Lean Manufacturing as a Sustainable Approach to Minimize Waste in Traditional Food Production

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Abstract

MZA. Food Cake Factory produces traditional cakes like peanut cookies, *bakpia*, and *kreme*s. During the production process, some activities fall into the categories of non-value added (NVA) and necessary but non-value added (NNVA), leading to waste. The objectives of this study are to select research products using the Simple Additive Weighting (SAW) method, calculate the total time for value-added (VA), non-value added (NVA), and necessary but non-value added (NNVA) activities using Process Activity Mapping (PAM), identify waste in the research products using Value Stream Mapping (VSM), and propose improvements to reduce waste. Based on the Simple Additive Weighting (SAW) calculations, *bakpia* and *kremes* were selected as the research products. For *bakpia*, there are 37 NNVA activities, while *kremes* has 4 NVA activities and 19 NNVA activities. According to the priority quadrant scale, the proposed improvements for *bakpia* include: 1) providing storage space for raw materials on the production floor to prevent operators from repeatedly going back to the storeroom, and 2) having operators store the *bakpia* moulds at the moulding station to minimize the time spent searching for moulds. For kremes, the suggested improvements are: 1) having operators check the frying temperature, and 2) providing a designated area for peeled sweet potatoes.

Keywords: waste, value-added, simple additive weighting, value stream mapping, process activity mapping

INTRODUCTION

MZA.Food is a traditional cake factory specializing in producing *kue kacang, bakpia,* and *kreme*s, which are popular souvenirs for travellers. This demand has led to an increase in production, which, if not managed efficiently, can result in increased waste (Rahmanasari et al., 2021). Waste negatively impacts productivity and profitability, causes customer dissatisfaction, and can even pose risks to human safety (Sutrisno et al., 2018).

Initial observations at MZA.Food revealed several non-value-adding activities in the production process that contribute to waste. For instance, operators often have to move between stations to retrieve raw materials, as they are not readily available at the point of use. Another example is the time-consuming process of manually printing cakes one by one using a single mould.

Traditionally, seven types of waste are recognized: overproduction, delays, transportation, excessive processing, excess inventory, unnecessary movement, and defective products. However, according to Sutrisno et al., (2018), new categories of waste have emerged, such as underutilized human creativity, environmental waste, behavioural waste, demand flow failure, excess demand flow, outdated information, information distortion, lack of stakeholder involvement, and digital waste.

To address the waste at MZA.For food and increased product value, a lean manufacturing approach is proposed. Lean manufacturing has been widely used to eliminate inefficiencies and boost productivity across various industries, including food processing (Gebeyehu et al., 2022; Jimenez et al., 2019; Palange & Dhatrak, 2021; Putri & Dona, 2019).

Several studies in the food industry that utilize lean manufacturing include those conducted by Dora et al., (2012, 2014), Hartini et al., (2023), Putri & Dona (2019), Rose et al., (2019), Widiwati et al., (2024), Yaseen et al., (2021). All these studies use value stream mapping (VSM) to visualize activities in the production process. VSM is a method for identifying waste in manufacturing processes (Schoeman et al., 2021; Wang et al., 2022). This study also employs VSM to describe and identify waste occurring during the production process. However, in this study, VSM was applied to the product with the most waste, selected through the Simple Additive Weighting (SAW) method. Additionally, improvement proposals were developed using the Eisenhower Matrix, which prioritizes tasks based on their importance and urgency—an approach not explored in previous studies. This research aims to eliminate waste using lean manufacturing, supported by the SAW method for product selection, Process Activity Mapping (PAM) for activity analysis, VSM for waste visualization, and the Eisenhower Matrix for proposing improvements.

METHOD

This research has several objectives as described in the introduction. Several methods were used to achieve the goals. The mixture of methods used is expected to reach robust research results (Pinto & Patanakul, 2015). The steps taken in this study are:

1. Determining the research product that produces the most waste using the simple additive weighting (SAW) method. The sequence of work using SAW follows the research of Sutrisno et al., (2023), namely as follows:
   1) Determining the criteria.
   2) Giving a weight value to each criterion.
   3) Perform normalization. The normalization process aims to convert the alternative suitability rating into a value range between 0 and 1 based on the criteria's characteristics. The formula for normalizing the matrix is provided in the following equations:

$$rij = \begin{cases} \dfrac{Xij}{Max(Xij)} & if\ j\ is\ benefit\ atribute \\ \dfrac{Min(Xij)}{Xij} & if\ j\ is\ cost\ atribute \end{cases} \quad (1)$$

Where,

rij	= normalized performance rating value
Xij	= attribute value owned by each criterion
Max Xij	= the greatest value of each criterion
Min Xij	= the smallest value of each criterion

4) Calculation of final grades and ranking. The equation for the preference value as follow:

$$V_i = \sum_{j=1}^{n} wj.rij \tag{2}$$

Where:

Vi	= final value or alternative preference ranking
wj	= attribute weight value
rij	= normalized performance rating value

2. Classifying activities using process activity mapping (PAM) and composing a current state value stream mapping.
3. Identify waste, determining improvements from the highest waste using the Eisenhower Matrix and creating a future state value stream mapping.
   The Eisenhower method categorizes and organizes tasks based on the level of urgency and importance of a task and divides them into four priority levels, as follows (Ngandam Mfondoum et al., 2019):
   - Tasks that are both "Important" and "Urgent" should be prioritized and completed immediately, as they represent critical issues requiring immediate attention.
   - Tasks that are "Important" but "Not Urgent" typically relate to long-term goals. Although significant, they lack an immediate deadline and should be planned for completion at a later time.
   - "Not Important" but "Urgent" tasks can be delegated to others, as they are less critical compared to the previous categories.
   - Tasks that are neither "Important" nor "Urgent" are often distractions and should be avoided or discarded, as they tend to waste time.

RESULTS AND DISCUSSION

The results of this study are based on the steps that have been explained in the method section, namely as follows:

1. Determination of research products

The process of selecting research products begins by identifying the criteria for product selection. According to Hermanto & Izzah, (2019), the criteria used in this study include quality, popularity, durability, raw materials, and production time. The weights assigned to each criterion are shown in Table 1.

Table 1. Weight Value of Each Criteria

Criteria	Quality	Popularity	Durability	Raw materials	Production time
Weight	0.3	0.2	0.2	0.2	0.1

Next, normalize each product for each criterion according to equation (1). The suitability attribute values of each product are shown in Table 2, and the normalization matrix is presented in Table 3.

Table 2. Product-Criteria Match Attribute Values

No	Product	Criteria				
		Quality	Popularity	Durability	Raw materials	Production time
1	*Kue kacang*	80	80	4	100 kg	80
2	*Bakpia*	90	100	1	112 kg	100
3	*Kremes*	100	70	2	250 kg	70
	Divider	100	100	4	100	70

Based on equation (1), there are two attribute categories: benefit and cost. The criteria of quality, popularity, and durability are included in the benefit category, so the divisor in this category is the maximum value. The cost category includes raw materials and production time, and the divisor is the minimum value.

Table 3. Normalization Matrix

No	Product	Criteria				
		Quality	Popularity	Durability	Raw materials	Production time
1	*Kue kacang*	0.8	0.8	1	1	0.875
2	*Bakpia*	0.9	1	0.25	0.893	0.7
3	*Kremes*	1	0.7	0.5	0.4	1

Example of normalization calculation:

- Quality of *kue kacang* = $\frac{value\ of\ the\ suitability\ of\ the\ quality\ of\ \ kue\ kacang}{Quality\ devider} = \frac{80}{100} = 0.8$

After the data is normalized, the products are ranked using equation (2). The ranking results indicate that the highest score corresponds to the product with the least waste, while the lowest score reflects a product with higher waste levels. The detailed ranking results are presented in Table 4.

Tabel 4. Product Ranking

No	Product	Value	Rank
1	*Kue kacang*	0.8911	1
2	*Bakpia*	0.7399	2
3	*Kremes*	0.7235	3

Based on equation (2), the value for *kue kacang* is obtained based on the multiplication of the weight value and the normalized criteria value on the peanut cake/*kue kacang*. The example calculation is as follows:

Value on *kue kacang* = (0.3 x 0.8) + (0.2 x 0.8) + (0.2 x 1) + (0.2 * 0.91) + (0.1 x 0.875)
= 0.8911

According to Table 4, *kue kacang* has the highest score, indicating minimal waste. Therefore, *Bakpia* and *Kremes* were selected as the research products for further waste analysis.

2. Process activity mapping (PAM)

Process activity mapping (PAM) is one of the tools found in the value stream mapping analysis tools (VALSAT). Process activity mapping is used to identify activities, into value adding activities, non-value adding activities and necessary but non-value adding activities (Gebeyehu et al., 2022):

- Value-Adding Activity (VA): These activities enhance the value of a product or service from the customer’s perspective, making it more appealing and something they are willing to pay for.
- Non-Value Adding Activity (NVA): These activities offer no value and are considered pure waste. Customers are not willing to pay for them, and they can be easily eliminated or minimized.
- Necessary Non-Value Adding Activity (NNVA): While these activities do not add value, they are essential for the current process. Although customers will not pay for them, they remain necessary unless the supply process undergoes significant changes. Reducing this type of waste is more difficult in the short term.

The activities on *bakpia* and *kremes* are tabulated in Table 5.

Table 5. Process Activity Mapping for *Bakpia* and *Kremes*

Activities	*Bakpia*			*Kremes*		
	Total activity	Time (second)	Percentage	Total activity	Time (second)	Percentage
VA	30	25,573.4	36.531%	10	1,733.8	71.450%
NVA	0	0	0	4	66.8	2.753%
NNVA	37	44,432.2	63.469%	19	626	25.797%

Table 5 presents the number of activities and the total time allocated for each activity in the production of *Bakpia* and *Kremes*. The largest portion of activities falls under the category of unnecessary but non-value-adding tasks, accounting for 63.469% in *Bakpia* and 25.797% in *Kremes*. These activities will be targeted for elimination in both product processes.

The next step involves developing a value stream map. Value stream mapping connects various relationships within a system to establish an optimal working environment. It illustrates the flow of materials and information between manufacturers, suppliers, and distributors, facilitating the coordination of product delivery to customers (Kumar et al., 2022). Figure 1 is the current value stream mapping for *Bakpi*a, while Figure 2 is the current value stream mapping for *Kremes*.

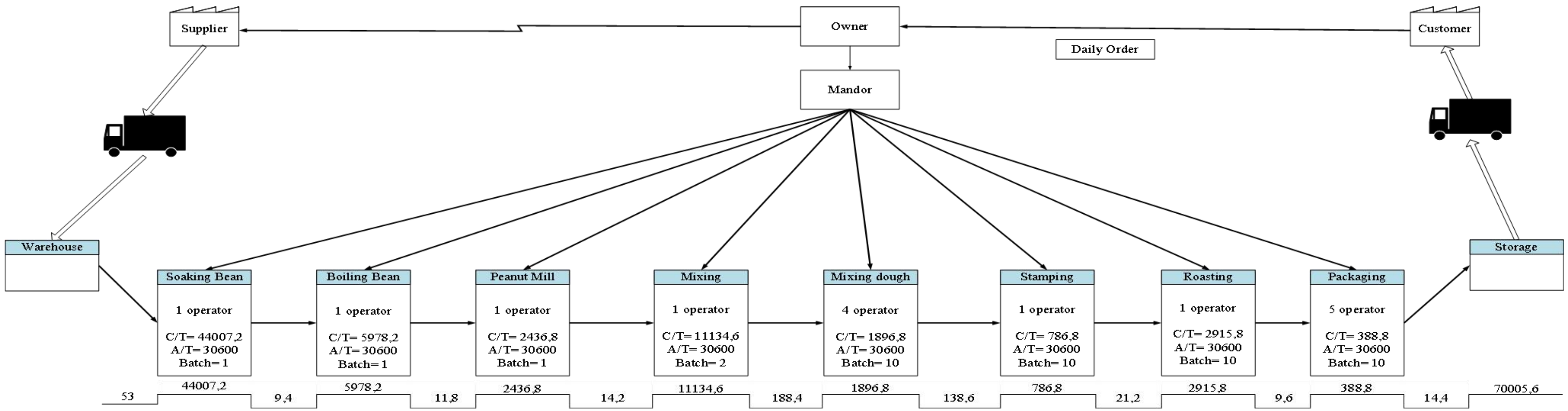

Figure 1. Current Value Stream Mapping of *Bakpia*

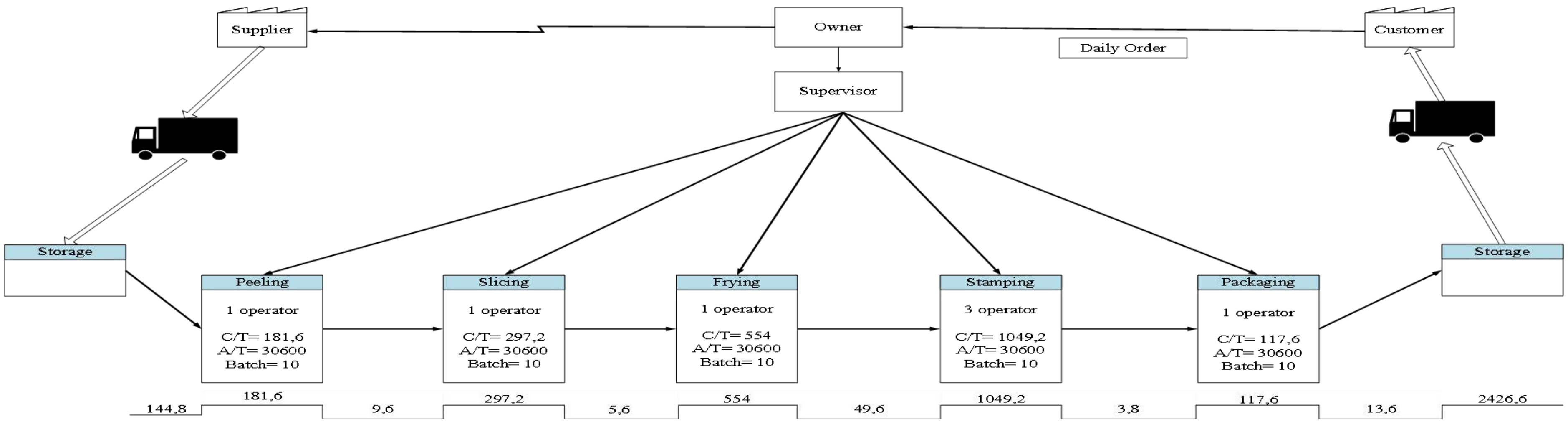

Figure 2. Current Value Stream Mapping of *Kremes*

Figure 2 and Figure 3, in succession, show the current value stream mapping (VSM) for *Bakpia* and *Kremes*. In each current VSM, there is information about the available time, cycle time, number of operators at the workstation and process repetition (batch) at each workstation. *Bakpia* has eight workstations, while *Kremes* has five workstations. The total processing time for *Bakpia* is 70,005.6 sec, and at the same time, for *Kremes* is 2,426.6 seconds.

3. Identify waste, determine improvements from the highest waste using the Eisenhower Matrix and create future VSM.

Waste refers to unimportant actions that produce unneeded results (Kumar et al., 2022). Lean manufacturing aims to remove waste that reduces industrial productivity and performance (Schoeman et al., 2021). A summary of waste identification for *Bakpia* and *Kremes* can be seen in Table 6 and Table 7.

Table 6. Waste Identification for *Bakpia*

Type of Waste	Definition	What is the waste	Source of waste	Why does it occur	Improvement suggestion
Defect	Incomplete or inappropriate product	Burnt *bakpia*	Roasting machine	Uneven fire	The operator checks the machine's fire before placing the *bakpia* inside
				No temperature measurement on the roasting machine	Provide an oven thermometer
				No spesific time for baking	Create a schedule and set an alarm for baking time
Transportation	Unnecessary movement of raw materials and semi-finished goods	Take sugar	Warehouse	Take sugar from the warehouse to the mixing station	Operator stores the sugar that has been used at the mixing station
		Take flour, salt, oil and water	Warehouse	Take flour, salt, oil and water from the warehouse to the mixing station	Operator can store the goods so as not to take them back to the warehouse
		Take *bakpia* mould	Warehouse	Take *bakpia* mould from the warehouse through the stamping station	The operator can store the *bakpia* mould at the stamping station for immediate use, avoiding trips to the warehouse
Delay	Waiting for raw materials, products, or people	Soaking beans	Soaking station	Ancient soaking of beans for up to 11 hours	Operators can use hot water when soaking so that the soaking time can be faster than before
		Boiling beans	Boiling station	The process of bean boiling is lengthy	Using softer beans
		Stamping *bakpia*	Stamping station	Operators stamp each *bakpia* individually, resulting in prolonged stamping times.	A new mould design is needed to stamp multiple *bakpia* simultaneously reducing time.

Table 7. Waste Identification for *Kremes*

Type of Waste	Definition	What is the waste	Source of waste	Why does it occur	Improvement suggestion
Defect	Products that are not crispy	Chewy crips	Frying station	Uneven fire from the frying place	The operator checks the frying fire so that it is even
Motion	An operator's movements during the production process that do not have added value	Peeling sweet potatoes	peeling station	The operator peels sweet potatoes with a knife, causing a significant amount of sweet potato to be wasted	The operator uses a peeling tool to minimize the waste of sweet potato pieces
		Tidying up sweet potato skin	peeling station	Scattered sweet potato skin	The operator determines a specific area for removing sweet potato skins so that the peeling process can be carried out directly at that location.
		Preparing the tool	Slicing station	Snapshot tool that does not have a specific maintenance schedule	Carrying out routine maintenance of the shredder machine
		Searching for sweet potatoes in the pile	Slicing station	Peeled sweet potatoes are often mixed with grated sweet potatoes, making it difficult to locate them	The operator can provide a designated area for peeled sweet potatoes to prevent the need for searching through a pile of grated sweet potatoes.
		Tidying up the grated sweet potato results	Slicing station	grated sweet potatoes are often scattered and become stuck in the slicing machine	By providing an elevated storage area for the grated sweet potatoes, the operator can ensure the grated pieces are properly collected and do not become stuck during the slicing process.
		Collecting glasses	Stamp station	glasses used for printing are often discarded haphazardly, resulting in time wasted collecting them	The operator can organize the glasses neatly after use, eliminating the need for time-consuming collection of scattered glasses.
Transportation	Operator movement from station to warehouse	Retrieving sugar syrup	Warehouse	Retrieving sugar syrup from the warehouse and delivering it to the frying station.	The operator can store the sugar syrup at the frying station for immediate use, allowing it to be added directly during the frying process without the need to return to the warehouse.

Table 6 and Table 7 outline the types of waste occurring in the production processes of *Bakpia* and *Kremes*. The types of waste identified in Bakpia are defects, transportation, and delays. *Kremes* has three types of waste: defects, motion, and transportation. This waste identification serves as a guide for proposing improvements based on the levels of "importance" and "urgency" as determined by the Eisenhower Matrix. The priority quadrant scale using the Eisenhower Matrix for *Bakpia* is illustrated in Figure 3, and for *Kremes* in Figure 4.

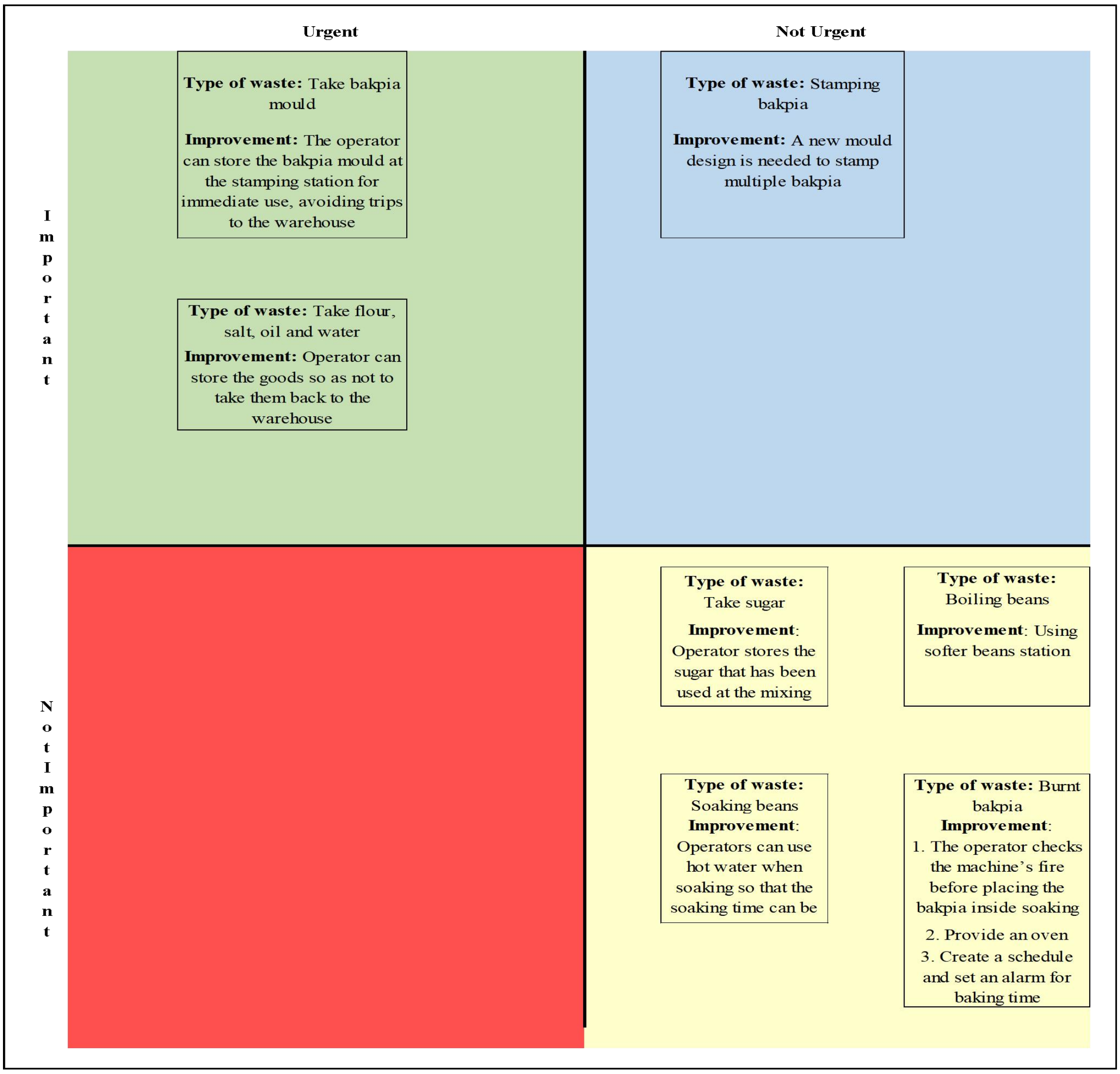

Figure 3. Eisenhower Matrix for *Bakpia*

Based on the priority quadrant scale using the Eisenhower Matrix for *Bakpia*, the proposed improvements in the important and urgent quadrant address two key types of waste:

1. Retrieving flour, salt, oil, and water from the warehouse – The recommended improvement is for operators to store these ingredients on a tiered rack at the mixing station, eliminating the need to repeatedly fetch them from the warehouse.

2. Retrieving *bakpia* moulds from the warehouse – Operators can store the moulds at the stamping station, placing them on the table used for stamping to ensure immediate availability.

In the important but not urgent quadrant, the identified waste is in stamping *bakpia* one by one. The proposed solution is to design a new mould that can stamp multiple *bakpia* at once, improving efficiency.

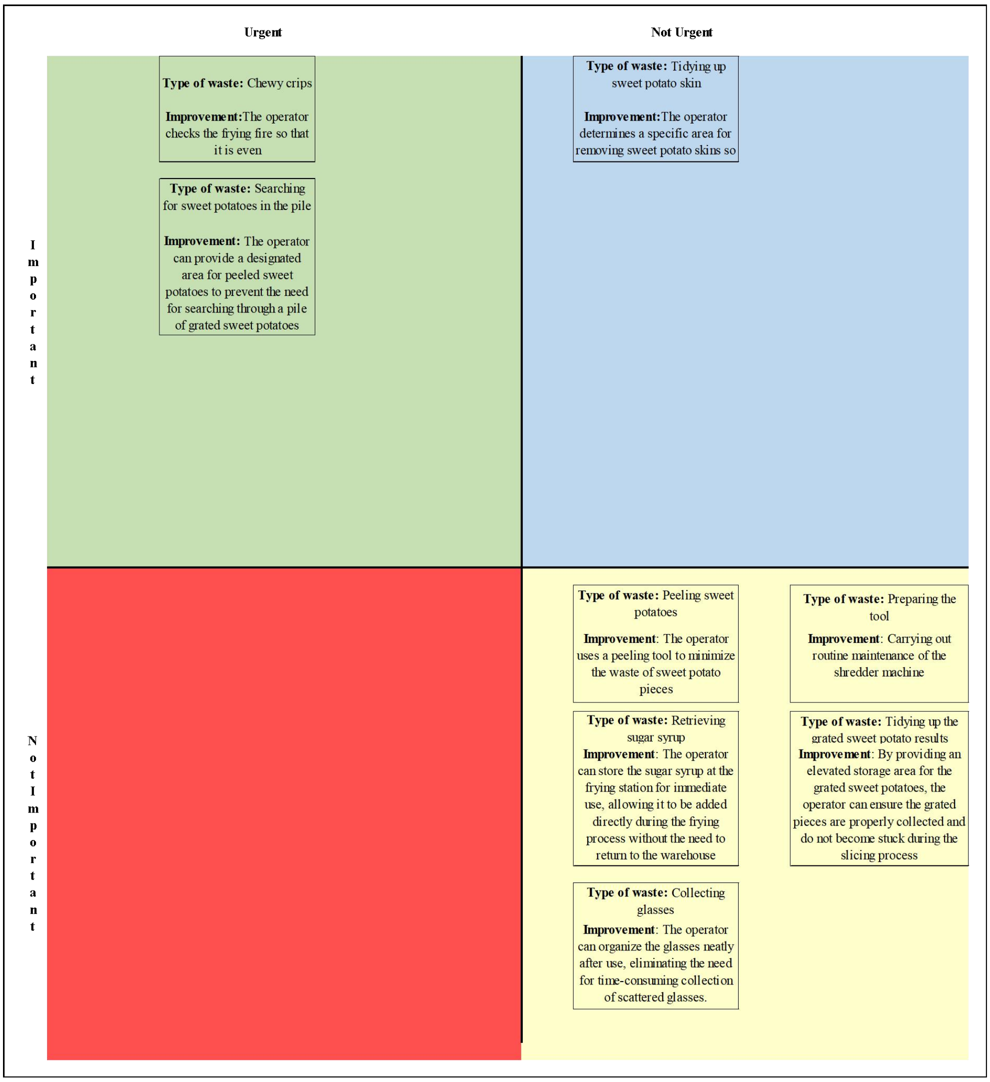

Figure 4. Eisenhower Matrix for *Kremes*

Based on the priority quadrant scale using the Eisenhower Matrix for *Kremes*, the proposed improvements in the important and urgent quadrant address two main types of waste:

1. Tough *Kremes* – The suggested improvement is for the operator to check the frying temperature to ensure the sweet potatoes cook evenly when added to the fryer.
2. Searching for peeled sweet potatoes in a pile – The improvement involves providing a dedicated space for peeled sweet potatoes, located near the grated sweet potatoes, to minimize unnecessary movement and eliminate the need to search through piles.

In the important but not urgent quadrant, the waste identified is scattered sweet potato skins on the floor. The proposed solution is for the operator to designate a special container for the skins, allowing them to peel directly into it.

The next step is to create a future state value stream mapping from the proposed improvements that have been given to *Bakpia* and *Kremes*. Figure 5 and Figure 6.

Based on the future state value stream mapping for *Bakpia* (Figure 5), the total production time is reduced from 70,005.6 seconds in the current state to 69,846.4 seconds. Specifically, transportation time for retrieving raw materials at the mixing dough decreases from 188.4 seconds to 42.6 seconds, a reduction of 145.8 seconds. Additionally, the time required to retrieve the *Bakpia* mould at the stamping station is reduced by 13.4 seconds, from 21.2 seconds to 7.8 seconds. These reductions are achieved by eliminating unnecessary activities at the mixing and stamping stations.

Whilst *Kremes* (Figure 6), there is a reduction in total processing time, from 2,172.8 seconds in the current state to 2,160 seconds. The time spent searching for sweet potatoes at the shredding station decreases by 44.2 seconds, from 297.2 seconds to 253 seconds, due to the elimination of the search activity.

Table 8 is a summary comparing the current and future state value stream mappings for *Bakpia* and *Kremes*.

Table 8. Summary comparing the current and future state value stream mappings for *Bakpia* and *Kremes*.

Information	Time (detik)	Activity	Percentage
	Bakpia		
Current state value stream mapping	70,005.6	67	1.05%
Future state value stream mapping	69,846.4	64	
	Kremes		
Current state value stream mapping	2,426.6	33	1.22%
Future state value stream mapping	2,160	27	

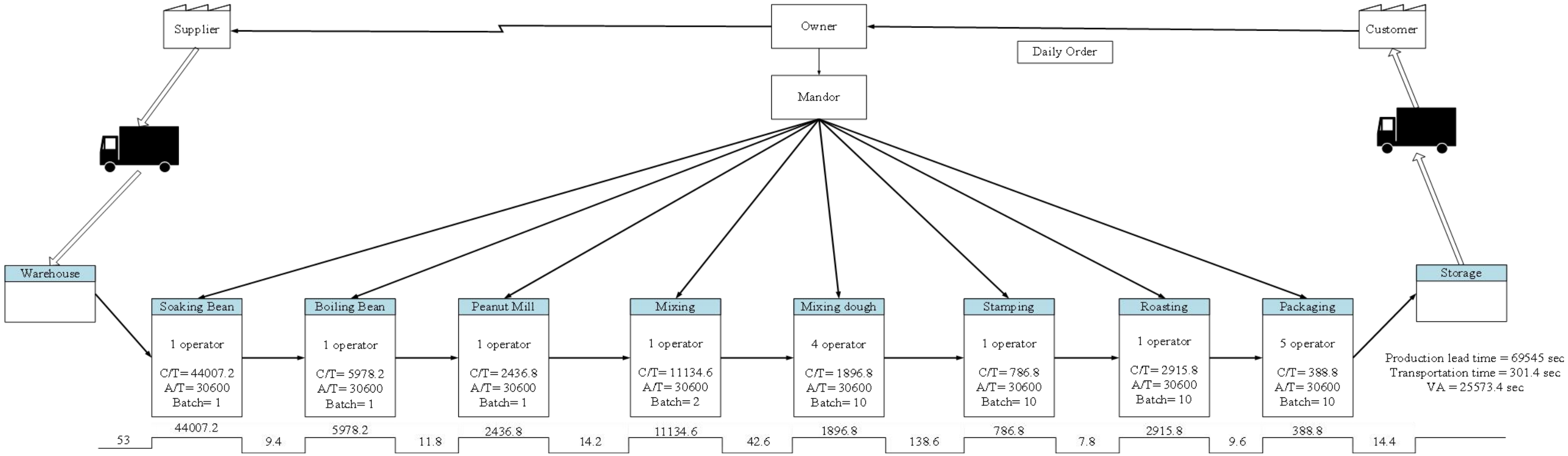

Figure 5. Future Value Stream Mapping of *Bakpia*

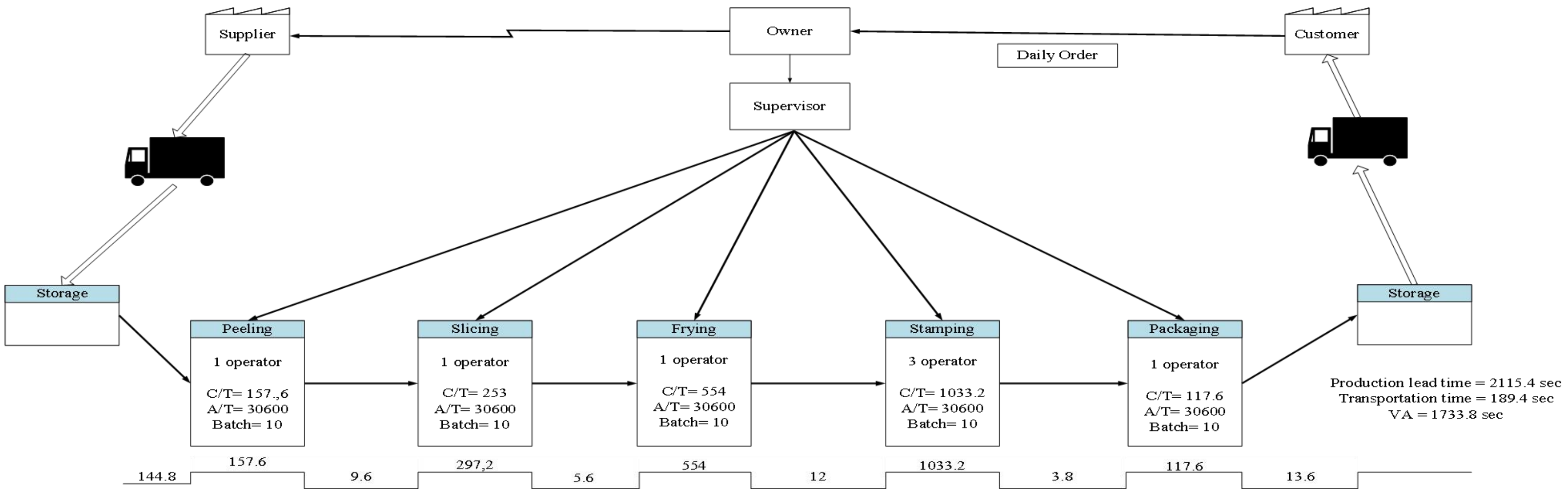

Figure 6. Future Value Stream Mapping of *Kremes*

CONCLUSION

Based on the data analysis and discussion, the following conclusions were drawn:

1. Using the Simple Additive Weighting (SAW) method, two products had the lowest final scores: *Bakpi*a's score of 0.7399 and *Kremes*'s score of 0.7235.
2. The total time for value-added (VA) activities in *Bakpia* production was 25,573.4 seconds, while necessary but non-value-added (NNVA) activities took 70,005.6 seconds. For *Kreme*s, VA activities took 1,733.8 seconds, non-value-added (NVA) activities 66.8 seconds, and NNVA activities 626 seconds.
3. Waste identification revealed three types of waste in *Bakpia* production: defect, transportation, and delay. In *Kremes* production, the three identified wastes were defect, motion, and transportation.
4. Based on the waste identified, improvement proposals were made using a priority quadrant scale. For *Bakpia*, two key improvements in the important and urgent quadrant were suggested: (1) Operators should store raw materials, such as flour and oil, on a stacking rack at the kneading station to eliminate trips to the warehouse, and (2) *Bakpia* moulds should be stored at the printing station for immediate use, reducing the need to retrieve them from the warehouse. For *Kremes*, two important and urgent improvements were recommended: (1) Operators should check the frying temperature to ensure sweet potatoes cook evenly, and (2) A designated area for peeled sweet potatoes should be provided to avoid searching through piles of grated sweet potatoes.

SUGGESTIONS

Future research can combine potential hazard risks with lean manufacturing and redesign facilities with lean manufacturing in the food processing industry

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