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Redesign of The Warehouse of a Beverage Distributor to Decrease the Rate of Damaged Products by Applying SLP, ABC Matrix, and Standardized Work

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Abstract

The present investigation develops a comprehensive solution to improve logistics management in the Scottish Distributor, located in Arequipa, Peru, which has 8,45% of damaged products, more than double the sector standard (3%). The company faces significant operational challenges. Identified causes include inefficient warehouse layout, lack of inventory classification, and lack of clear handling procedures. The study uses key industrial engineering tools. Systematic Layout Planning (SLP) reorganizes the warehouse, improving material flow and reducing unnecessary manipulations by 40%. The ABC Matrix, based on product rotation, optimizes inventory distribution, reducing stacking damage by 21%. Finally, Standardized Work establishes clear procedures, reducing human errors by 13%. The results include a reduction in the percentage of damaged products to 3.92%, exceeding the proposed goal. This achievement translates into projected economic savings of more than five million soles annually, highlighting the financial and operational viability of the improvements. The research contributes to the literature by combining these tools in an emerging distribution sector, validating their effectiveness through simulations with Arena software. This comprehensive approach offers a replicable model for companies facing similar problems, establishing a robust framework for future research on sustainability and advanced technology in warehouse management.

Keywords
Redesign, Warehouse, SLP, ABC Matrix and Standardized Work

1. Introduction
Logistics management is a critical aspect in the beverage distribution industry, as it directly impacts profitability, operational efficiency, and customer satisfaction. Companies face constant challenges due to inefficient handling, poor warehouse design, and the lack of standardization in their processes. In this context, damaged products represent a significant problem that affects both operational costs and service quality. The Beverage Distributor faces a critical challenge, as it currently has a 5,45% gap above the damaged product rate in storage, while the industry standard is 3%. This issue not only impacts the company's profitability but also compromises customer satisfaction and logistics efficiency.

The main problem identified at the Scottish Distributor is the high percentage of damaged products (8,45%), which exceeds the industry standard (3%). This issue stems from three main causes:

- Inefficient warehouse design: The material flow and product layout do not optimize the available space.
- Lack of inventory classification: Products are not organized based on their turnover, leading to unnecessary handling.
- Non-standardized processes: The absence of clear procedures leads to errors in product handling by operators.

The main research question is: How can the percentage of damaged products in the Scottish Distributor's warehouse be reduced using industrial engineering tools, optimizing operational costs, and improving service quality?

- Economic Impact: Reducing damaged products will save millions of soles annually, improving the company's financial sustainability.
- Contribution to the state of the art: Few studies have explored the combined impact of SLP, ABC Matrix, and Standardized Work in the beverage distribution sector, especially in emerging markets like Peru.
- Practical Applicability: The results obtained can be replicated in other companies in the sector, enhancing industry competitiveness at the regional level.

Additionally, this study addresses the need to optimize resources and improve operational efficiency in the context of high demand and competition.

1.1 Objectives

General Objective:

- Reduce the percentage of damaged products in the warehouse by 27% through the implementation of SLP, ABC Matrix, and Standardized Work.

Specific Objectives:

- Optimize the warehouse layout using the SLP tool.
- Classify inventory products based on their turnover using the ABC Matrix.
- Establish clear procedures and train operators in standardized work.
- Validate the implemented changes through simulations in Arena.

2. Literature Review

The use of logistics tools such as SLP and the ABC Matrix has been extensively documented in academic literature. According to Bevilacqua et al. (2019), SLP allows for the reorganization of warehouses through a systematic approach, reducing picking times and improving product handling efficiency. In a case applied to a footwear company, a 50% improvement in operational times and a significant reduction in handling errors were achieved. On the other hand, the ABC Matrix, primarily used to classify products based on turnover and value, is key to strategically organizing inventories. Guidani et al. (2024) applied this tool in an agri-food supply chain, achieving a 30% reduction in damaged products through better space allocation in the warehouse.

Finally, standardized work has become an essential practice to ensure consistency in product handling. Trojanowska et al. (2023) demonstrated that combining this tool with simulation technologies, such as Arena software, improves operational accuracy and minimizes errors. Despite the advances made in these studies, there is limited research combining these tools in the specific context of beverage distribution in emerging markets. This represents a knowledge gap that this study seeks to address.

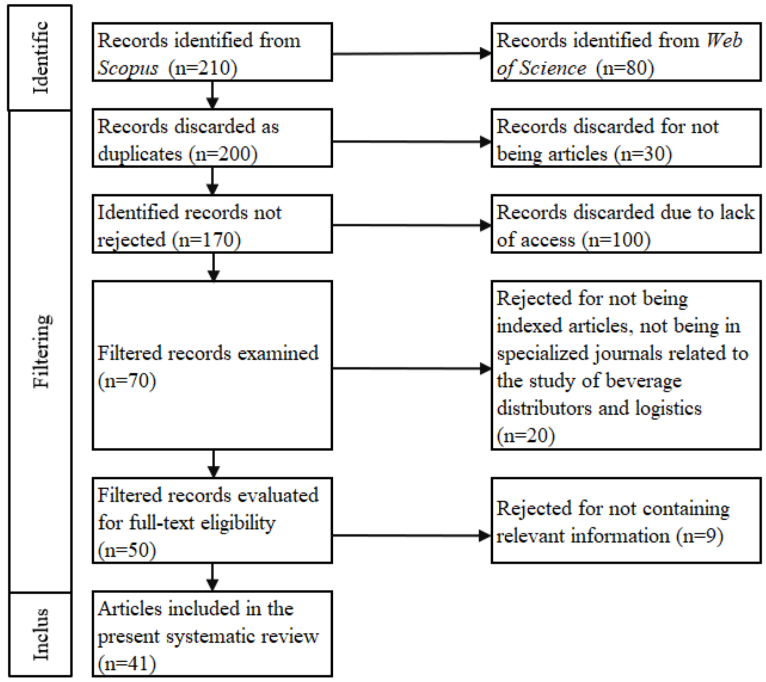

Figure 1. PRISMA research flow diagram

3. Methods

Quantitative sampling is a fundamental technique to ensure that the data obtained in this study are representative of the general population. In this case, the population consists of all products stored in the warehouse of Distribuidora Escocesa during the month of August, which is a month of high demand and distribution volume. This period was selected because it accurately reflects the operational conditions of the company at its peak performance. The unit of analysis in this study is the damaged products in the warehouse. Probabilistic and systematic random sampling is used to ensure that all product categories and different areas of the warehouse are covered. This involves selecting products regularly at specific intervals within categories A, B, and C, and from different locations within the warehouse. In this way, a representative sample will be obtained that encompasses all types of stored products, regardless of their turnover or value.

The sample size will be calculated using a standard sampling formula for finite populations, considering a 95% confidence level (Z = 1,96) and a margin of error of 5%. An estimated proportion of 0,5 will be used, which is common in situations where there is no prior estimate of the variability in the population. The sample calculation formula is as follows:

$$n = \frac{N * Z \propto 2 * p * qd2}{(N-1) + Z \propto 2 * p * q}$$

Where N is the total population size (products stored in August), Z is the value of the normal distribution for a 95% confidence level, p is the estimated proportion of damaged products (0.5), and E is the margin of error (0,05). Once the sample size is calculated, products will be randomly selected within the warehouse, ensuring that all categories and storage areas are covered.

The inclusion criteria for the sample are the damaged products stored during the month of August, which have gone through the entire storage cycle, from reception to distribution. The exclusion criteria include products that were not stored during that period or those that were removed before being distributed. For data collection, several instruments will be used. First, the damaged product records maintained by the quality department will be employed, which document in detail the products that have suffered damage. These records will be used to calculate the percentage of damaged products in the selected sample, both before and after the implementation of optimization tools. Additionally, Arena software will be used to run simulations to model the warehouse's operational flows, validating the effects of the layout redesign and product classification through the ABC Matrix.

The analysis of the results will be based on comparing the percentage of damaged products before and after the implementation of the improvement tools. Furthermore, the efficiency of the implemented tools will be evaluated using indicators such as the damaged product rate, layout efficiency, and product handling time. The information obtained will allow for determining the effectiveness of the tools used and providing recommendations for future optimizations.

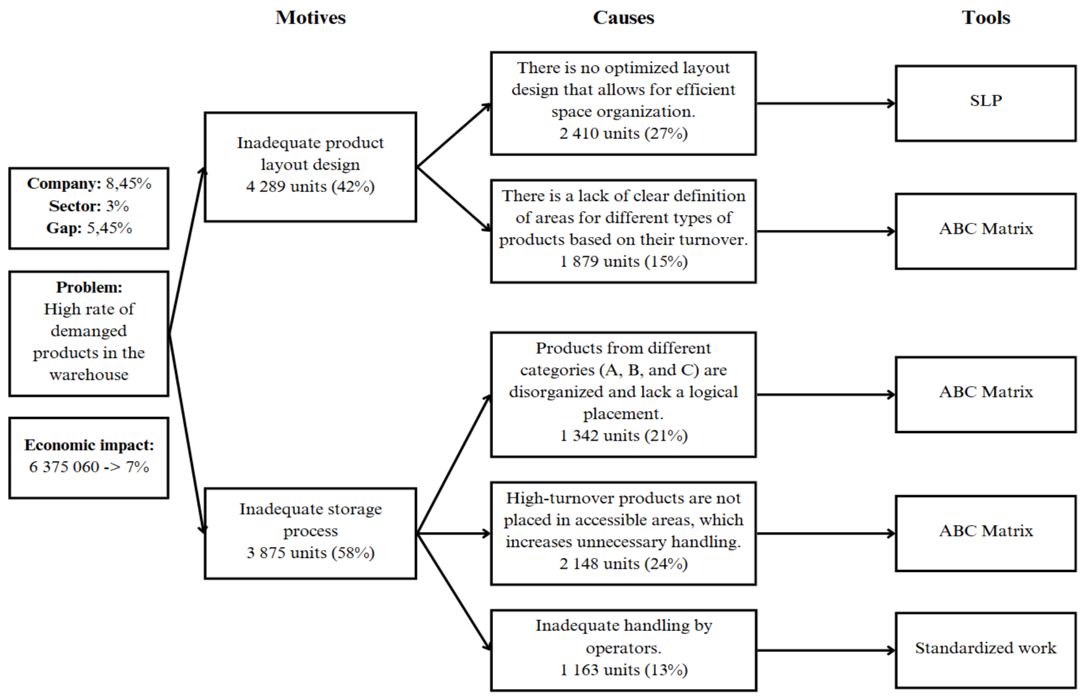

Figure 2. Method, cause and tool diagram

4. Data Collection

The main indicators of this research article that had the most significant impact will be presented.

Defective Product Rate: This will measure the percentage of damaged products compared to the total number of products arriving at the warehouse in 2024.

$$\frac{Total\ number\ of\ damaged\ products}{Total\ number\ of\ products\ stored} \times 100 = \frac{3\,329\,844}{38\,957\,460} = 8{,}5\%$$

Inventory Turnover Rate: This will measure the frequency at which inventory is replenished, as a low turnover rate may indicate a higher number of damaged products.

$$\frac{Cost\ of\ sales}{Average\ inventory} = \frac{52\,070\,819}{7\,896\,746} = 6{,}59$$

Storage Efficiency: This will evaluate how the warehouse design impacts on the number of damaged products.

$$\frac{Number\ of\ products\ stored\ correctly}{Total\ warehouse\ space} = \frac{32\,627\,616}{1\,520\ m^2} = 21\,465{,}54$$

5. Results and Discussion

5.1 Numerical Results

Improved indicator: Reduction of unnecessary product handling by 40%. For the SLP validation model, an Arena simulation was used, which includes data in the report such as "OutputStatsByRep" and "DiscreteTimeStatsByRep." These contain detailed information about the simulation replicas, the quantity of processed products, operation times, and other key metrics to analyze warehouse performance.

Counter Statistics (Reports End of Replication Value)

Project Name	Name	Type	Source	Average Across Replications	Half-Width	Overall StDev Across Replications	Min Replication Value	Max Replication Value
Unnamed Project	Productos dañados por descarga	Count	User Specified	17,5	0,957855844	1,507556723	16	20
	productos dañados por carga	Count	User Specified	11,58333333	1,806432489	2,843120352	7	16
	productos dañados por exceso de manipulacion	Count	User Specified	12,08333333	2,035678423	3,203927514	7	17
	productos sin daños	Count	User Specified	77,25	8,350943	13,14343943	56	98

Figure 3. Arena simulation report

For the ABC Matrix we have a 21% improvement that was achieved in the defective products indicator due to poor stacking. As a result, the number of damaged products decreased from 5 369 to 4 242.
Product classification based on turnover:

- Category A: 80% of sales, high-turnover products located in accessible areas.
- Category C: 5% of sales, located in less critical areas.

To validate the classification criteria, products should be arranged according to their sales volume: those in the "A" zone generate 80% of sales, and those in the "C" zone generate 5%. The ABC matrix prioritizes higher value and impact products, placing the most important ones (category A) in accessible and safe areas, reducing the risk of damage. This optimizes space and minimizes excessive handling, protecting delicate and high-turnover products.To validate the standardized work, warehouse workers will receive biweekly training on Mondays, except in cases of exceptions. The goal is to identify improvements and communicate new measures to ensure continuous enhancement of the process. The result is a reduction in damage from incorrect handling by 13%.

Table 1. Standardized work results

Metric	Before Standardized Work	After Standardized Work	Improvement (%)
Cycle time (seconds)	120	95	20,80%
Production per hour (units)	50	65	30,00%
Defect rate (%)	4,5	2,1	53,30%
Cost per unit ($)	5	4,2	16,00%
Resource utilization rate (%)	75	90	20,00%
Errors per-shift	15	6	60,00%
Worker satisfaction (%)	70	85	21,40%
Reduction in damage due to improper handling (%)			**13%**

5.2 Graphical Results

Before implementing the improvements, we can see that the process was longer and generated errors in the transportation process.

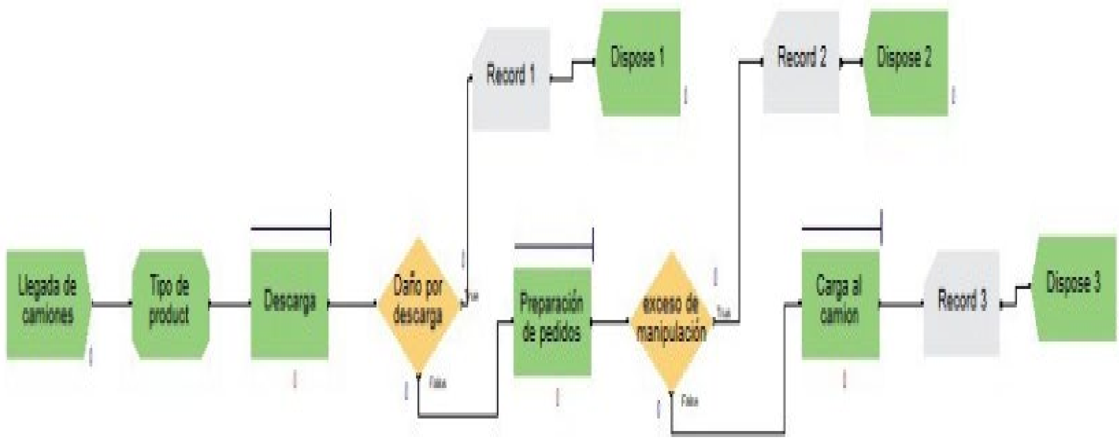

Figure 4. First Arena simulation

Then, with the implemented improvements, an improvement in the process was observed. After analyzing the current situation and evaluating tools, the improved scenarios are presented. In the case of the SLP, a 51.82% improvement in space allocation was achieved, confirming its correct application. However, as Trojanowska et al. (2023) point out, it is key to familiarize employees with the system and consider design aspects to increase efficiency. Regarding the inadequate space allocation, a 28.1% improvement was achieved, although it could exceed 40% with better implementation.

In Arena, the arrival of products was modeled with a uniform distribution of 10 to 28 packs per truck, with up to 7 trucks per day. This reflects variability and ensures a realistic representation. The uniform distribution efficiently captures uncertainty, facilitating the analysis and adjustment of resources to optimize receiving and dispatch times.

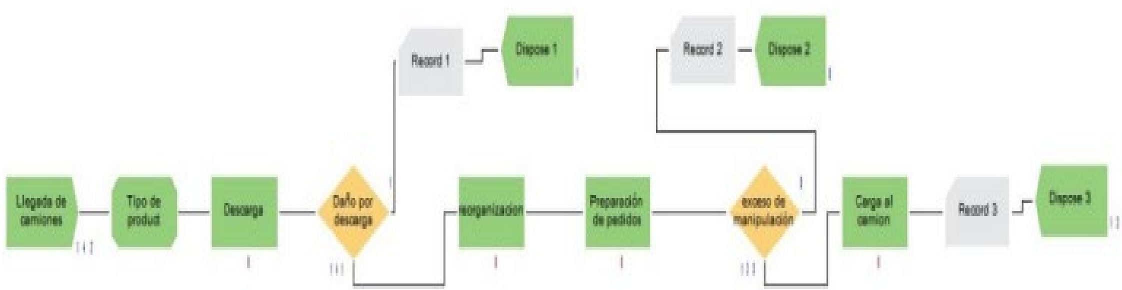

Figure 5. Improved Arena simulation

In the case of the ABC Matrix and warehouse layout, the warehouse initially had a chaotic setup with the following distribution.

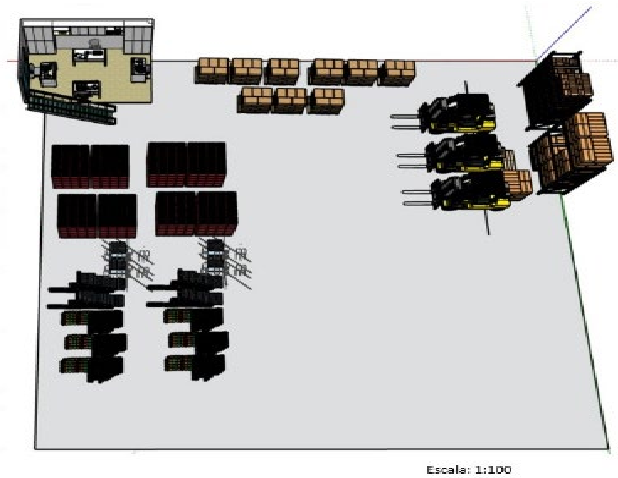

Figure 6. Initial warehouse distribution

Finally, an improvement was made in the layout, considering the plant size of 1,520 m² and the use of 4 static shelves to prevent product stacking. This is due to the rotation cycle of 6 to 7 days and an average of 105,618 products rocessed daily. The optimal shelves for the proposal measure 4 x 2.4 meters. Based on this and the product volume, 16 shelves will be required, distributed as follows:

- A products: 7 shelves
- B products: 5 shelves
- C products: 4 shelves

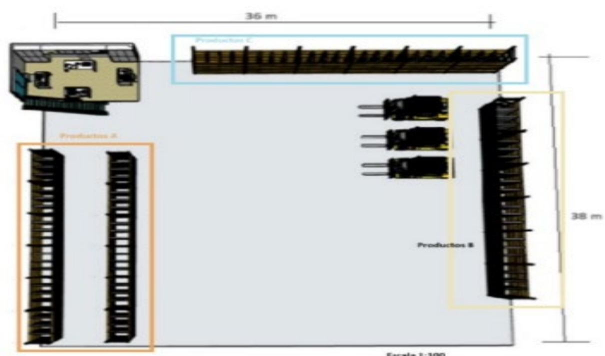

Figure 7. Final warehouse distribution

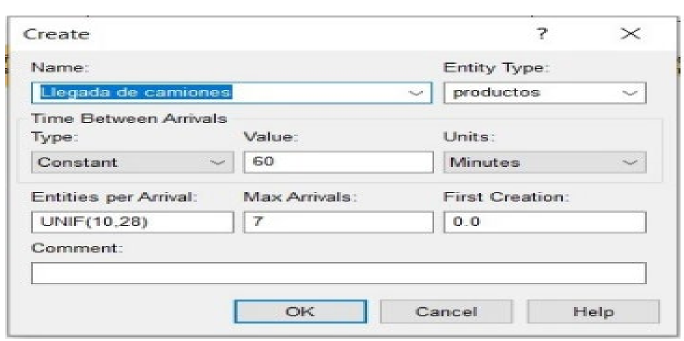

Figure 8. Improved model data

5.3 **Proposed Improvements**

This section provides an explanation of the data used in Arena. The arrival of products was modeled using a uniform distribution of 10 to 28 packs per truck, with up to 7 trucks per day. This reflects variability and ensures a realistic representation. The uniform distribution effectively captures uncertainty, allowing for better analysis and resource adjustment to optimize receiving and dispatch times.

In Arena, products are represented as integers using the Assign block and the formula ANINT(UNIF(1,28)), which rounds values and assigns a product type from the 28 available, ensuring realism and accuracy in the simulation.
Regarding the ABC Matrix, a 46.72% improvement was achieved in handling and movement, and a 36.22% improvement in inadequate stacking. While significant, the second improvement could exceed 40% with adjusted strategies, particularly for C-class products, which account for most damaged items despite not representing a significant percentage of the total.

Counter Statistics (Reports End of Replication Value)

Project Name	Name	Type	Source	Average Across Replications	Half-Width	Overall StDev Across Replications	Min Replication Value
Unnamed Project	Productos dañados por de	Count	User Specified	2,916666667	1,163968933	1,831955405	0
	productos dañados por exc	Count	User Specified	9,416666667	2,191934732	3,449857265	4
	productos sin daños	Count	User Specified	110,1666667	10,20494899	16,06143508	86

Figure 9. Functional scenario model report

5.4 Validation

For this validation, the results and a comparison with the previously cited research articles will be considered. Systematic Layout Planning (SLP) reduced product handling by 40%, optimizing space usage, which aligns with the findings of Trojanowska et al. (2023), who reported a 50% reduction in picking time with optimized layouts. However, this study did not analyze the impact of loading schedules on operational times. After analyzing the current situation and evaluating tools, the improved scenario for SLP resulted in a 51.82% improvement in space allocation, confirming its correct application. Despite this, as pointed out by Trojanowska et al. (2023), it is crucial to familiarize employees with the system and consider design aspects to enhance efficiency. Concerning inadequate space allocation, there was a 28.1% improvement, though better implementation could potentially exceed a 40% improvement.

		BEFORE	NOW
COD	Description	Improper stacking of products	Improper stacking of products
20121	KOLA ESCOCESA 600 ML PET NR BONIF. CAM	1	0
20123	KOLA ESCOCESA 2.26LT PET NR	69	31
20126	KOLA ESCOCESA 1.5 L PET NR (BONIF)	0	0
20127	KOLA ESCOCESA 1.5 L NP PET NR	566	391
20128	KOLA ESCOCESA 355 ML NP VNR	15	6
18142	AREQUIPA DRY GINGER ALE 1.5 L PET NR BONI	0	0
20218	NECTARIN MANZANA 1.5 L BAJO EN AZUCAR PQTE X 6	16	9
20219	NECTARIN MANZANA 600 ML BAJO EN AZUCAR PQTE X 12	30	12
20220	NECTARIN 600ML PI#A NRET	177	72
20221	NECTARIN 600ML NARANJA NRET	50	21
20222	NECTARIN 600ML TUTTI FRUTTI NRET	96	44
20223	NECTARIN 1.5 L PI#A NRET	20	16
20224	NECTARIN 1.5 L NARANJA NRET	40	17
20225	NECTARIN 1.5 L TUTTI FRUTTI NRET	49	33
20226	NECTARIN TORONJA 600 ML PQTE X 12	30	28
20227	NECTARIN TORONJA 1.5 L PQTE X 6	20	16
20110	KOLA ESCOCESA LITRO 1L NP	26	21
20111	KOLA ESCOCESA MEDIANA 1/2 NP	25	13
20115	KOLA ESCOCESA 440ML PET NR	216	192
20116	KOLA ESCOCESA 600 ML PET NR	536	356
20117	KOLA ESCOCESA 1.5 L PET NR	10	2
20118	KOLA ESCOCESA LIGHT 600 ML PET NR	22	10
20206	AREQUIPA DRY GINGER ALE 1.5 ML NP PET NR	10	3
20308	AGUA MINERAL YURA MEDIANA	1	1
20309	AGUA MINERAL YURA 600 ML C/G PET	81	59
20310	AGUA MINERAL YURA 1.5 L C/G PET	40	16
20311	AGUA DE MESA FONTAINE BLEAU NR	2	1
39036	AREQUIPA DRY 1.5 BONI CAMP.	0	0
TOTAL		2148	1370
	Standard number of damaged products per day	143.32	99.14

Figure 10. Improvements with the SLP tool

The ABC Matrix strategically organized high-turnover products, reducing stacking-related damages by 21%, which is consistent with the results found by Guidani et al. (2024). However, this study differs in that it focused solely on beverages, limiting the generalizability of the findings. In the improved scenario, the ABC Matrix led to a 46.72% improvement in handling and movement, and a 36.22% improvement in improper stacking. While these results are significant, the improvement in improper stacking could surpass 40% with better strategies, particularly for Class C products, which account for most damaged goods, despite representing a smaller proportion of the total inventory.

		BEFORE	NOW
COD	Description	Excessive Handling and Movement of Products	Excessive Handling and Movement of Products
20121	KOLA ESCOCESA 600 ML PET NR BONIF. CAM	1	1
20123	KOLA ESCOCESA 2.26LT PET NR	276	162
20126	KOLA ESCOCESA 1.5 L PET NR (BONIF)	1	0
20127	KOLA ESCOCESA 1.5 L NP PET NR	97	37
20128	KOLA ESCOCESA 355 ML NP VNR	15	4
18142	AREQUIPA DRY GINGER ALE 1.5 L PET NR BONI	0	0
20218	NECTARIN MANZANA 1.5 L BAJO EN AZUCAR PQTE X 6	30	21
20219	NECTARIN MANZANA 600 ML BAJO EN AZUCAR PQTE X 12	50	24
20220	NECTARIN 600ML PI#A NRET	67	31
20221	NECTARIN 600ML NARANJA NRET	80	25
20222	NECTARIN 600ML TUTTI FRUTTI NRET	64	51
20223	NECTARIN 1.5 L PI#A NRET	49	37
20224	NECTARIN 1.5 L NARANJA NRET	20	16
20225	NECTARIN 1.5 L TUTTI FRUTTI NRET	31	11
20226	NECTARIN TORONJA 600 ML PQTE X 12	20	17
20227	NECTARIN TORONJA 1.5 L PQTE X 6	24	13
20110	KOLA ESCOCESA LITRO 1L NP	44	23
20111	KOLA ESCOCESA MEDIANA 1/2 NP	31	21
20115	KOLA ESCOCESA 440ML PET NR	184	92
20116	KOLA ESCOCESA 600 ML PET NR	164	78
20117	KOLA ESCOCESA 1.5 L PET NR	10	3
20118	KOLA ESCOCESA LIGHT 600 ML PET NR	18	11
20206	AREQUIPA DRY GINGER ALE 1.5 ML NP PET NR	6	1
20308	AGUA MINERAL YURA MEDIANA	1	1
20309	AGUA MINERAL YURA 600 ML C/G PET	27	17
20310	AGUA MINERAL YURA 1.5 L C/G PET	30	18
20311	AGUA DE MESA FONTAINE BLEAU NR	1	0
39036	AREQUIPA DRY 1.5 BONI CAMP.	1	0
TOTAL		1342	715
	Standard number of damaged products per day	63.93	34.98

Figure 11. Improvements with ABC Matrix

Standardized work proved effective in reducing damaged products by 13%, confirming its ability to minimize human errors, as noted by Adeodu et al. (2023). However, the study did not evaluate the long-term impact on productivity. In the improved scenario, the standardized work approach achieved a 45.22% improvement, indicating that standardized times were applied correctly.

Figure 12. Improved scenario functional model

6. Conclusion

This study significantly reduced the percentage of damaged products in the warehouse of Distribuidora Escocesa, meeting the proposed objectives and demonstrating the effectiveness of the combined use of Systematic Layout Planning (SLP), ABC Matrix, and Standardized Work.

Outstanding and Innovative Aspects of the Study:

- The implementation of SLP optimized the warehouse layout, improving material flow and reducing unnecessary handling. This resulted in a 51.82% decrease in damaged products related to inefficient design.
- The ABC Matrix proved to be a strategic tool by reorganizing products based on their turnover, reducing damage associated with stacking and improper placement.
- Standardized Work improved consistency in product handling by establishing clear procedures, decreasing human errors by 45.22%.

Comparison with Similar Publications:

This study aligns with research like that of Bevilacqua et al. (2019), which highlighted the impact of SLP in reducing time and errors in footwear warehouses. However, it stands out by simultaneously addressing three key tools, demonstrating that their integration can yield more significant results in industries like beverage distribution, where logistical characteristics are more complex.

Identified Limitations and Issues:

Initial resistance to change from operational staff was a significant challenge, requiring continuous training to mitigate. The lack of advanced technology, such as real-time monitoring systems, limited the ability to evaluate changes in real-time.

Significance and Practical Application of Results:

The findings of this study have immediate and practical applications in the logistics sector, especially for medium-sized distribution companies. By optimizing internal processes, Distribuidora Escocesa not only reduced economic losses but also improved customer satisfaction and competitiveness in its market.

Key Findings:

The reduction in damaged products went from 8.45% to 3.92%, surpassing the proposed goal of 6.17%.

- A projected annual savings of S/. 5,274,742, demonstrating the economic impact of the improvements made.
- A 41.67% improvement in warehouse layout efficiency.

Suggestions for Future Stages and New Work:

- Technological Integration: Implement advanced monitoring systems, such as digital twins, to measure the impact of improvements in real-time and adjust strategies.
- Longitudinal Studies: Assess the long-term sustainability of the implemented solutions, considering potential changes in demand and product turnover.

- Scope Expansion: Apply these tools to other areas of the logistics chain, such as distribution and transportation, to further optimize processes.
- Cross-Industry Comparison: Conduct studies in other industries to validate the universality of the results and explore specific adjustments based on the sector.

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Biographies

Sheramy Alexandra Guanilo Juli is a 23-year-old young Peruvian professional passionate about innovation in business management. With training in Industrial Engineering, he has acquired solid work experience with more than two years in the commercial area, standing out in direct sales and retail. She is currently a graduate and belongs to the upper fifth of the Faculty of Engineering at the University of Lima. Her multidisciplinary approach has led her to combine knowledge of logistics processes, simulation and strategic planning to drive operational efficiency. As part of his most recent projects, he has led warehouse optimization using tools such as Systematic Layout Planning (SLP) and Matrix ABC, validating results with advanced simulations. Recently, she was promoted to Commercial Strategy Analyst at Yanbal, where she contributes to the design of strategies focused on improving the competitiveness and sustainability of the business. She has participated as a volunteer in consulting for businesses and collaborated in support programs for vulnerable areas of her country, reinforcing her social commitment and humanistic approach. Additionally, Sheramy is a sports enthusiast, practicing running and yoga, activities that she complements with her passion for personal development and fashion. With his analytical capacity and comprehensive vision, he aspires to continue generating positive impact in the business field and expand his expertise in strategic management.

Ana Micaela is a graduate of Industrial Engineering from the University of Lima, with professional experience in process management, personnel management and administrative control in sectors such as mining and distribution. During his training and work experience, he has stood out for his focus on optimizing operations and sustainability, implementing methodologies such as Poka-yoke, 5S and SLP to improve warehouse management and reduce damaged products. He has experience in analysis and redesigning logistics processes, as well as in the use of advanced tools such as Excel, Power BI and Arena Simulation. His career includes academic exchanges in the United States and Germany, which has allowed him to develop multicultural skills and an advanced command of English and German. Ana Micaela has a solid social vocation, reflected in her annual participation in volunteer work since 2015, collaborating in hospitals, homes and residences for people in vulnerable situations.

Rafael Villanueva is a senior executive with more than 10 years of experience in production and operations management in multinational consumer products companies. Throughout his career, he has demonstrated a results orientation and a great ability to meet goals through his leadership, creativity, analysis and continuous process improvement. His success has been reflected in effective management, strategy development and achievement of corporate objectives, which has earned him recognition for his leadership skills, interpersonal relationships, staff motivation and teamwork. He began his career in the food industry and, over the years, held various key positions. Since 2011, he has been Operations Manager at Anita Food, where he has successfully led various production and operation improvement projects. Previously, he held senior roles at Molitalia (2007-2011), where he was Production

Manager, and at Kraft Foods Perú (1994-2005), where he also held the position of Production Manager. In addition to his practical experience, he has a solid academic background. He is an Industrial Engineer from the University of Lima (1982) and has a Master of Science in Food Science from Kansas State University (1991). He has also shared his knowledge as an Associate Professor at the University of Lima since 1982, contributing to academic development in his field.

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