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INTEGRATION OF LEAN MANUFACTURING AND CRAFT TO IMPROVE SOY FOOD INDUSTRY EFFICIENCY

Integración de Lean Manufacturing y CRAFT para mejorar la eficiencia de la industria alimentaria de soja
Integração do Lean Manufacturing e do CRAFT para melhorar a eficiência da indústria de alimentos em base de soja

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ABSTRACT
Operational inefficiencies in the soy food industry are commonly caused by waste, suboptimal machine performance, backtracking in material flow, and ineffective labor management, resulting in extended production times and increased material handling costs (OMH). This study applies a lean manufacturing approach using Process Activity Mapping (PAM) and Value Stream Mapping (VSM) to distinguish value-added and non-value-added activities, while the DOWNTIME framework and the 5 Whys method are employed to identify waste types and their root causes. Facility layout inefficiencies are further analyzed using the Computerized Relative Allocation of Facilities Technique (CRAFT) to develop a more efficient layout design. The results show that waiting time is the dominant form of waste, driven by limited machine capacity, inefficient production methods, and suboptimal layout design. Improvement measures, including the application of a 10% citric acid solution to accelerate soaking and the adoption of a continuous band sealer machine, reduced waiting time by 45.86% and total process time by 43.11%. In addition, the redesigned layout reduced material handling costs by 17.07%, demonstrating that integrating lean manufacturing tools and the CRAFT algorithm effectively enhances production efficiency in the soy food industry.

KEYWORDS
Plant layout design, operational performance improvement, soy industry processing, waste elimination.

RESUMEN
Las ineficiencias operativas en la industria alimentaria de la soja suelen estar asociadas con el desperdicio, el rendimiento subóptimo de las máquinas, los retrocesos en el flujo de materiales y una gestión laboral ineficaz, lo que incrementa el tiempo de producción y los costos de manejo de materiales (OMH). Este estudio aplica un enfoque de manufactura esbelta mediante el uso del Mapeo de Actividades del Proceso (PAM) y el Mapeo del Flujo de Valor (VSM) para diferenciar las actividades con valor añadido de aquellas sin valor añadido. Los tipos de desperdicio y sus causas raíz se identifican utilizando el marco DOWNTIME y el método de los 5 Porqués. Además, las ineficiencias del diseño de planta se analizan mediante la Técnica Computarizada de Asignación Relativa de Instalaciones (CRAFT) para desarrollar un diseño de distribución más eficiente. Los resultados indican que el tiempo de espera es la forma dominante de desperdicio, impulsada por la capacidad limitada de las máquinas, métodos de producción ineficientes y un diseño subóptimo. Las medidas de mejora, incluida la aplicación de una solución de ácido cítrico al 10% para acelerar el remojo y el uso de una selladora de banda continua, redujeron el tiempo de espera en un 45,86% y el tiempo total del proceso en un 43,11%. Asimismo, el rediseño del layout permitió reducir los costos de manejo de materiales en un 17,07%, demostrando que la integración de manufactura esbelta y CRAFT mejora significativamente la eficiencia productiva.

PALABRAS CLAVE
Diseño de distribución de planta, mejora del rendimiento operativo, procesamiento industrial de soja, eliminación de desperdicios.

RESUMO
As ineficiências operacionais na indústria de alimentos à base de soja estão geralmente relacionadas ao desperdício, ao desempenho subótimo das máquinas, ao retrabalho no fluxo de materiais e à gestão ineficaz da mão de obra, resultando em maior tempo de produção e aumento dos custos de manuseio de materiais (OMH). Este estudo aplica uma abordagem de manufatura enxuta utilizando o Mapeamento de Atividades do Processo (PAM) e o Mapeamento do Fluxo de Valor (VSM) para distinguir atividades com valor agregado e sem valor agregado. Os tipos de desperdício e suas causas raiz são analisados por meio do framework DOWNTIME e do método dos 5 Porquês. As ineficiências do layout também são avaliadas utilizando a Técnica Computadorizada de Alocação Relativa de Instalações (CRAFT), com o objetivo de desenvolver um layout mais eficiente. Os resultados mostram que o tempo de espera é a principal forma de desperdício, causado pela capacidade limitada das máquinas, métodos de produção ineficientes e layout subótimo. As medidas de melhoria, incluindo a aplicação de uma solução de ácido cítrico a 10% para acelerar o processo de remolho e a adoção de uma seladora de banda contínua, reduziram o tempo de espera em 45,86% e o tempo total do processo em 43,11%. Além disso, o layout redesenhado reduziu os custos de manuseio de materiais em 17,07%, comprovando que a integração da manufatura enxuta e do algoritmo CRAFT aumenta significativamente a eficiência produtiva.

PALAVRAS-CHAVE
Projeto de layout industrial, melhoria do desempenho operacional, processamento industrial de soja, eliminação de desperdícios.

Introduction

Efficiency in production systems is a critical factor affecting industrial profitability and competitiveness. One of the primary sources of inefficiency is waste, defined as the utilization of time and resources that does not contribute to value creation (Nurwahidah et al., 2021). Previous studies have shown that a 15% decline in productivity may result in a profit reduction of up to 25%, particularly when inefficient factory layouts lead to production delays of as much as 45% (Aminuddin and Perdana, 2022). Comparable conditions are observed in the Super Sumber Mas soy food industry in Indonesia, which operates with a production capacity of approximately 550 kg per day. This industry experiences prolonged waiting times, excessive material handling, and suboptimal labor utilization, resulting in increased operational costs, reduced productivity, and weakened competitiveness. These challenges highlight the need for a systematic approach to improving production efficiency.

Lean manufacturing is widely recognized as an effective approach for eliminating non-value-added activities and enhancing process efficiency (Suwasono et al., 2022: 37-45). Within this framework, Process Activity Mapping (PAM) and Value Stream Mapping (VSM) are employed to identify value-added and non-value-added activities and to analyze inefficiencies in production flow (Suryaningrat et al., 2022). To further structure waste identification, the DOWNTIME framework is used to classify seven categories of waste, while the 5 Whys method is applied to systematically determine the root causes of inefficiencies (Basudewa et al., 2022; Susendi, 2021).

Beyond process-related inefficiencies, facility layout plays a crucial role in production performance. The Computerized Relative Allocation of Facilities Technique (CRAFT) has proven effective in optimizing facility layouts due to its computational efficiency and accuracy in minimizing material handling costs (Kuswardhani et al., 2021). This method is particularly suitable for small and medium-sized industries operating within limited spatial constraints and simple building structures (Azmilatun et al., 2025). Although lean manufacturing and the CRAFT algorithm have demonstrated significant efficiency improvements when applied independently, empirical studies integrating both approaches remain limited, particularly within the context of the soy food industry in Indonesia. Therefore, this study aims to integrate lean manufacturing tools and the CRAFT algorithm to identify dominant waste, redesign facility layout, and improve overall production efficiency.

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Research method

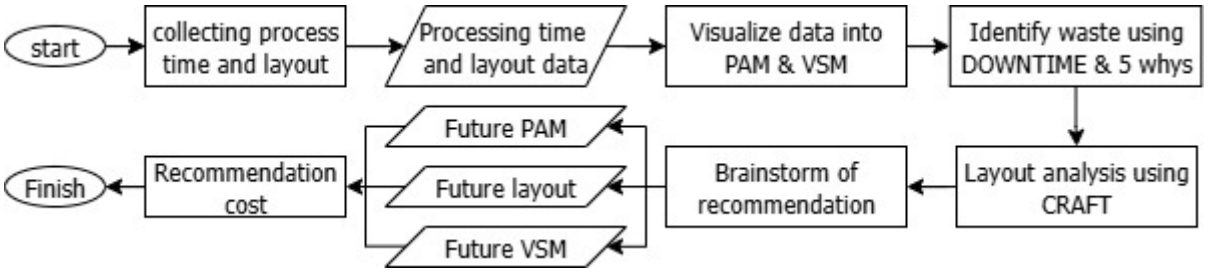
Materials

The tools used to process the data in this study were stationery, a stopwatch, a lasermeter, Microsoft Word software, a Microsoft Excel add-in, and Microsoft Visio. The materials used in this study included primary and secondary data. Primary data consisted of observations and interviews at the soy food industry in Indonesia, while secondary data came from scientific journals and literature to support the research statement.

Methods

This study employs a mixed-methods approach using quantitative and qualitative data within a lean manufacturing framework. Process Activity Mapping (PAM) and Value Stream Mapping (VSM) are applied to identify waste and inefficiencies in the production process, as illustrated in the research flow presented in Figure 1.

Figure 1. Research framework
Figura 1. Marco de investigación



Source: own elaboration. Fuente: elaboración propia.

Observational data and process time measurements are used to map production activities and classify them into value-added (VA), non-value-added (NVA), and necessary but non-value-added (NNVA) categories. PAM is used to identify operations, transportation, inspection, delay, and storage activities based on their value contribution, while VSM visualizes material and information flows and is used to calculate cycle time and lead time (Ansyah et al., 2025; Fatma et al., 2025). Takt time and active time are subsequently calculated to evaluate production performance and system balance (Ahmad and Aditya, 2019).

$$Takt\ time = \frac{Available\ time\ per\ day}{Customer\ demand\ rat\ per\ day}$$

$$Uptime\ (\%) = \frac{Available\ time\ -\ Change\ over\ time}{Available\ time}\ x\ 100\%$$

Root cause analysis of the seven waste categories is conducted using the DOWNTIME framework and the 5 Whys method to systematically identify underlying causes of inefficiencies (Keyser and Pooyan, 2023). Facility layout data, including inter-departmental distances, material flow frequency, and handling costs, are then analyzed using the Computerized Relative Allocation of Facilities Technique (CRAFT). The CRAFT algorithm is applied iteratively to generate a more efficient layout configuration and to support the development of improvement recommendations and future-state PAM and VSM.

Discussion

This research aims to analyze current waste and determine a system to reduce it in the future. Therefore, this research begins with VSM mapping and concludes with a VSM overview of the future.

Current PAM and VSM

The soy food industry currently operates an eight-hour workday with eleven production stages: initial boiling, milling, sorting, soaking, cooking, draining, cooling, sieving, packaging, and storage. Each production stage will be explained to understand the overall cycle time and how it changes over time.

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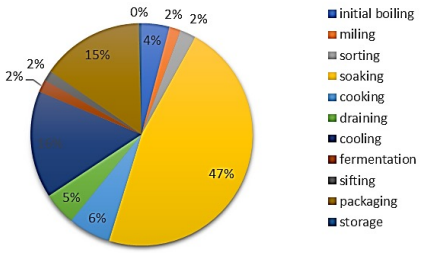
Table 1. Current process activity mapping
Tabla 1. Mapeo de la actividad del proceso actual

No.	Play activities	Activities	Time	Type of activity	Activity category
1.	Preparation	Cooking furnace preparation	00:03:43	Operation	NNVA
		Boiling water	00:03:15	Operation	NNVA
		Opening soybean bags	00:07:25	Operation	NNVA
2.	Initial boiling	Transferring materials to cooking furnace	00:06:05	Transport	NNVA
		Initial boiling (until the soybeans swell)	01:01:00	Operation	VA
		Material waiting for milling process	00:24:38	Delay	NVA
3.	Milling	Transferring materials to the furnace	00:05:37	Transport	NNVA
		Preparing the milling machine	00:02:48	Operation	NNVA
		Milling process	00:29:13	Operation	VA
4.	Sorting	Transferring materials to the sorting furnace	00:02:45	Transport	NNVA
		Sorting process	00:49:22	Operation	VA
5.	Soaking	Transferring materials to the soaking process	00:03:17	Transport	NNVA
		Soaking the materials	17:20:00	Operation	VA
		Changing materials soaking water	00:06:06	Operation	VA
		Transferring materials to the draining basket	00:05:48	Transport	NVA
6.	Cooking	Transferring and draining materials to the cooking furnace	00:02:30	Transport	VA
		Boiling the materials until cooked	02:12:40	Operation	VA
		Removing foam	00:04:03	Operation	VA
7.	Draining	Transferring materials to the draining basket	00:17:46	Transport	NNVA
		Draining process	01:30:21	Operation	VA
8.	Cooling	Transferring materials to the cooling table	01:00:30	Transport	NNVA
		Cooling process	04:32:33	Operation	VA
		Materials waiting to be fermented	00:19:00	Delay	NVA
9.	Fermentation	Yeast preparation	00:19:00	Operation	NNVA
		Fermentation process	00:22:12	Operation	VA
10.	Sifting	Taking the sieve	00:00:30	Operation	NNVA
		Sifting process	00:33:36	Operation	VA
11.	Packaging	Packaging preparation	00:04:57	Operation	NNVA
		Packaging, weighing, and sealing process	05:33:12	Operation	VA
12.	Storage	Transferring soy food industry to the storage	00:03:58	Transport	NNVA
		Arrangin soy food industry on storage	00:05:18	Storage	NNVA
Total process time			37:53:08		
Total value added time			34:36:48		
Total non-value added time			00:49:26		
Total necessary non-value added time			02:26:54		

Source: own elaboration. Fuente: elaboración propia.

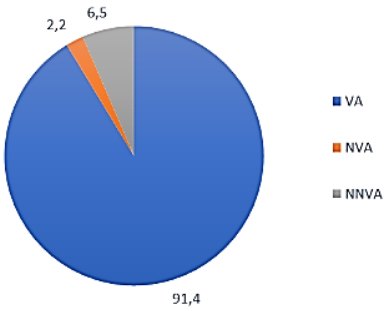
The soy food production process consists of preparation, thermal treatment, fermentation, and packaging stages. Preparation includes stove setup, water boiling, and soybean handling, followed by partial boiling to facilitate hull removal and expansion, milling to separate the skins, and sorting to remove impurities. The soybeans are then soaked for approximately 17 hours at ambient temperature (around 30 °C) to enable sufficient water absorption prior to fermentation. After soaking, the soybeans are drained, cooked to soften their texture and inhibit undesirable microorganisms, cooled, and inoculated with yeast to initiate fermentation, during which enzymatic activity supports mycelial penetration and nutrient development (Kusumawati et al., 2020). The fermented soybeans are subsequently sifted, weighed, packaged, and stored at room temperature to allow complete mycelial development. Overall, the process requires 2,273.13 hours to produce approximately 380 kg of soy food product.

Figure 2. Percentage of processing time
Figura 2. Porcentaje de tiempo de procesamiento



Source: own elaboration. Fuente: elaboración propia.

Figure 3. Percentage of activity category
Figura 3. Porcentaje de la categoría de actividad



Source: own elaboration. Fuente: elaboración propia.

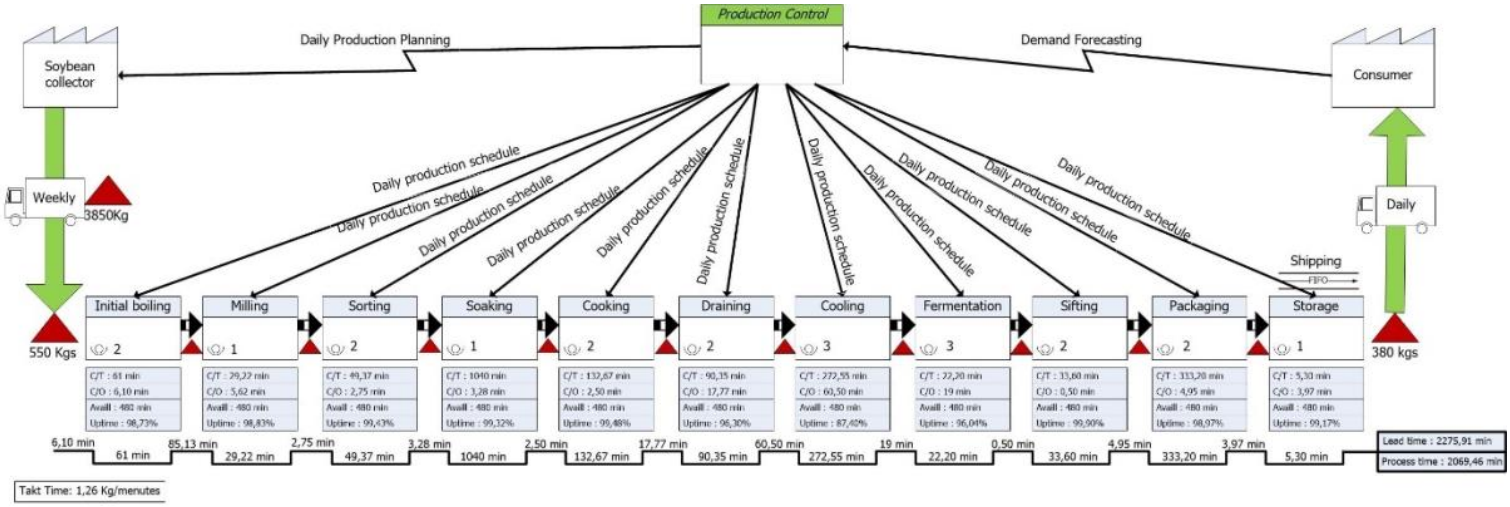
Figure 2 indicates that soaking, packaging, and draining are the stages with the longest processing times. The extended soaking duration results from the conventional cold-water method, which typically requires overnight soaking and may extend up to two days depending on processing conditions (Kusumawati et al., 2020). In addition, the packaging stage is time-consuming due to the use of manual sealers with inconsistent heat, leading to frequent packaging defects. Consequently,

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the dominant waste identified in the process is waiting time, particularly during soaking, cooling, and packaging, which increases total processing time and operational costs.

Figure 3 shows that value-added (VA) activities account for 91.4% of total processing time, while necessary non-value-added (NNVA) and non-value-added (NVA) activities account for 6.5% and 2.2%, respectively. Although VA activities dominate, NNVA activities primarily transportation remain inefficient due to backtracking and should be minimized, as they do not contribute to product value or process efficiency (Suwasono et al., 2022).

Figure 4. VSM current
Figura 4. Corriente VSM



Source: own elaboration. Fuente: elaboración propia.

Figure 4 shows that overtime is most pronounced in the soaking, packaging, and cooling stages, primarily due to extended waiting times. The current VSM indicates a total lead time of 2,275.91 minutes, exceeding the total process time of 2,069.46 minutes, which reflects substantial waiting and non-value-added activities across several workstations. Among these stages, soaking exhibits the longest cycle time (1,040 minutes), identifying it as the primary production bottleneck. Cooling (272.55 minutes) and packaging (333.20 minutes) also represent critical stages due to their high processing times and relatively low uptime.

Seven wastes analysis

A descriptive analysis combining the DOWNTIME framework and the 5 Whys method was conducted to identify the root causes of waste in the soy food industry. This approach enabled systematic identification of underlying factors contributing to inefficiencies across each waste category. The results of the waste analysis are presented in Table 2.

Table 2. Seven waste analysis
Tabla 2. Análisis de siete residuos

Type of waste	5 Why result		Recommendation
	Waste	Root cause	
Defects	Soybeans spills from cooking container.	There is no cooking SOPs.	Establishing SOPs for capacity, time, and temperature.
	Materials are not uniform.	There are no modern machines.	Investing in automatic sieving machine.
	Product defected in inventory.	There is no packaging SOP.	Testing and establishing packaging standards.
Overproduction	Not found any.	Not found any.	Not found any.
Waiting	Waiting before cooking process.	No production schedule.	Create a fixed production schedule.
	Waiting before milling process.	Limited grinding machines.	adjust the amount of machine or its capacity.
	Milled soybeans await soaking.	Suboptimal layout.	Analyze and improve the layout.
	Soaked soybeans await cooking.	Small pans.	Upgrade pans according to capacity.
	Ripe soybeans await draining.	Small baskets.	Upgrade drainers as needed.
	Cooked soybeans await fermentation.	Employee job descriptions unclear.	Train and assign tasks crearly.
	Fermented soybeans await sieving.	Sifter far away, lack of supervision.	Make equipment available nearby and add supervisors.
	Sifted soybeans await packaging.	Plastic packaging not ready.	Train employees and prepare packaging early.
Non-Utilized Talent	Workers are idle during cooking.	No division of labor while waiting.	Create flexible work schedules and tasks.
Transportation	Transportation to the milling machine os carried out back and forth.	Small baskets, back and forth transport.	Use larger trolleys/conveyors or equipment.
	Transportation to the cooling table is carried out back and forth.	Small baskets, back and forth transport.	Use larger trolleys/conveyors or equipment.
Inventory	Product damaged before shipment.	No storage SOP.	Create SOPs for temperature and storage time.
Motion	Reciprocating motion to the milling machine.	Small baskets, back and forth transport.	Upgrade equipment and improve the layout.
	Reciprocating motion to the cooling table.	Small baskets, back and forth transport.	Upgrade equipment and improve the layout.
	The position for picking up milled soybeans is quite low.	Low/non-ergonomic tool position.	Ergonomic SOPs and modify tables/ equipment.
	The position for picking up milled soybeans is quite low.	Low-non-ergonomic layout.	Ergonomic SOPs and modify tables/ equipment.
	The position for picking up yeast and sifter is quite far and low.	Suboptimal layout.	Reanalyze the layout using 5S.
	The soy food industry storage rack has high and low places.	Suboptimal layout.	Reanalyze the layout using 5S.
Extra Processing	The presence of foreign materials.	No supplier quality standards.	Implement raw material inspection from the start.

Source: own elaboration. Fuente: elaboración propia.

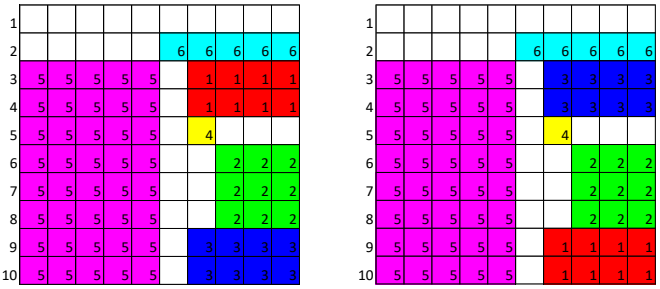
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Waste reduction is essential to improve industrial productivity. The proposed improvements include layout optimization and equipment maintenance to enhance worker safety and comfort, as non-ergonomic working postures have been shown to reduce productivity and increase the risk of musculoskeletal disorders (Andrian and Renilaili, 2021). In addition, the implementation of structured work scheduling is recommended to improve time management, increase productivity, and clarify task priorities (Azzahra and Amanda, 2024). The establishment of standard operating procedures (SOPs) for each production stage is also critical, as SOPs provide clear operational guidelines, ensure process consistency, and support accountability in achieving organizational objectives (Nabillaa and Hasin, 2022).

Layout Improvement

The facility layout was redesigned using the Computerized Relative Allocation of Facilities Technique (CRAFT) to reduce material handling costs through inter-departmental relocation. The production system comprises six departments: cooking (Department 1), milling (Department 2), sorting and soaking (Department 3), draining (Department 4), soy food processing/printing (Department 5), and storage (Department 6).

Figure 5. Layout changes using the CRAFT method
Figura 5. Cambios de diseño utilizando el método CRAFT



Where a) before, and b) after. Source: own elaboration. Donde a) antes y b) después. Fuente: elaboración propia.

Figure 5 shows a comparison of the layout before and after improvements made using the CRAFT method. The layout recommended by the CRAFT method includes a position swap between departments 1 and 3, namely between the cooking department and the sorting and grinding department. Details of the calculations related to distance and time are presented in Tables 4 and 5.

Table 3. Current distance and time calculation
Tabla 3. Cálculo de la distancia y el tiempo actuales

From	To	Distance (meters)	Frequency (times)	Total distance (m/day)	Movement time (s/d)
Cooking department	Milling department	1	39	39	337
Milling department	Sorting and soaking department	2	39	78	165
Sorting and soaking department	Draining department	2	39	78	150
Draining department	Cooking department	4	39	156	150
Cooking department	Draining department	2	39	78	1066
Draining department	Soy food industry manufacturing department	8	39	312	3630
Soy food industry manufacturing department	Storage department	8	5	40	238
Total movement (second/day)					5.736
Total material handling cost (USD)					37,02 USD

Source: own elaboration. Fuente: elaboración propia.

Table 4. Future distance and time calculation
Tabla 4. Cálculo de distancia y tiempo futuros

From	To	Distance (meters)	Frequency (times)	Total distance (m/day)	Movement time (s/d)
Cooking department	Milling department	1	39	39	180
Milling department	Sorting and soaking department	1	39	39	120
Sorting and soaking department	Draining department	2	39	78	60
Draining department	Cooking department	2	39	78	150
Cooking department	Draining department	2	39	78	1066
Draining department	soy food industry manufacturing department	8	39	312	3630
Soy food industry manufacturing department	Storage department	8	5	40	238
Total movement (second/day)					5.444
Total material handling cost (USD)					30,70 USD

Source: own elaboration. Fuente: elaboración propia.

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Based on the data in Tables 3 and 4, the change in inter-departmental layout successfully reduced daily travel time from 5.736 seconds to 5.444 seconds per day. This reduction in travel distance contributed to a decrease in material handling costs and overall travel time. Material handling costs decreased from USD 37.02 to USD 30.70, representing a 17.07% increase in cost efficiency. The new layout shortened the distance between departments, resulting in a more efficient production flow, operational cost savings, and increased productivity (Syafrina et al., 2025).

Recommendation and cost

The two stages with the longest processing time are recommended, namely soaking and packaging. Soaking can be done using citric acid with a concentration of 10% to speed up the soaking process without damaging the quality of the soy food industry. The addition of organic acids affects the complex compounds found in soybeans. The H^+ ions contributed by citric acid will break down proteins into amino acids such as isoleucine, leucine, lysine, and others, so that simpler proteins will more easily become sources of carbon (C) and nitrogen (N) nutrients for yeast to live (Mubarok, 2019: 18-20).

Therefore, the soaking time can be shortened from 17 hours and 20 minutes to 4 hours, or can reduce the time by 76.92%. Meanwhile, recommendations for packaging can use a continuous band sealer machine that can pack for 11 seconds per package (Ilhami et al., 2024: 2189-2199). This machine can save time from 333.20 minutes to 241 minutes, or can save time by 27.01%. A cost analysis is required to make recommendations for more efficient time. The cost analysis includes citric acid and a continuous band sealer machine.

Table 5. Recommendation cost
Tabla 5. Costo de recomendación

No.	Recommendation	Cost (USD)
1.	Citric acid	34.40
2.	Continuous band sealer machine	173.40
Total Cost	207,8	

Source: own elaboration. Fuente: elaboración propia.

Based on Table 5, It can be observed that the required cost is relatively low, enabling more efficient processes in the future and increasing benefits for the industry.

Future PAM & VSM

The proposed improvements are illustrated through Process Activity Mapping (PAM) and Value Stream Mapping (VSM). The redesigned PAM and VSM have been adjusted to represent the layout changes obtained through the CRAFT method, the implementation of the improvement recommendations, and the reduction in waste levels in the production process.

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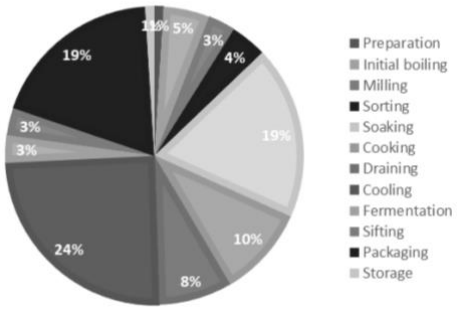
Table 6. Process activity mapping future
Tabla 6. Mapeo de la actividad del proceso futuro

No.	Play activities	Activities	Time	Type of activity	Activity category
1.	Preparation	Cooking furnace preparation	00:03:43	Operation	NNVA
		Boiling water	00:03:15	Operation	NNVA
		Opening soybean bags	00:07:25	Operation	NNVA
2.	Initial Boiling	Transferring materials to cooking furnace	00:06:05	Transport	NNVA
		Initial boiling (until the soybeans swell)	01:01:00	Operation	VA
3.	Milling	Transferring materials to the furnace	00:03:00	Transport	NNVA
		Preparing the milling machine	00:02:48	Operation	NNVA
		Milling process	00:29:13	Operation	VA
4.	Sorting	Transferring materials to the sorting furnace	00:02:00	Transport	NNVA
		Sorting process	00:49:22	Operation	VA
5.	Soaking	Transferring materials to the soaking process	00:03:17	Transport	NNVA
		Soaking the materials	04:00:00	Operation	VA
		Changing materials soaking water	00:06:06	Operation	VA
6.	Cooking	Transferring and draining materials to the cooking furnace	00:01:00	Transport	VA
		Boiling the materials until cooked	02:12:40	Operation	VA
		Removing foam	00:04:03	Operation	VA
7.	Draining	Transferring materials to the draining basket	00:17:46	Transport	NNVA
		Draining process	01:30:21	Operation	VA
8.	Cooling	Transferring materials to the cooling table	01:00:30	Transport	NNVA
		Cooling process	04:32:33	Operation	VA
9.	Fermentation	Yeast preparation	00:19:00	Operation	NNVA
		Fermentation process	00:22:12	Operation	VA
10.	Sifting	Taking the sieve	00:00:30	Operation	NNVA
		Sifting process	00:33:36	Operation	VA
11.	Packaging	Packaging preparation	00:04:57	Operation	NNVA
		Packaging, weighing, and sealing process	04:00:48	Operation	VA
12.	Storage	Transferring soy food industry to the storage	00:03:58	Transport	NNVA
		Arrangin soy food industry on storage	00:05:18	Storage	NNVA
Total Process Time	22:06:26				
Total Value Added Time	19:42:54				
Total Necessary Non-Value Added Tim	02:22:02				

Source: own elaboration. Fuente: elaboración propia.

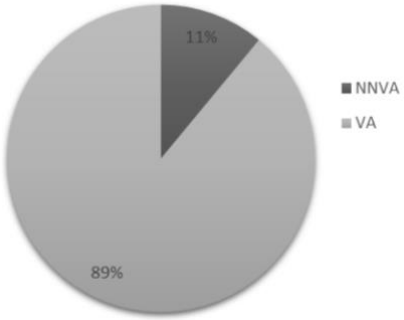
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Figure 6. Future percentage time
Figura 6. Porcentaje de tiempo futuro



Source: own elaboration. Fuente: elaboración propia.

Figure 7. Category activity
Figura 7. Actividad de categoría

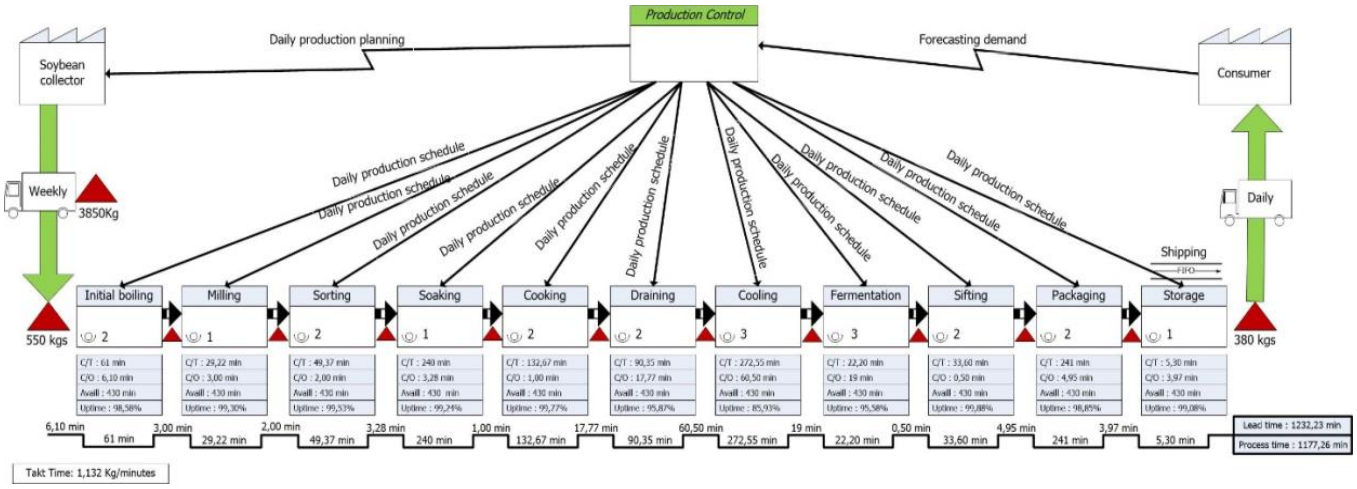


Source: own elaboration. Fuente: elaboración propia.

Based on Table 6, total process time decreased by 42%, from 2,731.0 minutes to 1,326.4 minutes, primarily due to the elimination of non-value-added activities, layout reconfiguration, and improvements in soaking and packaging processes. The duration of necessary but non-value-added (NNVA) activities was slightly reduced from 146.9 to 142.0 minutes (3%), while value-added (VA) time decreased by 43%, from 2,076.8 to 1,182.9 minutes, reflecting improved process efficiency.

Figure 7 shows that 89% of total time is now allocated to VA activities, with non-value-added (NVA) activities fully eliminated, although the proportion of NNVA activities increased from 6.50% to 11%. Overall, the implementation of lean manufacturing and layout optimization effectively reduced total processing time and enhanced production efficiency by concentrating activities on value creation.

Figure 8. Value stream mapping future
Figura 8. Mapeo del flujo de valor future



Source: own elaboration. Fuente: elaboración propia.

The Value Stream Mapping (VSM) comparison between the initial and improved conditions indicates substantial efficiency gains. Total lead time decreased from 2,275.91 to 1,232.23 minutes, while processing time was reduced from 2,069.46 to 1,177.26 minutes. These improvements are primarily attributed to the elimination of non-value-added activities, particularly in the soaking and packaging stages that previously acted as major bottlenecks. The simultaneous reduction in lead time and processing time reflects improved workflow integration, more efficient resource utilization, and enhanced responsiveness to production demand (Surdadi et al., 2023).

Conclusion

This study identifies waiting time as the dominant source of waste in the Indonesian soy food production process, driven by limited machine capacity, inefficient work methods, and suboptimal facility layout. The integrated application of lean manufacturing tools and the CRAFT algorithm effectively reduced non-value-added activities, improved production flow, and lowered material handling costs, while process improvements such as citric acid soaking and the use of a continuous band sealer significantly shortened processing time without compromising product quality. Notably, this study demonstrates the practical novelty of integrating lean manufacturing and CRAFT into a unified improvement framework for small-scale soy food industries, offering a replicable and cost-efficient approach to enhancing operational performance.

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Contributor Role Taxonomy (CRediT)

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Ida Bagus Suryaningrat: Data curation, formal analysis, supervision, validation, and writing — review and editing.

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