereby enhancing the company's production efficiency.

DATA COLLECTION

The methods used consist of several techniques as follows:

1. Interviews

Interviews are a data collection method conducted through direct question and answer between the researcher and relevant parties within the company. The purpose of the interviews is to gather more in-depth and specific information regarding issues in the production process and waste management at PT XYZ. The individuals interviewed in this research include the production manager and several employees directly involved in the production process.

2. Observation

Observation is a data collection technique carried out by directly observing the research object, namely the production process at PT XYZ. The researcher will be present on-site to systematically monitor the production flow, identify parts that have the potential to generate waste, and observe employee behavior during the production process. The aim of this observation is to obtain objective data regarding the company's operational conditions and to better understand the factors affecting production efficiency.

3. Questionnaire

A questionnaire is a data collection method used to gather information related to the perceptions, attitudes, and opinions of respondents regarding the production process at PT XYZ. The questionnaire used in this research is the Waste Assessment Model (WAM), which contains questions related to waste occurring in the production process. The discussion process and completion of the WAM questionnaire involved 5 respondents. These 5 individuals were selected not based on statistical calculations, but rather on their capabilities and knowledge about the conditions of the Cut Up 9 R MCD production process (Hidayatullah & Widjajati, 2024). The chosen respondents were from PPIC, Head Production, Head Quality Control, Supervisor Production, and Supervisor Quality Control.

RESEARCH FLOWCHART

This research will be conducted through the following stages:

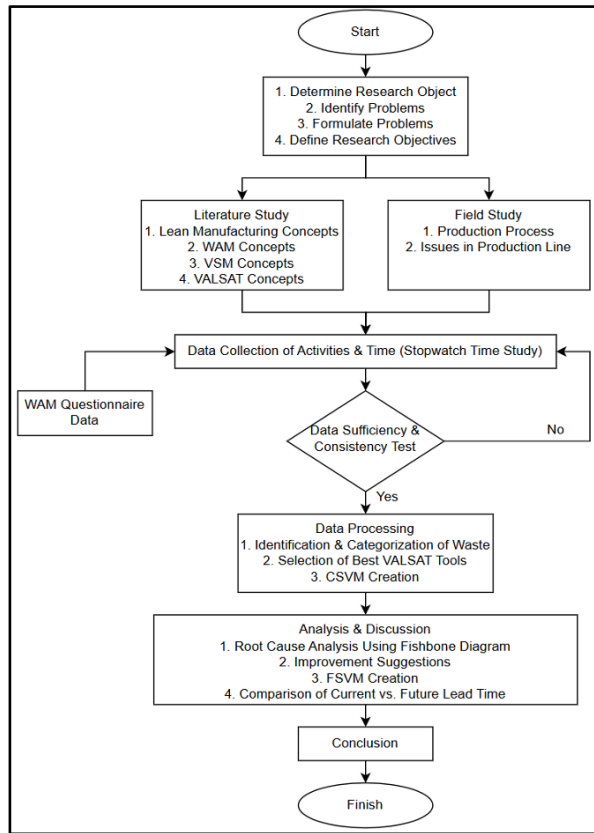


FIGURE 3. Research Flowchart

RESULTS AND DISCUSSION

WASTE IDENTIFICATION & WEIGHTING WITH WASTE ASSESSMENT MODEL (WAM)

Waste identification was carried out using WAM, which consists of two methods: the Waste Relationship Matrix (WRM) & the Waste Assessment Questionnaire (WAQ). The WRM method aimed to analyze the relationships between various types of waste in a process. Meanwhile, the WAQ method was used to identify the most dominant waste and assess the severity level of each waste.

The following were the calculation results for the WRM and WAQ data, along with their weightings.

1. Waste Relationship Matrix (WRM)

After the questionnaire scores were obtained, these scores were converted into a value range, which was then represented by WRM letter symbols, as explained in the following table.

TABLE 1. Converting WRM Score Range to Letter Symbols

Score range	Relationship type	Symbol
17-20	Absolutely necessary	A
13-16	Especially important	E
9-12	Important	I
5-8	Ordinary closeness	O
1-4	Unimportant	U

TABLE 2. WRM Letter Symbols

From /To	O	I	D	M	T	P	W
O	A	E	E	I	A	X	A
I	O	A	E	O	E	X	X
D	I	A	A	E	E	X	I
M	X	O	E	A	X	I	I
T	I	I	E	E	A	X	E
P	A	A	A	A	X	A	A
W	O	I	A	X	X	X	A

Here is the WRM table that has been obtained.

TABLE 3. WRM Numerical Weights

From /To	O	I	D	M	T	P	W
O	10	8	8	6	10	0	10
I	4	10	8	4	8	0	0
D	6	10	10	8	8	0	6
M	0	4	8	10	0	6	6
T	6	6	8	8	10	0	8
P	10	10	10	10	0	10	10
W	4	6	10	0	0	0	10

This conversion followed the established value for each letter: A = 10, E = 8, I = 6, O = 4, U = 2, and X = 0.

2. Waste Assessment Questionnaire (WAQ)

Once the weighting results from the WRM were obtained, the next step was to perform weighting using the WAQ algorithm. The following table presented the waste ranking based on the WAQ calculation results.

TABLE 4. Waste Ranking with WAQ

	O	I	D	M	T	P	W
Score (Yj)	10,93	13,70	13,93	23,92	10,89	33,99	18,78
Pj Factor	103,03	103,03	125,42	33,76	96,89	6,30	21,12
Yj Final	1126,49	1411,25	1747,69	807,49	1054,74	214,07	396,56
Total	6758,29						
Final Result (%)	16,67	20,88	25,86	11,95	15,61	3,17	5,87
Ranking	3	2	1	5	4	7	6

These results provided an initial indication of the types of waste that needed to be eliminated. The three highest-ranked wastes identified as critical were defect, inventory, and overproduction. However, since overproduction waste did not align with the existing conditions at the company, it was considered an outlier. Consequently, the three critical wastes that were the primary focus for waste reduction efforts in the Cut Up 9 R MCD production process at PT XYZ were defect, inventory, and transportation.

VALUE STREAM ANALYSIS TOOLS (VALSAT)

After the final results of waste identification using the WAM method were known, the next step was to select the appropriate detailed mapping tools corresponding to the types of waste occurring at PT XYZ.

TABLE 5. VALSAT Analysis

Seven Waste	Weight	VALSAT						
		PAM	SCRM	PVF	GFM	DAM	DPA	PS
Overproduction	16,67	16,67	50	0	16,67	50	50	0
Waiting Time	5,87	52,81	52,81	5,87	0	17,6	17,6	0
Transportation	15,61	140,46	0	0	0	0	0	15,61
Overprocessing	3,17	28,51	0	9,50	3,17	0	3,17	0
Inventory	20,88	62,65	187,94	62,65	0	187,94	62,65	20,88
Motion	11,95	107,53	11,95	0	0	0	0	0
Defect	25,86	25,86	0	0	232,74	0	0	0
Total		434,48	302,7	78,02	252,58	255,54	133,42	36,49
Ranking		1	2	6	4	3	5	7

Based on the analysis conducted using the VALSAT method in the Table 5, it was found that the tool ranked

first was Process Activity Mapping (PAM) with a score of 434.48. This indicated that PAM was highly recommended for analyzing waste.

TABLE 6. Activity Mapping Using PAM

Code	Activity	Machine/Tool	Time (S)	Man Power	Activity Category					Relationship type
					O	T	I	S	D	
A1	Loading livebird	Exhaust fan	15	2	P					NVA
A2	Weighing livebird	Digital scale	6	1			P			NNVA
B1	Hanging livebird	Overhead conveyor shackle	4	3	P					NNVA
B2	To stunning	Overhead conveyor shackle	79	0		P				NVA
B3	Stunning	Stunner machine	34		P					VA
B4	To slaughtering	Overhead conveyor shackle	16	0		P				NVA
B5	Slaughtering	Victorinox knife	3	1	P					VA

continue...

...cont.

Code	Activity	Machine/Tool	Time (S)	Man Power	Activity Category					Relationship type
					O	T	I	S	D	
B6	Bleeding	Overhead conveyor shackle	224						P	NNVA
B7	Going to scalding	Overhead conveyor shackle	44			P				NVA
B8	Scalding	Scalder machine	85		P					VA
B9	To coarse feather plucking	Overhead conveyor shackle	15			P				NVA
B10	Coarse feather plucking	Drum Plucker machine	37	0	P					VA
B11	To fine feather plucking	Overhead conveyor shackle	37			P				NVA
B12	Fine feather plucking	Dip Plucker machine	40		P					VA
B13	To evisceration	Overhead conveyor shackle	16			P				NVA
B14	Evisceration	Victorinox knife	154	12	P					VA
B15	To water spraying	Overhead conveyor shackle	13			P				NVA
B16	Water spraying	Water Sprayer machine	14	0	P					NNVA
B17	To final evisceration stage	Overhead conveyor shackle	27			P				NVA
B18	Final evisceration stage	Victorinox knife	4	1	P					VA
B19	To immersion in cold water container	Overhead conveyor shackle	2			P				NVA
B20	Immersion in cold water container	Spin Chiller	2281		P					VA
C1	Transferring from cold water container from drum chiller to draining	Manual	2	1		P				NVA
C2	Draining	Manual	4	1					P	NNVA
C3	Weighing & sorting in crates according to size	Digital scale	4	1		P				NNVA
C4	Arranging in crates according to product specifications	Manual	189	3		P				NNVA
C5	Weighing raw materials (according to chicken receipt)	Digital scale	10	2			P			NNVA
C6	To fat removal	Crate wheel base	14			P				NVA
D1	Fat removal	Manual	486		P					VA
E1	Feather correction	Manual	2550		P					NNVA
E2	To carcass cutting (cut-up)	Crate wheel base	14			P				NVA
F1	Carcass cutting (cut-up) & removing maras	Poultry Cutter machine	1133	1	P					VA
G1	Putting cut-up & seasoning	Manual	76			P				NNVA
G2	Marinading cut-up	Allergen Tumbler machine	349	1	P					VA
G3	Preparing crate for marinade	Manual	67						P	NNVA
G4	To marinade packing	Crate wheel base	9			P				NVA
H1	Marinade packing	Manual	775	1	P					VA

continue...

...cont.

Code	Activity	Machine/Tool	Time (S)	Man Power	Activity Category					Relationship type
					O	T	I	S	D	
H2	To packing sealing	Crate wheel base	12			P				NVA
I1	Packing sealing	Vacuum Sealer machine	279		P					VA
I2	To foreign object inspection	Crate wheel base	9	2		P				NVA
I3	Foreign object inspection	Metal Detector	102				P			NNVA
I4	To result weighing	Crate wheel base	12			P				NVA
J1	Result weighing (according to chicken receipt)	Digital scale	13	2			P			NNVA
J2	To product storage in chill room	Crate wheel base	20	2		P				NVA
J3	Product storage in chill room	Manual	29					P		NNVA
K1	Moving product from chill room to anteroom	Crate wheel base	15	4		P				NVA
K2	Product search (according to recipient's box truck)	Manual	31						P	NVA
K3	Weighing	Digital scale	3	2			P			NNVA
K4	Adding ice	Ice scoop	2	1				P		NNVA
K5	Placing product in box truck	Crate loading slide	5	1		P				NVA

TABLE 7. Recap Of Activity Types Using PAM

Activity Category	Number of Activities	Time (S)	Percentage (%)
Operation	15	8221	87,8
Transportation	25	717	7,7
Inspection	5	134	1,4
Storage	2	31	0,3
Delay	3	259	2,8
Total	50	9362	100
Activity Category	Number of Activities	Time (S)	Percentage (%)
VA	13	5657	60
NNVA	16	3298	35
NVA	21	407	4
Total	50	9362	100

The most dominant activity category was operation, with 15 activities totaling 8221 seconds, accounting for 87.8% of the total time. Regarding activity types, Value Added (VA) activities dominated with 13 activities, consuming 5657 seconds or 60% of the total time. Necessary Non-Value Added (NNVA) activities numbered 16, taking 3298 seconds or 35%, while Non-Value Added (NVA) activities occurred 21 times, consuming 407 seconds or 4%. The total number of activities was 50, with a total time of 9362.24 seconds or 156 minutes.

CURRENT STATE VALUE STREAM MAPPING (CSVSM)

Figure 4 showed a bottleneck in the feather correction process because the production capacity at this stage was the lowest, directly limiting the overall production rate. This bottleneck was evident from the accumulation of WIP, which were products awaiting further processing. Furthermore, if the feather correction process only involved one work group with a production capacity of 900 chickens per day, it was insufficient to meet the daily target

production of 1500 chickens for Cut Up 9 R MCD products. Therefore, to meet this target, assistance from additional work groups working at the same workstation was needed,

but they could only be involved when they were not producing other products or when all other product production had been completed.

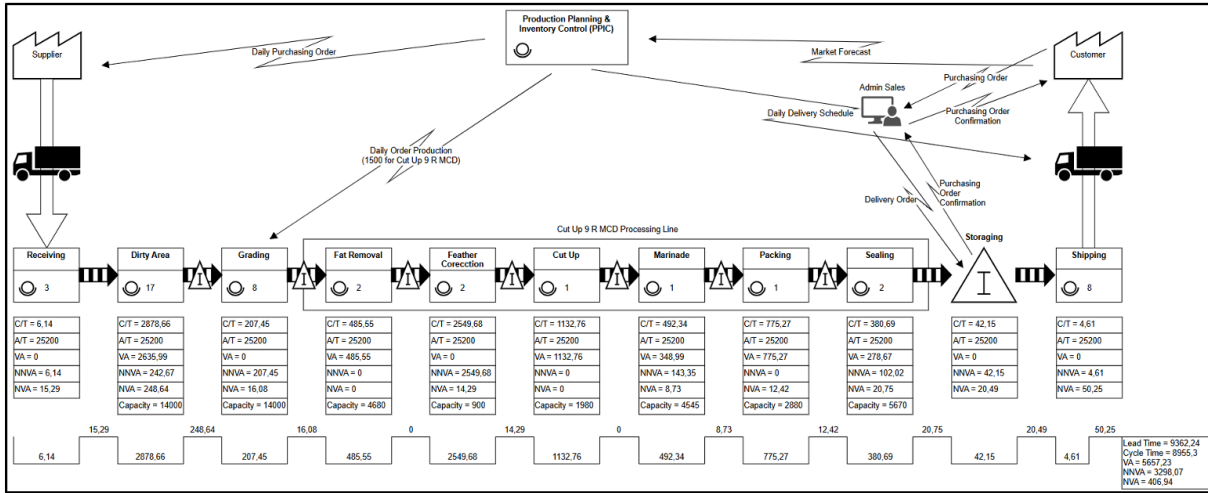


FIGURE 4. Current state value stream mapping

Furthermore, the bottleneck in this process also had implications for overtime hours, which extended from the feather correction process all the way to storage. This overtime was caused by the mismatch between production capacity and target requirements in the feather correction process, forcing the company to increase operational hours beyond regular working times to meet daily order production.

ANALYSIS OF THE TOP 3 WASTES USING FISHBONE DIAGRAM

Root cause analysis using a fishbone diagram was conducted to identify the primary causes of the three critica wastes.

1. Defect

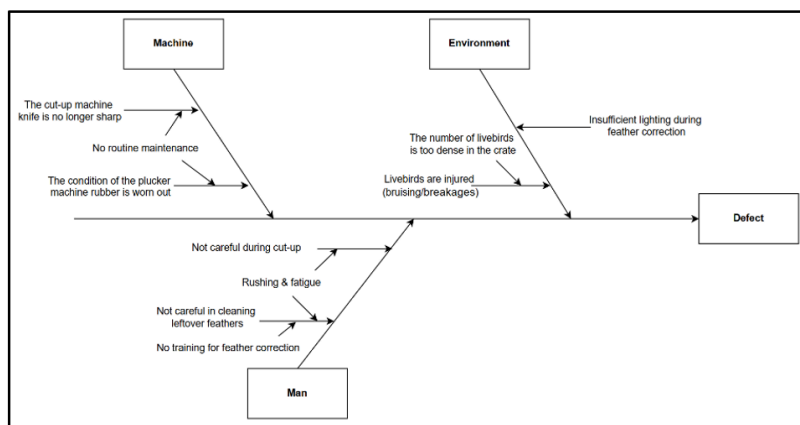


FIGURE 5. Defect Fishbone Diagram

There were three factors that caused waste defect: machine, environment, and man. Here’s an explanation for each of these factors.

- a. Machine factor
 - i. Dull blades on the cut-up machine hindered precise chicken cutting, leading to uneven cuts or miscuts, which resulted in rejected products.

- ii. Worn-out rubber fingers on the plucker machine reduced the effectiveness of feather removal, leaving residual feathers on the chicken and producing items that failed to meet established quality standards.
 - iii. Lack of routine machine maintenance could lead to component damage or performance degradation, consequently impacting the quality of the products generated.
- b. Environment factor
- i. When live birds were too dense in crates during transportation, this condition could cause injuries to chickens, such as bruising or fractures. Chickens that sustained such injuries resulted in rejected products because they failed to meet quality standards.
 - ii. Insufficient lighting during the feather correction process prevented operators
- from clearly seeing residual feathers. This led to a suboptimal feather correction process, resulting in feathers remaining on the chickens and the produced items failing to meet quality standards or being rejected.
- c. Man factor
- i. Operator carelessness during chicken cutting (miscuts) was often caused by factors such as rushing or fatigue due to overtime work. This led to imprecise cuts and resulted in rejected products.
 - ii. Operator carelessness during feather correction could be caused by factors such as rushing or fatigue due to overtime work. Additionally, insufficient adequate training led to the inability of certain operators to clean feathers perfectly, which resulted in rejected products.

2. Inventory

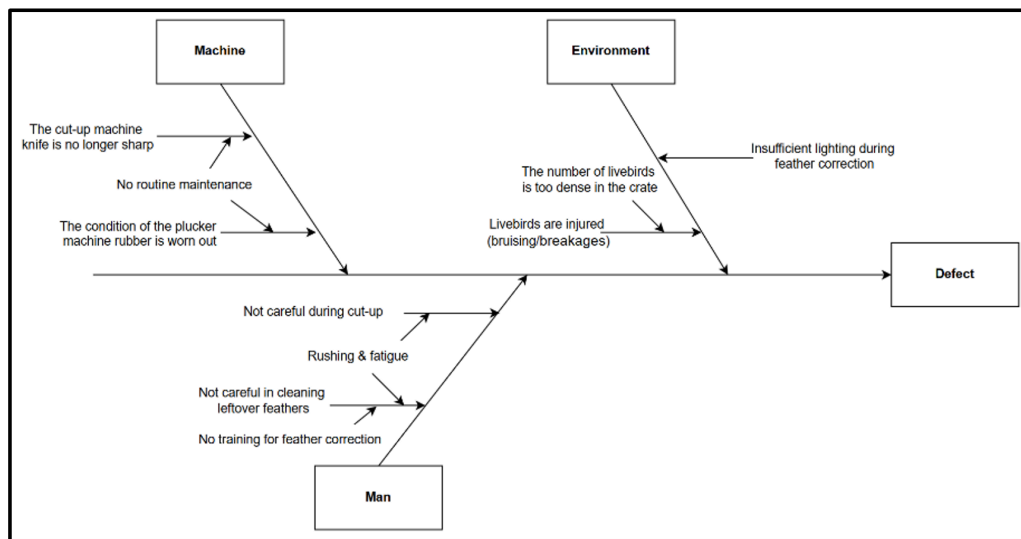


FIGURE 6. Inventory Fishbone Diagram

There were 4 factors that caused waste inventory: machine, environment, man, and material. Here’s an explanation for each of these factors.

materials, ultimately increasing inventory waste, as semi-finished products had to wait for further processing.

a. Machine factor

Machine downtime caused by a lack of routine maintenance could hinder smooth production. When machines broke down or malfunctioned, material or Work In Process (WIP) accumulated at the affected production station. The time lost due to machine downtime disrupted the flow of

b. Environment factor

Limited space in the production area led to inefficient material movement between workstations. This confined space resulted in the accumulation of WIP on the production floor, as materials could not move smoothly or quickly between stations.

c. Man factor

Insufficient training for operators at the feather correction workstation led to inconsistencies in work speed among operators. Without adequate training, operators could not perform the process efficiently, which resulted in the accumulation of WIP at the feather correction station. Additionally, operator fatigue due to long working hours or overtime also reduced operators' ability to complete tasks quickly.

d. Material factor

Disorganized WIP storage led to accumulation in the production area. Limited space in the production area affected how WIP was stored and moved, making materials difficult to access when needed. This disorderly WIP storage resulted in inefficient material flow and slowed down the production process, ultimately leading to inventory waste because semi-finished products could not be processed immediately.

3. Transportation

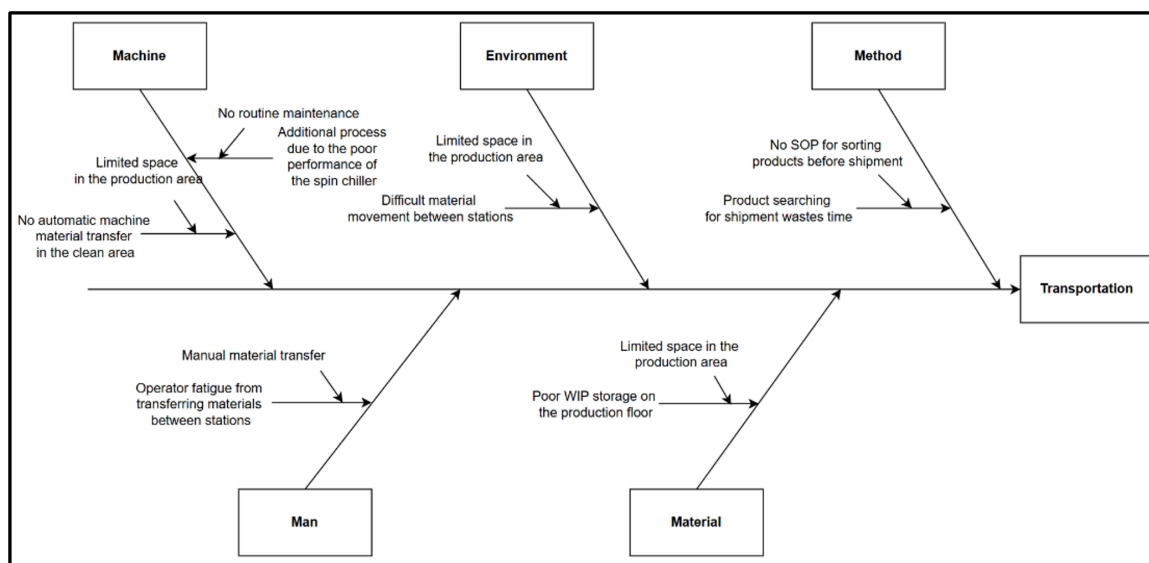


FIGURE 7. Transportation Fishbone Diagram

There were five factors that caused waste transportation: machine, environment, method, man, and material. Here's an explanation for each of these factors.

a. Machine factor

i. The absence of automated machinery to facilitate material transfer between workstations was due to limited space in the production area. Confined spaces hindered the installation and use of automated tools like conveyors, which could speed up material flow. Without automated aids, operators had to rely on manual methods to move materials, increasing the time required for transportation and potentially leading to material accumulation on the production floor.

ii. An additional process of adding ice to containers after they exited the spin chiller was implemented to maximize carcass cooling. This was because the spin chiller was not operating optimally, a consequence of the company's lack of routine machine maintenance, which led to a decline in machine component performance.

b. Environment factor

Limited space in the production area hindered material movement between stations. Confined spaces made materials difficult to access and transfer efficiently between workstations. This impeded the smooth flow of materials, ultimately slowing down inter-station transportation and reducing production efficiency. Additionally, an unsupportive work environment, such as

accumulated goods or narrow pathways, caused delays and bottlenecks in the production process, leading to waste transportation.

c. Method factor

The process of selecting products for shipment was time-consuming, which slowed down the transportation process. This was due to the lack of a Standard Operating Procedure (SOP) from the company regarding the proper method for sorting products before shipment.

d. Man factor

Manual material handling by operators, such as lifting or pushing materials, caused operator fatigue. Material transfer processes performed without efficient tools required more time and effort. Fatigue slowed down the material transfer process between workstations, ultimately reducing productivity. This led to waste transportation, as operators became slower in delivering materials between stations.

e. Material factor

Accumulated Work-in-Process (WIP) obstructed space or pathways for further material movement. When WIP was not immediately processed or transferred, the time required to complete each production stage increased, and the delivery of materials to the next station was hindered. This created transportation waste due to the impeded flow of materials.

PROPOSED IMPROVEMENTS

The objective of this proposal was to enhance the efficiency and effectiveness of the Cut Up 9 R MCD chicken production process based on the findings from the root cause analysis using a fishbone diagram.

1. Machine Maintenance

It was proposed that the company implement routine maintenance for the stunner, cut-up, plucker, and spin

chiller machines to ensure they remained in optimal working condition. This would help avoid breakdowns that could lead to rejected products and additional processes, while also minimizing downtime to reduce the accumulation of Work In Process (WIP) on the production floor.

According to Medyński et al. (2023), Total Productive Maintenance (TPM) is a Lean Manufacturing tool intricately linked to the standardization of production processes. This tool facilitates the attainment of optimal efficiency in production equipment by involving many employees in the maintenance process. The primary objective of TPM is to minimize downtime and reduce defects (rejects) by engaging all personnel in maintenance activities. TPM promotes the empowerment of operators by assigning them responsibility for the maintenance and repair of their equipment, while simultaneously providing the necessary training and expertise to perform these tasks effectively. The main elements of TPM include:

- a. Autonomous Maintenance: Operators are equipped with the skills to carry out regular maintenance tasks, including cleaning, inspections, and lubrication. The objective is to avoid equipment failures and decrease reliance on external maintenance services.
- b. Planned Maintenance: Maintenance activities are proactively scheduled and organized to reduce downtime and make efficient use of maintenance resources.
- c. Quality Maintenance: This approach concentrates on eliminating defects (rejects) and preventing their reappearance, aiming to enhance product quality and minimize waste.

By implementing TPM for all machinery, not just the stunner, cut-up, plucker, and spin chiller, the company can achieve more stable production performance, enhance product quality, and reduce potential losses from unexpected downtime or machine breakdowns. The success of this initiative will heavily depend on the active involvement of all employees in routinely maintaining and caring for the machines.

TABLE 8. Future PAM Machine Maintenance Improvement Proposals

Code	Machine/ Tool	Time (S)	Man Power	Activity Category					Activity Type
				O	T	I	S	D	
C1	Manual	2	1		P				NVA
E1	Manual	2550	6	P					NNVA

Explanation:

- Activity C1 can be eliminated because its purpose is to briefly cool carcasses a second time after the spin chiller process. According to the Head of Production, this is happening because the spin chiller machine is not operating optimally due to a lack of routine maintenance.
- Activity E1 can be eliminated because its purpose is to clean residual feathers after the plucker drum and dip processes in the dirty area. According to the Head of Production, this is occurring because the scalding, plucker drum, and plucker dip machines are not operating optimally due to a lack of routine maintenance.

1. Operator Training

To ensure precision and accelerate work pace, preventing WIP accumulation caused by inconsistent operator speeds, the company should have provided or enhanced operator training. More intensive training would reduce errors leading to rejected products and ensure a smooth flow of materials at every stage of the production process.

According to Herjuna et al. (2024), structured and continuous training significantly impacts increased productivity and reduced operational errors. In manufacturing, as studied in the context of machine operator training, employees who undergo focused technical training demonstrably reduce error rates and enhance work efficiency. For instance, machine operators receiving technical skills training can lower the rate of errors leading to product defects (rejects), thus reducing the need for replacing damaged products. This, in turn, ensures a smoother production process and reduces the accumulation of WIP that can occur due to inconsistencies in work speed among operators.

Thus, it can be concluded that more intensive and continuous operator training not only increases precision and reduces rejected products but also ensures the smoothness and effectiveness of the production process flow. This is crucial for maintaining optimal productivity and avoiding disruptions that can slow down the entire production workflow.

2. Use of Automated Machines for Material Transport

Investing in automated machinery, such as conveyors in the clean area, to accelerate material movement between production stations and reduce reliance on manual methods was proposed. An automated conveyor system could continuously transfer materials

between production stations. With proper design, conveyors could reduce waiting times, minimize WIP accumulation, and increase the efficiency of material flow.

3. Production Layout

According to Bučko et al. (2024), a crucial aspect of designing and optimizing a production line was the arrangement of the production space, aiming to enhance the efficiency of material flow. In redesigning a production line, it was vital to prevent the accumulation of WIP, which could obstruct the smooth flow of materials between production stations. An efficient spatial arrangement would ensure that material transport paths were unhindered and work areas remained clean and organized. This, in turn, would facilitate the movement of materials and support an unimpeded production process. Some key considerations for efficient production space arrangement include:

- Efficient Material Flow Arrangement:** Redesigning the production space should prioritize optimal material flow. Analysis tools like Sankey diagrams can visually represent material movement between production stations. This helps identify areas with potential obstructions or bottlenecks, allowing for immediate optimization to improve production smoothness.
- Optimal Space Utilization:** Effective production space arrangement can minimize wasted space and ensure each area is used efficiently. A well-designed production layout can reduce empty space and maximize space utilization for production activities.
- Avoiding Production Obstacles:** Good space design also aims to prevent irregular material

flow and excessive transportation distances. By establishing clear and unobstructed transport paths, the production process can run more smoothly and quickly.

By adhering to these principles, the company can reduce wasted space, optimize material flow, and improve overall production efficiency. A well-planned and efficient spatial arrangement will ensure that the production process runs smoothly and can enhance the performance of the production line.

4. Standard Operating Procedures (SOPs)

- a. Stricter SOPs for product sorting in the warehouse were implemented before shipment. This reduced the time required to locate products for customer delivery trucks.

One of the most widely implemented Lean tools in warehouses is 5S (Sort, Set in Order, Shine, Standardize, Sustain), which focuses on more efficient product arrangement and sorting. By implementing stricter sorting SOPs in the warehouse, the company can enhance the application of 5S principles to ensure a more organized workspace, accelerate product search times, and reduce waste in the sorting process (Pereira et al. 2020).

TABLE 9. Future PAM Proposed SOP Implementation Improvements

Code	Machine / Tool	Time (S)	Man Power	Activity Category					Activity Type
				O	T	I	S	D	
K2	Manual	31	4					P	NVA

Activity K2 can be eliminated because with the implementation of SOPs in the warehouse, specifically 5S, operators won't need to search for products (according to the receiving box truck) before shipment to the customer.

- b. SOPs that specified the maximum number of chickens per shipping crate were given to suppliers. This action prevented the overcrowding that had previously led to injuries and rejected products.

Beyond internal sorting, it's crucial to extend SOPs to suppliers by specifying the maximum number of chickens per shipping crate to prevent overcrowding. This is vital to avoid injuries such as bruising or fractures in the chickens, which can lead to them being rejected products after processing. According to Delanglez et al. (2024), over-handling chickens in a single crate significantly increases injury risks, particularly if methods like catching more than three chickens per hand are used; their research suggests the two-leg catching method is superior for animal welfare, reducing dislocations and fractures common with one-leg catching. Overloading

crates also causes stress, injury, and discomfort, potentially leading to carcass failure during slaughterhouse processing. Therefore, adjusting the number of chickens per crate to a maximum of five, aligned with stricter animal welfare standards, will not only reduce injury risks but also improve transportation quality in line with existing regulations.

5. Adding Operators to the Feather Correction Process

Even with regular machine maintenance, increasing the number of workers in the feather correction process became essential if machine conditions remained unchanged. By adding more personnel, the feather correction process can be completed more quickly and thoroughly. This minimizes residual feathers on the chickens and eliminates overtime hours. This action not only speeds up the material flow on the production line but also reduces potential rejected products, all while ensuring quality standards are maintained. If the operator team for the feather correction process is increased from one team of two operators to three operators, the production capacity will increase as shown in the following table.

TABLE 10. Future PAM Proposed Operator Addition Improvements

Code	Machine / Tool	Time (S)	Man Power	Activity Category					Activity Type
				O	T	I	S	D	
E1	Manual	1700 (2550:1,5)	3	P					NNVA

TABLE 11. Future Capacity of Feather Correction Process After Adding Operator Team

Process	Capacity/Shift	Number of Shifts	Number of Teams	Capacity	
				Gilling	Chicken
Feather Correction	9,83	2	1,5 (3 persons)	29	1305

With the feather correction production capacity reaching 29 giblets or 1,305 chickens per day, overtime should be avoidable, even if the daily production capacity for the 9 R MCD cut-up process doesn't reach 1,500 chickens (the average daily production demand). This is thanks to the addition of operators to the team working at the same station. It's important to note that this additional team will only be involved in the 9 R MCD cut-up feather correction process if no other products are being produced or if all other product production is complete. This is because other teams typically finish their products faster, as the demand for those products isn't as high as for the 9 R MCD cut-up product.

and incandescent lighting, significantly helps inspectors distinguish defects more clearly, including detecting residual feathers on carcasses that can lead to rejected products. Lighting with good color rendering will enhance an operator's ability to detect small defects that might be invisible with low-quality lighting. They also recommend that lighting systems at inspection stations prioritize high CRI lighting to ensure more accurate defect detection.

Thus, improving the quality of lighting can reduce the potential for rejected products due to residual feathers.

6. Improving Lighting in the Feather Correction Process

According to Collins and Worthey (1985), proper lighting at inspection stations is crucial for accurate defect identification in meat and poultry products. They found that using light sources with a high Color Rendering Index (CRI), such as cool white fluorescent

FUTURE STATE VALUE STREAM MAPPING (FSVSM)

After implementing the improvement proposals based on the fishbone diagram analysis of the three highest types of waste in the Cut Up 9 R MCD production process at PT XYZ, the next step is the creation of the following FSVSM.

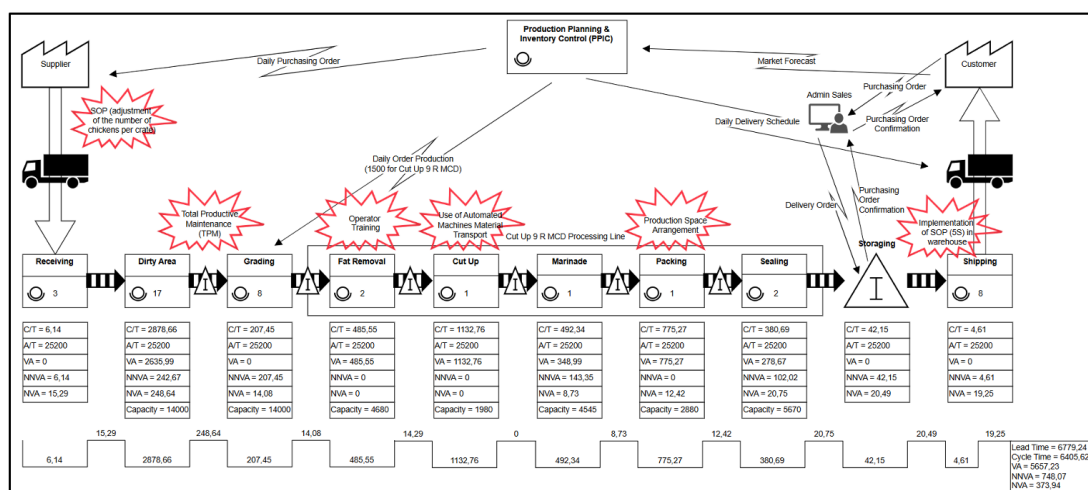


FIGURE 8. Future state value stream mapping 1

Future State 1 is achieved when machines operate optimally according to their functions after routine maintenance based on the proposed Total Productive Maintenance (TPM) improvements. This includes the scalding machine (to loosen feathers for easier plucking),

the plucker drum machine (to remove coarse feathers), and the plucker dip machine (to eliminate fine feathers remaining after coarse feather removal). With this Future State 1, a lead time reduction of 6779.24 seconds is achieved.

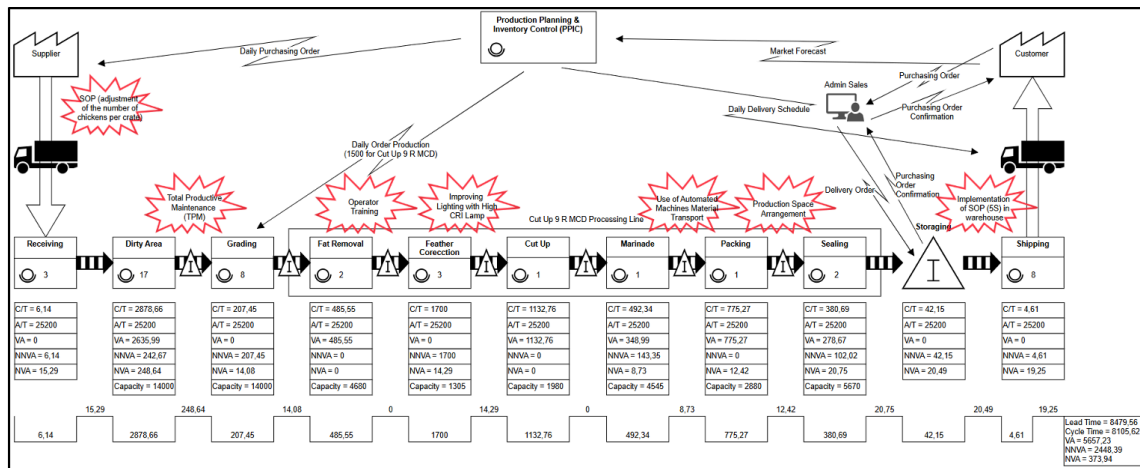


FIGURE 9. Future state value stream mapping 2

Future State 2 occurs when the machines still don't operate optimally (still leaving residual feathers on the carcass) even after implementing the proposed TPM improvements. In this scenario, the implemented improvement is the addition of operators to the feather correction process. With this Future State 2, the achieved lead time reduction is 8479.56 seconds.

LEAD TIME REDUCTION AFTER IMPLEMENTING PROPOSED IMPROVEMENTS

The next step is to calculate the lead time reduction and assess PCE improvement after implementing the proposed changes. Future value stream mapping will show the impact of these improvements, with PCE calculations evaluating their effectiveness (Jonny, 2021). Below are the PCE calculations for the current and future state VSM.

TABLE 12. Lead Time Reduction and PCE Improvement

Current state		Future state 1		Lead Time Reduction (s)	PCE Increase (%)
Lead Time	PCE	Lead Time	PCE		
9362,24	60,43	6779,24	83,45	2583	23,02
Current state		Future state 2		Lead Time Reduction (s)	PCE Increase (%)
Lead Time	PCE	Lead Time	PCE		
9362,24	60,43	8479,56	66,72	882,68	6,29

The calculations in the table compare the lead time reduction and PCE improvement achieved across two future state scenarios after implementing the proposed improvements. Starting from a current state with a total lead time of 9362.24 seconds and a PCE of 60.43%, Future State 1 demonstrates a significant lead time reduction of 2583 seconds, increasing the PCE by 23.02% to 83.45%. Meanwhile, Future State 2 shows a lead time reduction of 882.68 seconds, with a PCE increase of 6.29% to 66.72%.

CONCLUSION

Based on the results of the analysis and discussion, it can be concluded that all:

1. Through the Waste Assessment Model (WAM) methodology, it was found that the waste with the largest or most critical impact at PT XYZ originated from the defect category at 25.86%,

- inventory at 20.88%, and transportation at 15.61%. These results provide initial guidance on the waste that needs to be reduced.
2. An analysis of the current process activity mapping using the most effective VALSAT method for the 9 R MCD cut-up production process at PT XYZ revealed that 13 activities are classified as Value-Added (VA). These are B3, B5, B8, B10, B12, B14, B18, B20, D1, F1, G2, H1, and I1, totaling 5657.23 seconds or 94.29 minutes. Conversely, Non-Value-Added but Necessary (NNVA) activities comprise 16 tasks: A2, B1, B6, B16, C2, C3, C4, C5, E2, G1, G3, I3, J1, J3, K3, and K4, consuming a total of 3298.07 seconds or 54.97 minutes. Lastly, Non-Value-Added (NVA) activities account for 21 tasks: A1, B2, B4, B7, B9, B11, B13, B15, B17, B19, C1, C6, E2, G4, H2, I2, I4, J2, K1, K2, and K5, with a total duration of 406.94 seconds or 6.78 minutes.
 3. The primary goal of this research was to analyze the root causes of the three critical wastes in the production process—defect, inventory, and transportation—using the fishbone diagram method. The analysis revealed that the contributing factors to these wastes include aspects related to machines, environment, human factors, methods, and materials. For defect waste, the causes identified were a lack of routine maintenance, high live bird density per crate, insufficient lighting during feather correction, and operators being rushed and fatigued. For inventory waste, the causes were linked to machine downtime, limited space in the production area, and inconsistent operator work speeds. Finally, for transportation waste, the causes included limited space hindering material movement, the absence of automated machines, and manual methods for material transfer.
 4. By designing the Future State Value Stream Mapping (FSVSM), it was found that implementing the proposed improvements successfully reduced lead time in the production process. A significant lead time reduction was achieved in Future State 1, with a decrease of 2583 seconds, leading to a Process Cycle Efficiency (PCE) increase of 23.02% to 83.45%. Meanwhile, Future State 2 also showed a lead time reduction of 882.68 seconds, with a PCE increase of 6.29% to 66.72%. This indicates that the implemented improvements successfully accelerated the production process flow, enhanced efficiency, and reduced waste, ultimately

- contributing to an overall increase in production performance. With the implementation of the FSVSM design, the improvements not only reduced lead time and increased PCE but also addressed bottleneck issues, eliminated the need for overtime, and minimized rejected products.
5. While the proposed FSVSM provides a clear path to reduce lead time, its long-term success hinges on the company's adoption of a supportive 'Lean Culture.' As suggested by Abu et al. (2024), the sustainability of lean benefits is intrinsically linked to the successful inculcation of a continual improvement (CI) framework within the organization.

DECLARATION OF COMPETING INTEREST

None.

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