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# Implementing Lean Six Sigma to Enhance Operational Efficiency and Reduce Waste in Essential Food Storage SMEs: A Case Study

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## Abstract

Small and medium-sized enterprises (SMEs) in the essential food storage sector play a crucial role globally, especially in Latin America and Peru. These businesses are vital for ensuring the availability and distribution of necessities, contributing significantly to community well-being. However, they face significant challenges, including low operational efficiency and high rates of defective products, which hinder their competitiveness and sustainability. Addressing these issues is essential for improving productivity, profitability, and overall economic development. This research addresses these challenges by proposing a Lean Six Sigma production model integrated with 5S, Poka Yoke, and Standardized Work tools. The model aims to streamline processes, reduce defects, and optimize resource utilization. The study implemented these tools in a case study to demonstrate their effectiveness in enhancing operational performance and competitiveness. Key findings include a significant improvement in operational efficiency and waste reduction. The 5S methodology increased compliant activities from 63.3% to 70%, while Poka Yoke reduced defective products by 59% and packaging time by 34%. Standardized Work reduced operation times by an average of 48% and product waste by 36%, demonstrating substantial improvements in process efficiency and quality. The academic and socio-economic impact of this research is profound. It contributes to the field by providing empirical evidence on the effectiveness of Lean Six Sigma tools in SMEs, offering a practical framework for enhancing operational processes and reducing waste. The study's findings promote a sustainable and profitable business model, enhancing the competitiveness of SMEs in the essential food storage sector and ensuring a reliable supply of necessities to the population. This research underscores the importance of continuous improvement and suggests further studies to explore the integration of Lean Six Sigma with emerging technologies such as the Internet of Things (IoT) and artificial intelligence (AI) for even greater operational efficiency. Future research should focus on the long-term effects of these tools and their impact on organizational culture and employee engagement, encouraging ongoing innovation and improvement in the sector.

## Keywords
Lean Six Sigma, Standardized Work, Waste Reduction, Essential Food Storage, Poka Yoke, 5S.

## 1.Introduction
The sector of small and medium-sized enterprises (SMEs) in the essential food storage industry plays a vital role globally, particularly in Latin America and Peru. These businesses are crucial in ensuring the availability and

distribution of basic necessities to the population (Wang et al. 2022). In a world where food security is a significant concern, SMEs in the food storage sector are at the forefront of providing access to essential food items, contributing significantly to the overall well-being of communities (Hutahayan & Yufra 2019). Their role in ensuring the availability of first-necessity products cannot be overstated, as they form the backbone of the food supply chain, especially in regions where access to food is a critical issue (Perea et al. 2019).

The problems faced by SMEs in the essential food storage sector are multifaceted, with one of the primary challenges being low operational efficiency due to high rates of defective products and losses (Tarmizi et al. 2020). Issues such as product defects not only lead to financial losses but also impact on the reputation and reliability of these businesses in providing quality products to consumers (Alpers et al. 2021). Moreover, inefficiencies in workstations, operational errors by staff, and inadequate product handling further exacerbate the problem, resulting in significant losses of inputs and finished goods (Mohezar et al. 2023). These challenges hinder the smooth operation of SMEs in the food storage sector, affecting their competitiveness and sustainability in the market (Mwenda et al. 2023).

Addressing the challenges faced by SMEs in the essential food storage sector is of paramount importance to ensure the continuous supply of basic necessities to the population. By improving operational efficiency and reducing product defects, these businesses can enhance their productivity and profitability, contributing to the overall economic development of the region (Reardon et al. 2021). Resolving these issues not only benefits individual enterprises but also has a broader impact on society by ensuring a reliable supply of essential food items to the population (Khalid 2024). Additionally, enhancing the operational processes of SMEs in the food storage sector can lead to cost savings, improved resource utilization, and better customer satisfaction, thereby creating a more sustainable business model (Frau et al. 2022).

Despite the critical role of SMEs in the essential food storage sector and the challenges they face, there is a significant gap in the existing literature regarding effective solutions to enhance their operational efficiency and productivity. This research aims to bridge this knowledge gap by proposing a Lean Six Sigma production model integrated with tools such as Poka Yoke, 5S, and Standardized Work (Wicaksono & Illés 2022). By leveraging these methodologies, SMEs in the food storage sector can streamline their processes, reduce defects, and optimize resource utilization, leading to improved operational performance and competitiveness (Taneo et al. 2020). This study seeks to contribute to the existing body of knowledge by providing practical insights and solutions to enhance the operational capabilities of SMEs in the essential food storage industry, ultimately fostering sustainable growth and development in the sector (Qurniawati & Nurohman 2020).

## 2. Literature Review

### 2.1 Application of Lean Six Sigma in Small Essential Product Warehousing Businesses

The Lean Six Sigma methodology has been extensively studied in various industries, including small essential product warehousing businesses, with the aim of enhancing operational efficiency. Research such as that by Psomas and Antony (2019) has identified gaps in the Lean manufacturing literature, emphasizing the need for further studies in this field. Ali et al. (2020) have explored the impact of Lean and Six Sigma on small businesses' performance, spanning industries such as manufacturing and retail, suggesting the relevance of these methodologies in different business contexts. Furthermore, studies like that of Muhammad et al. (2022) have demonstrated how Lean and Six Sigma can contribute to achieving operational excellence, especially in challenging situations like the COVID-19 pandemic. Lastly, Adeodu et al. (2021) have focused their research on optimizing production processes through Lean Six Sigma, highlighting the applicability of these tools in manufacturing environments.

### 2.2 Application of Poka Yoke in Small Essential Product Warehousing Businesses

The Poka Yoke tool, which focuses on error prevention in operational processes, has garnered interest in the context of small essential product warehousing businesses. While there are no specific studies in this area, academic literature, such as the critical review by Patel & Patel (2021) on the Lean Six Sigma methodology, underscores the importance of integrating approaches that ensure quality and efficiency in operations. Additionally, research on the pros and cons of ISO 18404 by Antony et al. (2021) highlights the relevance of effective tools for process improvement, suggesting that Poka Yoke could be a valuable addition in essential product warehousing environments. Although direct studies are lacking, existing literature supports the idea that tools like Poka Yoke can benefit small businesses' operational settings.

### 2.3 Application of the 5S Methodology in Small Essential Product Warehousing Businesses

The 5S methodology, which focuses on organizing and cleaning workspaces, has been applied in various industries, including small essential product warehousing businesses. While no specific research has been found in this context, studies such as that by Demirtaş et al. (2022) on mask production during the COVID-19 pandemic have shown how continuous improvement through approaches like Kaizen and 5S can significantly increase production efficiency. Furthermore, Prabha and Mani's (2022) research on integrating IoT and DMAIC in small businesses in India highlights the importance of systematic approaches to process improvement, supporting the potential relevance of the 5S methodology in essential product warehousing environments. Although direct studies are lacking, existing literature suggests that the 5S methodology could be beneficial in promoting efficiency and quality in small businesses.

### 2.4 Application of Standardized Work in Small Essential Product Warehousing Businesses

The Standardized Work methodology, which focuses on establishing standardized processes to enhance efficiency and quality, has attracted interest in the operational environments of small businesses, including essential product warehousing businesses. While no specific research has been found in this area, academic literature, such as the study by Wassan et al. (2022) on critical success factors for Lean and Six Sigma implementation in Pakistani small and medium enterprises, emphasizes the importance of identifying standardized practices for the success of these methodologies. Additionally, research by Abbes et al.(2022) on the impact of ISO 9001 certification on Lean Six Sigma application in textile companies highlights the relevance of defined standards and processes to improve operational efficiency, suggesting that Standardized Work could be a valuable tool in essential product warehousing environments. Although direct studies are lacking, existing literature supports the idea that the Standardized Work methodology could contribute to process improvement in small businesses.

## 3. Methods

### 3.1 Basis of the Proposed Model

Figure 1 shows the operations management model based on the Lean Six Sigma philosophy, which integrated the Define, Measure, Analyze, Improve, and Control (DMAIC) phases to increase packaging process efficiency. This model employed a systematic approach to continuous improvement by identifying and eliminating waste and reducing process variability. The Define phase focused on analyzing the process capability index (CPK), while the Measure phase centered on mapping the value stream (VSM) to identify bottlenecks and improvement opportunities. In the Analyze phase, tools such as the Ishikawa diagram, Pareto diagram, and problem tree were used to identify the root causes of issues. During the Improve phase, Lean tools such as 5S, Poka-Yoke, and standardized work were implemented to optimize processes. Finally, the Control phase included the use of visual controls, dashboards with key performance indicators (KPIs), and a continuous monitoring plan to ensure the sustainability of improvements. This model was designed to transform a low level of packaging process efficiency into a high level, promoting a culture of continuous improvement and operational excellence.

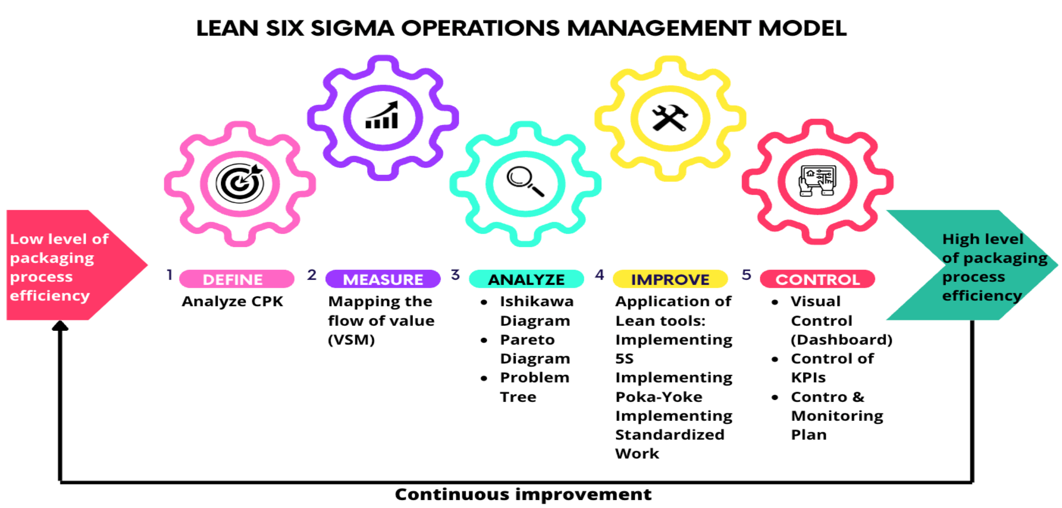


Figure 1. Proposed Model

## 3.2 Description of the model components

The Lean Six Sigma operations management model represents an integration of Lean and Six Sigma methodologies, aiming to enhance process efficiency and quality through a systematic approach. This model is grounded in the principles of continuous improvement, waste reduction, and variation minimization, which are achieved through the structured DMAIC (Define, Measure, Analyze, Improve, Control) framework. Lean Six Sigma has gained widespread acceptance in various industries due to its effectiveness in addressing complex operational challenges and its ability to deliver significant performance improvements (Antony et al. 2017; Patel & Patel 2021). By combining Lean's focus on eliminating waste with Six Sigma's emphasis on reducing process variability, the Lean Six Sigma model provides a comprehensive toolkit for organizations striving to achieve operational excellence. The following sections provide a detailed description of each phase of the DMAIC framework as applied in the Lean Six Sigma operations management model.

## Define Phase

The Define phase in the Lean Six Sigma operations management model focused on identifying and understanding the problem areas within the packaging process. This phase emphasized the importance of clearly defining the project goals, scope, and customer requirements to ensure alignment with business objectives. The primary tool used was the analysis of process capability indices (CPK), which provided a quantitative measure of the process's ability to produce output within specified limits. By establishing a clear problem statement and project charter, the team set the foundation for a structured approach to process improvement (Singh et al. 2019). This phase was critical in setting the stage for the subsequent phases by ensuring that the project had well-defined objectives and was aligned with customer needs and organizational goals.

## 3.3 Measure Phase

In the Measure phase, the focus shifted to quantifying the current state of the packaging process. This phase involved mapping the flow of value through the use of Value Stream Mapping (VSM), a tool that visualized the steps involved in the process and identified areas of waste. The objective was to collect accurate data on process performance, such as cycle time, defect rates, and throughput, to establish a baseline for improvement. Accurate measurement was essential for understanding the extent of the problem and for later validating the effectiveness of implemented solutions (Antony et al.2017). The collected data helped in identifying key performance indicators (KPIs) and set the stage for in-depth analysis in the next phase.

**Analyze Phase**

The Analyze phase involved a thorough examination of the data collected in the Measure phase to identify root causes of inefficiencies and defects. Key tools used in this phase included the Ishikawa diagram, Pareto chart, and problem tree analysis. These tools facilitated the identification of the most significant contributors to process variations and inefficiencies. The Pareto chart, for instance, helped in pinpointing the most frequent causes of defects, adhering to the Pareto principle that 80% of problems are often due to 20% of the causes. This analytical approach ensured that the team focused their efforts on the most impactful areas, thus optimizing the resources allocated for improvement (Pepper & Spedding, 2010). By understanding the root causes, the team could develop targeted solutions that addressed the fundamental issues rather than just the symptoms.

**Improve Phase**

In the Improve phase, solutions were developed and implemented to address the root causes identified in the Analyze phase. This phase leveraged Lean tools such as the 5S methodology for workplace organization, the implementation of Poka-Yoke (error-proofing) mechanisms, and the standardization of work procedures. The goal was to streamline the packaging process, reduce waste, and minimize the occurrence of defects. Poka-Yoke devices, for instance, were designed to prevent human errors, thereby enhancing process reliability and quality (Gijo et al.2019). Standardized work procedures ensured consistency and reduced variability, contributing to improved process stability and efficiency. The improvements were tested and validated to ensure they effectively addressed the identified issues and delivered the expected benefits.

**Control Phase**

The final phase, Control, focused on sustaining the improvements achieved in the previous phase. This involved the implementation of visual control tools such as dashboards and control charts to monitor ongoing process performance. Regular tracking of KPIs and the establishment of a comprehensive control and monitoring plan were essential to ensure that the process remained within the desired performance parameters. The Control phase also included training for employees to ensure they understood the new procedures and could effectively maintain the improved process (Patel & Patel 2021). By embedding these controls into the daily operations, the organization aimed to prevent regression and ensure continuous improvement over time.

## 3.4. Model Indicators

To evaluate the effectiveness of the proposed production model, specific metrics were devised to monitor and manage its outcomes within the case study. These metrics provided a structured approach to assess performance, ensuring that all critical aspects of the production process were systematically measured and analyzed. This enabled a comprehensive evaluation of the model's impact on overall efficiency and waste reduction.

**5S Audit:** this indicator Measures adherence to 5S methodology.

$$\text{5S Audit} = \frac{Number\ of\ items\ complying\ with\ 5S\ standards}{Total\ items} \times 100 \tag{1}$$

**Rate of Waste of Inputs:** A metric indicating percentage of input materials wasted.

$$\text{Rate of Waste of Inputs} = \frac{Quantity\ of\ wasted\ inputs}{Total\ Inputs} \times 100 \tag{2}$$

**Rate of Waste of Products:** A metric measuring Percentage of finished products wasted.

$$\text{Rate of Waste of Products} = \frac{Quantity\ of\ wasted\ products}{Total\ products} \times 100 \tag{3}$$

**Average Time:** this indicator measures average cycle time per process.

$$\text{Average Time} = \frac{Total\ time\ taken}{Number\ of\ cycles} \tag{4}$$

# 4. Validation

## 4.1 Initial Diagnosis

Figure 2 illustrates the problem tree summarizing the diagnosis conducted in the case study to identify the reasons and root causes generating the research problem. The main issue identified was the low efficiency in the packaging process, resulting in an economic impact of 143,392 PEN/year, representing 20.56% of the revenue. At the first level, two main reasons were identified: a high rate of defective products, accounting for 51.75%, and a high rate of input losses, accounting for 20.16%. Additionally, 10.10% of the causes were grouped under "other" reasons. At the second level, the preliminary causes for defective products were broken down: non-conformity in the quality of the baskets (28.95%), defects in the design of the baskets (26.18%), operator error (16.20%), and accumulation of inputs (9.63%). Finally, at the third level, the root causes were identified, including damage and blows to the baskets, incorrect use of the baskets, inadequate placement of inputs, and the saturation of inputs at filling stations. This model facilitated the structured identification of problems, effectively addressing the fundamental causes affecting the efficiency of the packaging process.

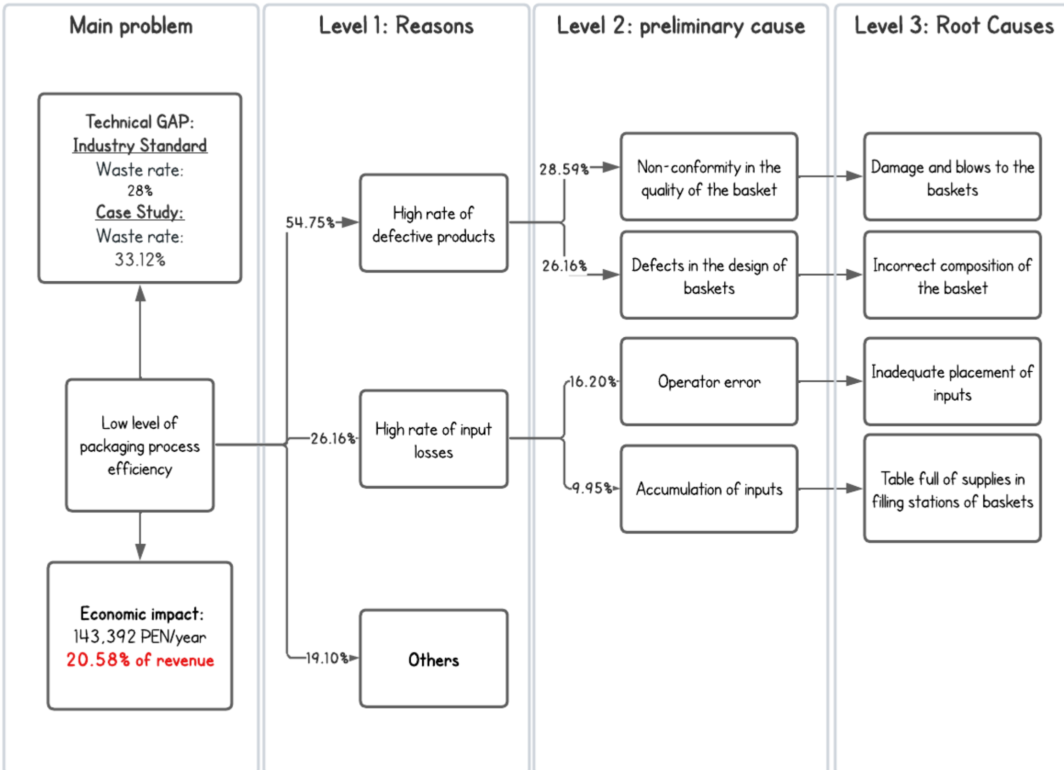


Figure 2. Problem Tree

## 4.2 Implementation of the model in the case study

**Implementation of the 5S Methodology**

The implementation of the 5S tool in the company had a significant impact on improving operational efficiency. The process began with the relocation of the work area, following the ABC analysis of materials to optimize the workflow. In the cleaning phase, specific cleaning and disinfection activities were assigned to operators, resulting in an increase in the number of compliant activities from 63.3% to 70%, while non-compliant activities decreased from 36.7% to 30%In addition, a final 5S audit was performed at the plant, which was initially at level D with 1.92 points. After implementation, the plant reached level A with 3.4 points, indicating a substantial improvement in the organization and cleanliness of the area. This evaluation showed that the criteria analyzed were in the right standards, bringing the plant closer to excellence in the process. Continuous improvement is crucial for maintaining and advancing this level of performance.

Table 1 shows the initial and final results of the implementation of the 5S tool in terms of the number of compliant and non-compliant activities. Initially, 63.3% of the activities were compliant, while 37% were non-compliant. After the implementation of the 5S tool, the percentage of compliant activities increased to 70%, and the percentage of non-compliant activities decreased to 30%. These results reflect a significant improvement in the organization and cleanliness of the work area, evidencing the positive impact of the 5S methodology on the company

Table 1. Comparative Results 5S

| Phase | Number of Compliant Activities | Number of Non-conforming Activities |
|---|---|---|
| Initial | 63,3% | 37% |
| Final | 70% | 30% |

Figure 3 shows the distribution of materials in the packaging area after the implementation of the 5S methodology. The image shows several waste containers located in one corner, labeled to facilitate waste segregation. Various materials essential for the packaging process, such as bags, blades, labels, tapes, and a tape dispenser, are organized on the work table. This orderly arrangement facilitates quick and efficient access to the required materials, thus improving productivity and cleanliness of the work area. The figure clearly illustrates the application of 5S principles to create a more organized and efficient working environment.

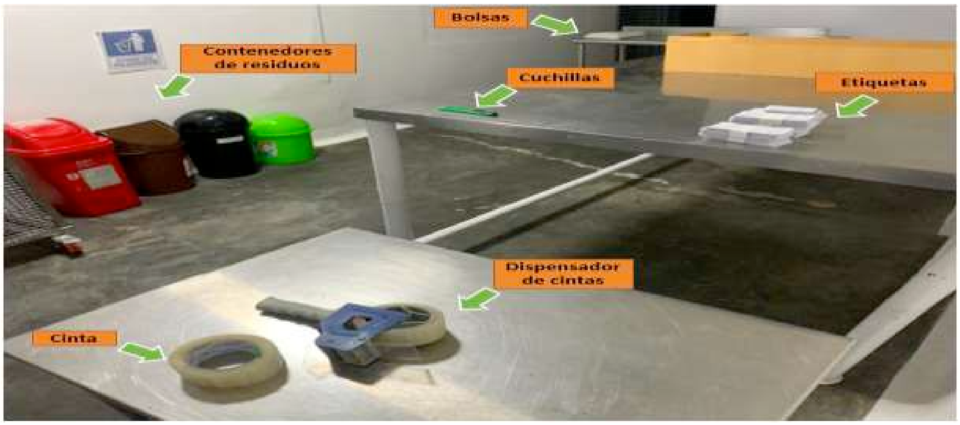


Figure 3. Materials Distributed in the Packaging Area.

## Implementation of the Poka Yoke

The implementation of the Poka Yoke devices resulted in a comprehensive training of the operators, accompanied by a detailed instruction of the packaging process. During the 15-day pilot test, defective products and baskets were recorded. The analysis showed a significant reduction in operational errors thanks to the Poka Yoke devices. Initially, 22 defective products were recorded, decreasing to 9 at the end of the trial period, representing an improvement of 59%. Similarly, the number of defective baskets was reduced from 5 to 2 in the same period. This is evidence that the Poka Yoke intervention mitigated operator errors, improving the quality of the final product.

In addition, an improvement in operational efficiency was observed, where packaging time was reduced by 34% on average. The use of Poka Yoke devices not only improved accuracy in input placement but also minimized damage and dropping, significantly reducing waste. This process allowed operators to hold and handle the baskets more easily, reducing the physical effort required.Table 2 shows the reduction in average operating time, product wastage and basket wastage after implementing Poka Yoke. Average times and wastage decreased significantly for all operators, showing improvements in process efficiency and quality.

Table 2. Comparative Actual vs Results

| **Data Registration** | **Average time (seconds)** | | **Product wastage (units)** | | **Basket wastage (units)** | |
|---|---|---|---|---|---|---|
| **N° Operator** | **Actual** | **Results** | **Actual** | **Results** | **Actual** | **Results** |
| Operator 1 | 456 | 121 | 48 | 25 | - | - |
| Operator 2 | 116 | 101 | 62 | 36 | - | - |
| Operator 3 | 127 | 113 | 39 | 21 | - | - |
| Operator 4 | 90 | 74 | 74 | 47 | - | - |
| Operator 5 | 248 | 128 | 47 | 44 | 25 | 20 |

Figure 4 shows the evolution of defective products during 16 days of sampling. The number of defective units decreased from 22 to 4, indicating a continuous improvement in product quality throughout the case study pilot.


Figure 4. Defective Product Developments.

## Implementation of Standardized Work

The implementation of the Standardized Work tool focused on improving efficiency and reducing waste in the packaging area. The average time of the activities performed by the operators was measured, as well as product and basket wastage. Initially, the average time for basket-making was 456 seconds for Operator 1, 116 seconds for Operator 2, 127 seconds for Operator 3, 90 seconds for Operator 4, and 248 seconds for Operator 5. After implementation, these times were reduced to 121, 101, 113, 74, and 128 seconds respectively, representing an average reduction of 48%. In terms of product waste, units were reduced from 48 to 25 for Operator 1, from 62 to 36 for Operator 2, from 39 to 21 for Operator 3, from 74 to 47 for Operator 4 and from 47 to 44 for Operator 5, achieving an average reduction of 36%. Basket wastage was only recorded for Operator 5, decreasing from 25 to 20 units. These results demonstrate that the standardization of the work contributed significantly to the continuous improvement of the process, effectively reducing time and waste.

Table 3, entitled "Comparison of Current vs Improved AVA-DAP Matrix," compares activities and time before and after implementation of the standardized work. In the AVA classification, activities that add value (VA) remained at 4, with a time of 232 seconds. Activities that do not add value to the business but add value to the customer (NNVA) were reduced from 12 to 5, and the time was reduced from 267 seconds to 58 seconds. Activities that add no value at all (NVA) decreased from 13 to 10, and the time was reduced from 858 seconds to 429 seconds. In total, activities decreased from 29 to 19 and total time was reduced from 1357 to 719 seconds, resulting in a 34.49% reduction in waste activities and a 47.02% reduction in waste time.

Table 3. Comparison of Current vs Improved AVA-DAP Matrix

| AVA Clasification | Actual | | Improved | |
|---|---|---|---|---|
| | Activities | Time(sec) | Activities | Time(sec) |
| **VA** | 4 | 232 | 4 | 232 |
| **NNVA** | 12 | 267 | 5 | 58 |
| **NVA** | 13 | 858 | 10 | 429 |
| Total | 29 | 1357 | 19 | 719 |
| **Improvements** | | | | |
| *Current vs improved waste reduction: ACTIVITY* | | | | 34.49% |
| *Current vs Improved Waste Reduction: TIME* | | | | 47.02% |

## 5. Results

Table 4 shows the key results from the validation of the proposed Lean Six Sigma operations management model to address the research problem. The 5S audit indicator improved from 32% to 85%, with a variation of 165.63%. The rate of input waste using Poka Yoke decreased from 4% to 1.98%, with a variation of -50.50%, and the rate of product waste was reduced from 11% to 1.30%, a variation of -88.18%. The average time in standardized work decreased from 207.4 seconds to 107.4 seconds, a variation of -48.22%.

Table 4. Results of the validation of the proposed model

| Tool | Indicator | Unit | As-Is | To-Be | Results | Variation (%) |
|---|---|---|---|---|---|---|
| 5S | 5S Audit | % | 32% | 100% | 85% | 165.63% |
| Poka Yoke | Rate of waste of inputs | % | 4% | 2% | 1.98% | -50.50% |
| | Rate of Waste of products | % | 11% | 7% | 1.30% | -88.18% |
| Standardized Work | Average time | sec. | 207.4 | 100 | 107.4 | -48.22% |
| | Rate of waste of inputs | % | 61% | 40% | 39% | -36.07% |
| | Rate of Waste of products | % | 56% | 20% | 44% | -21.43% |

## 6. Conclusions

The main findings of the study demonstrated that the implementation of Lean Six Sigma tools, specifically 5S, Poka Yoke, and Standardized Work, had a significant impact on improving operational efficiency and reducing waste in the company's packaging area. The use of the 5S methodology increased compliant activities from 63.3% to 70%, reducing non-compliant activities from 37% to 30%. The implementation of Poka Yoke resulted in a 59% reduction in defective products and a 34% reduction in packaging time. Finally, Standardized Work allowed an average reduction of 48% in operation times and a 36% reduction in product waste, evidencing significant improvements in process efficiency and quality.

The importance of this research lies in its contribution to enhancing the competitiveness and sustainability of small and medium-sized enterprises (SMEs) in the essential food storage sector. By addressing issues of operational efficiency and waste reduction, better resource utilization and increased customer satisfaction are ensured. Furthermore, this study offers a practical and systematic approach that can be replicated in other SMEs in the sector, promoting a more sustainable and profitable business model.The contributions to the field of study include the effective integration of Lean Six Sigma tools within the context of essential food storage SMEs, demonstrating their applicability and benefits in this sector. This study expands the existing body of knowledge by providing empirical evidence on the effectiveness of these tools in improving operational processes, reducing defects, and optimizing resource use. Additionally, it offers a methodological framework that can serve as a reference for future research and practical applications in the industry.

Final observations suggest that, although the results obtained are significant, it is crucial to maintain a continuous improvement approach to sustain and enhance the achieved gains. Additional studies are recommended to explore the implementation of these tools in other contexts and sectors, as well as to investigate the combination of Lean Six Sigma with emerging technologies such as the Internet of Things (IoT) and artificial intelligence (AI) to further enhance operational efficiency. Future studies could focus on the longitudinal analysis of the long-term effects of these tools and evaluate their impact on organizational culture and employee engagement..

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