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Increased On-Time In-Full orders rate in a mass-consumption warehouse by applying Lean Warehouse tools: A case Study

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Abstract– ***The FMCG sector is developing globally and has maintained exponential growth in recent years. However, this growth is hampered by various challenges and issues affecting customer satisfaction, leading to a significant revenue loss for companies. In this area, companies in the sector aim to reduce the rate of orders not delivered on time and complete to increase customer satisfaction and minimize lost sales. In this context, the problem that causes the most significant economic impact on the company under study is the low rate of the OTIF indicator. Implementing a model based on the Lean Warehouse methodology is proposed to face this challenge by applying Slotting, Standardized Work, and Slotting. The study focused on the standard products (Packaged Jelly), analyzed, and diagnosed the delivery process, identified and quantified the root cause of the problem, and subsequently provided tools to attack them. Ultimately, the proposed model successfully increased the OTIF indicator by 28.94%. Key results include a 20.22% increase in the inventory accuracy indicator, a 41.53% decrease in the time to reach the product location, and a 12.02% increase in operator efficiency in the picking process. In this context, a precedent is set to contribute to optimizing the processes of the company's division and maximizing customer satisfaction.***

Keywords-- Lean Warehouse, Slotting, Standardized Work, Poka Yoke, Picking, Mass-Consumption, OTIF.

I. Introduction

The manufacturing sector has the highest contribution to national production, with 16.52%. It is considered a fundamental part of the growth of the national economy since the contribution of companies in this sector to GDP in the last five years was 13.6% [1]. On the other hand, the food industry has 20% of the manufacturing GDP [2]. For companies in the sector, there are constantly challenging challenges and issues related to customer satisfaction, profitability, and inventories, which are detrimental to their growth. Under this context, companies are faced with the need to continuously improve their activities to achieve the objectives that allow them to achieve competitiveness and establish strategies and plans to control and manage inventory correctly in order to ensure the availability of products in the right place and at the right time for customers.

In this area, it is crucial to ensure the total fulfillment of the orders requested by customers, so the right products, with the correct quantity and shipped on time, must be provided [3]. In this way, it is evident that one of the most detrimental impacts is reflected in logistics costs, so measures must be taken to eliminate activities that do not generate value in the warehouse [4] since these unravel in unnecessary time and inefficient management of the merchandise, which ends up influencing the fulfillment of customer orders. In this framework, improvements should be made in time efficiency, productivity, and quality in the warehouse, since these are factors that improve the efficiency of logistics processes in a company, which unravels in an increase in customer satisfaction ratios and productivity [5]. Based on the significant impact this problem generates on companies, several authors have proposed solution tools to face this difficulty. Firstly, the case of a company that seeks to optimize processes with the appropriate procedures in inventory management was evidenced. This has shown that the use of the Lean Warehouse methodology achieved an increase in warehouse productivity by 3.95 times, as well as a decrease in product search time by 66.12% [6]. Secondly, the case of a distribution center was evidenced, where the Lean Warehouse methodology was implemented to eliminate the different wastes and minimize delivery times. In the study, reducing dispatch times from 1.88 to 0.91 hours and picking from 14.46 to 13 minutes allowed optimizing picking and storage times [7]. Thirdly, the case of a warehouse of a manufacturing company was evidenced, in which the Lean Warehouse methodology was implemented to improve warehouse operations by eliminating waste, achieving a reduction in picking a time of 46.26% and dispatch time by 20.77%, which allowed an increase in warehouse efficiency by optimizing the operations of picking and receiving orders [8].

Multiple success stories about Lean methodology in the industry are evidenced in the literature [7], [8], [9], [10]. However, there need to be more cases focused on the mass consumption food sector, so the need to propagate research on using Lean tools in the said sector is evident. As a result, there is a little scientific basis to attack the failure to deliver on time and in full in an FMCG company. Given these challenges, this research seeks to validate and disseminate the use of Lean Warehousing methodology in a new scenario, to establish a precedent that contributes to this sector's improvement, minimizes logistics costs, increases revenues, and maximizes customer satisfaction. The present study corroborates that a mass-consumption food company can decrease critical process times, organize its warehouse, eliminate waste, and maximize on-time and complete deliveries through the structured application of Slotting, Standardized Work, and Poka Yoke

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tools. Therefore, this research proposes a model based on the Lean Warehousing methodology to minimize the non-compliance of orders not delivered on time and with the quantity not established to analyze, solve and control the root causes of this problem.

II. Literature Review

A. Lean Warehousing methodology

During the last few years, a growing interest has been triggered to investigate the application of Lean Warehousing methodology in warehouses of different characteristics [11]. The such methodology covers the sourcing and picking process [12], which comprises 50% and 60% of total logistics costs [13]. Therefore, the need to reduce logistics costs arises, which has allowed taking measures to eliminate activities that do not generate value in the warehouse. The importance of this new practice is hinted at by [4], [5] since different studies concerning supply chain management show that the implementation of Lean Warehousing achieves improvements in time efficiency, productivity, and quality in the warehouse, factors that improve the efficiency of logistics processes in a company, increasing customer satisfaction, and productivity ratios. Additionally, Lean Warehousing seeks to maximize the use of available resources and activities in a warehouse by eliminating slack in the logistics system [9].

The reduction of non-value added is of relevance to the competitiveness of any company, which is increasingly voracious and constantly increasing. Furthermore, implementing Lean Warehousing is often crucial to ensure warehouse effectiveness and efficiency in an environment where technology is scarce and the primary resource is the workforce [14]. Therefore, indicators and parameters must be established for a subsequent diagnosis, analysis, and implementation of improvements [15]. For example, a study that seeks to optimize processes with proper procedures in inventory management has shown an increase in warehouse productivity by 3.95 times and a decrease in product search time by 66.12% [6]. Along the same lines, in a study seeking to reduce unplanned downtime, the tool managed to reduce incidents that stop the flow of the chain by 26.2% [16].

In this area, the objective of the present study is to employ practical tools of the Lean Warehouse methodology (Slotting, Poka-Yoke, and Standardized Work) in the company's logistics processes. Likewise, it can be evidenced that each of these cases shows improvements in the logistic processes evaluated. However, the need for more research on the Lean Warehousing methodology in the food sector is alarming, even though the various authors denote that it can be successfully applied in all industries. This demonstrates the need for a more scientific basis that serves as a precedent to increase the delivery of orders on time and with the requested quantity. In view of this lack, it is relevant to test and disseminate the implementation of the Lean Warehousing methodology in the food sector.

B. Standardization of Inventory Processes

Process standardization has its foundations in the improvement of activities and repetitive tasks, such as those performed in the warehouse, operations, maintenance, quality, and distribution areas [17]. This tool allows reducing overall development costs and increases the level of work control. The Toyota production system is a clear example [18]. It is appropriate to mention that standardization requires a great deal of staff training, personnel must be fully aware of it in order to reduce waste by identifying and eliminating non-value-added activities such as unnecessary movement, waiting, and defects to define different types of waste. Also, standardized work establishes precise work procedures for each operator based on three elements: Takt Time, work sequence, and standard inventory [19].

Standardized work is a fundamental tool for problem-solving in processes as it offers almost immediate results for organizational performance since it increases productivity and reduces lead times [20], [19]. Under the same approach, standardized work is a set of specific instructions that are necessary to perform processes most efficiently since it allows defining the best methods and sequenced tasks needed for each process and operator, which helps to reduce waste [21] and increase the welfare and performance of the human resource. There is evidence demonstrating the effectiveness of standardized work. In the first case study, which focused on the search to minimize defective products in a manufacturing company, Lean methodology principles were applied to eliminate activities that did not add value, saving costs by 12% through a reduction of defects [22]. In the second case, a study conducted in a food industry company in Medellin, the standardization of the work method was carried out to reduce inefficient activities, with the help of measurement tools such as the time study to determine standard times and others. This reduced 15.08% in operating times and 13% in defects [23]. On the other hand, a study conducted by an SME in the Peruvian food sector focused on improving inventory management to reduce the number of non-conforming products in the warehouse. They made use of this tool that allowed them to promote proper purchasing and warehouse management. This was given by the standardization of the associated processes that allowed an optimal flow of materials and increased the economic flow by 86% in the period analyzed [17]. However, there needs to be more research on using standardized work in the warehouse area within the sector under study, even though the literature shows significant improvements in similar industries. In this sense, validating and disseminating Standardized Work in the food sector is necessary to optimize and standardize the processes under study.

C. Poka Yoke

Poka Yoke integration is a trial-and-error method with a different approach to solving problems. Its objective is to eliminate defects by avoiding or correcting errors as soon as possible [24]. By analyzing the company's current VSM (Value Stream Mapping), it is possible to identify the main bottlenecks and waste. It was recommended to use Lean tools to improve this situation; one of them is the Poka Yoke. This tool has been used for many years to overcome the challenges that harm errors and defects in the production and warehouse processes

[25]. The Poka-Yoke technique is used to control the problematic achieving, reduce inventory level, lead time, and cycle time, eliminate rework, and increase productivity [26].

By applying the Poka-Yoke tool in the warehouse, certain benefits were obtained, such as increasing productivity by 8% and reducing cycle time. This was demonstrated in the manufacturing industry, a project at Pheonix International, Ludhiana (India). Also, organizations should maintain the effectiveness of the tools to get the best results [27]. In another case, a low labor productivity index was observed in the packing station. The current differential is 18.22%, causing a negative economic impact on sales representing 2.97%. Using the Poka Yoke tool and other tools, good results were obtained by increasing labor productivity and decreasing the risk of jobs by 19.83% and 54%, respectively. This shows the significant impact it has on operations, production, and the health and safety of employees [28], [29]. One general characteristic that motivates companies to apply the Lean technique is the agile supply chain. These tools reduce the defect rate by 66% and cycle time with 43% savings [30]. It has been evidenced that Poka-Yoke is highly recommended for the start of any lean manufacturing initiative [31]. However, most items applying the Poka Yoke tool are used for problems in the production area. Knowing that this technique can be used in different tasks for greater efficiency, the study provides relevant information on the use of Poka Yoke for the correct registration of the goods in the warehouse. This will be promoted in the FMCG sector, thus solving the problem of traceability.

D. Slotting

Warehouse logistics optimization focuses on optimizing storage location-allocation and material distribution [32]. Application process analysis, lean logistics, Slotting optimization, and SLP analysis comprehensively diagnosed the case company. In addition, manufacturing entities are currently interested in intelligent systems, logistics engineering, and project management, among others. In order to optimize the design of the storage center, Slotting is mentioned based on the Hungarian method [33]. The purpose of Slotting is to increase order-picking efficiency and decrease operating costs in the warehouse [34]. For the application of this tool, two fundamental questions need to be known and answered: [35] How to sort SKUs and How to assign sorted SKUs to locations [36], [37].

The technique known as Slotting is used to reduce the impact of the problem of non-conforming products. This is one of the biggest problems in the warehouse of manufacturing companies in Peru, affecting the OTIF indicator (orders delivered on time and completed). At the end of the implementation of the tool, good results were obtained, such as the reduction of the processing time by 19.12% and the distance traveled to prepare an order from 244.5 to 173.5 meters; and the OTIF value increased by 44.33% [3]. However, if storage operations are random or inadequate, this will affect the cost of movement, waiting time, and relocation [38]. Therefore, it is necessary to use the tool optimally by properly relocating the loading stations and finished product storage, increasing warehouse capacity, and improving overall efficiency [39]. Likewise, the performance of warehouse operations can critically affect the efficiency of supply chains; for this reason, Slotting will be applied to define the best location for each SKU, improving the picking operation and reducing travel times, reducing the distance traveled by 5%, maximizing the use of the warehouse, improving the use of human resources and vehicles in operation, and reducing logistics costs [40], [41]. However, despite the positive impact that can generate Slotting in the warehouse, only some study articles apply this tool.

Furthermore, studies support only a little scientific information. Therefore, companies are not encouraged to apply it, having problems with the locations in the warehouse, causing delays. More information is needed on the implementation and benefits. Consequently, this study will validate and promote the implementation of the Slotting tool in the food sector, achieving time optimization by finding the best location for the merchandise.

III. PROPOSED MODEL

The generation of value of this proposal was based on the tools highlighted in the state of the art; the proposed solution is a model integrated by Lean Warehousing tools as shown in Figure 1. Unlike the models proposed for the food sector, this project focuses on the warehouse area. The tools to be used are diverse due to the different difficulties that were delimited in the analysis of the problem, mainly those that stand out for its implementation are Slotting for an adequate allocation of product location, Standardized Work that will allow defining a standard of procedures in the processes, and Poka-Yoke for correct registration and follow-up of the merchandise in the warehouse.

1) Phase 1: Analysis of the current situation

This phase consists of all the activities before implementing the proposed model. For its development, different models of the Lean Warehousing methodology were taken into consideration, from which it was possible to extract the need to perform an initial diagnosis through the VSM, the analysis of KPIs, the Ishikawa Diagram, as well as the use of the Technique of Systematic Interrogation (TIS) and Lane Diagram to know the main processes of the warehouse and the primary deficiencies it has, to optimize the processes of a warehouse.

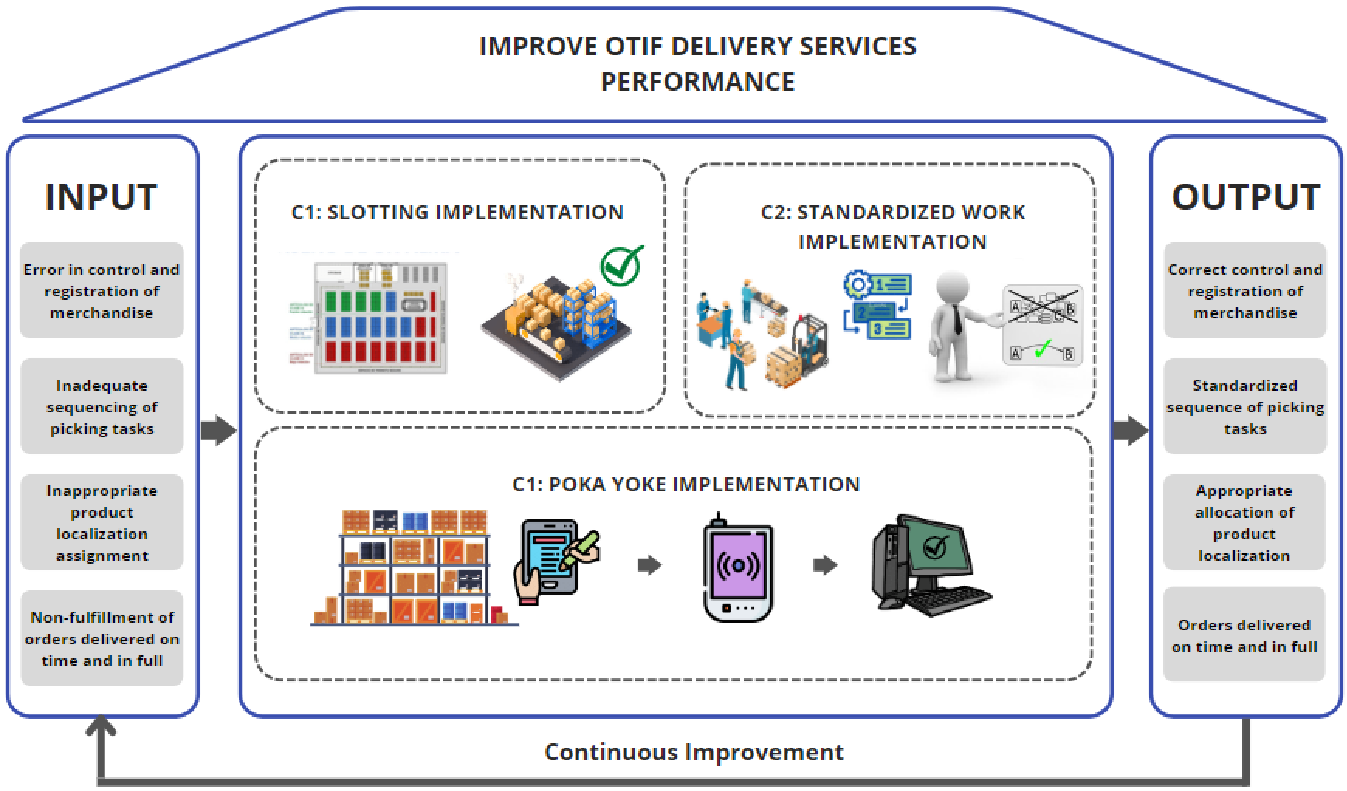

Fig. 1. Proposed Model. Adapted from [3],[10].

2) Phase 2: Methods of implementation

The second phase is based on developing the tools identified in the improvement model, which has three components.

A. Component 1: Slotting

The first component of the model is to organize the merchandise, which consists of correcting the location of the products to reduce process delays. For the execution of this component, the Slotting tool will be used. It must be implemented as the first tool since it will allow the execution of the others without reformulating when the process is already advanced. Slotting seeks to address the preparation of orders through an intelligent arrangement of products within the warehouse.

This tool will strategically redesign the location of the goods in the warehouse to improve the performance of identification and selection of products. This tool will allow the other tools to be implemented safely, and there will be no modifications in the middle of the process.

B. Component 2: Standardized Work

Secondly, uniformity in the execution of tasks, activities, and processes is implemented to eliminate errors, failures, and delays. Finally, standardization is based on improving sequential and repetitive tasks and activities.

This component achieves operational excellence, which ensures that the operations necessary for order fulfillment are carried out in the same way, thus eliminating process variability.

C. Component 3: Poka Yoke

Finally, the Poka Yoke tool will be applied to prevent and eliminate process errors. This tool was chosen for the reason that the standardized work implemented with the Poka-Yoke not only increases efficiency and reduces time but also avoids errors with greater precision by the warehouse operators through technology and a warehouse management system, thus achieving the objectives set concerning to the indicators, this implement will be after the Standardized Work because although it indicates the sequence of the processes to be followed, it is necessary to implement a Poka Yoke so that this follow-up only continues if no error has been made in the sequence proposed by the Standardized Work. Therefore, this work proposes implementing a device that alerts and prevents the error, that is, the implementation of a physical-sequential Poka Yoke. This will allow that once an order is completed without failure, it will be possible to move on to the next one. In this way, the operator cannot move on to the next activity until it is communicated to the picking system as completed correctly.

3) Phase 3: Verification

The third and final phase is verification. In this phase, it will be evaluated and verified whether the objectives set in the implementation are being met through indicators to ensure the development of the improvement model. For this purpose, a new evaluation of KPIs must be carried out to verify the effect of the new model by comparing them with those before its implementation. This is how the impact generated by the new model can be corroborated and measured. It is of utmost importance that this stage is carried out rigorously since the company must adjust, if necessary, to ensure that the improvement is being carried out correctly and achieves the objectives.

D. Model indicators

The following indicators will be used to evaluate the improvements obtained after the proposal's implementation.

1) Full-time and full-time (OTIF)

This performance indicator reflects the percentage of shipments that arrive on time and in quantity requested at the place indicated by the client.

Objective: Increase the OTIF to at least 67.62% to exceed the sector's average percentage.

$$\text{OTIF (\%)} = \text{\% On-time} \times \text{\% In full}$$

2) Time to reach product location

This indicator shows the time it takes to get to the product location

Objective: To achieve 4 sec/unit from routing receipt to product location.

3) Picking efficiency

It is a labor productivity indicator that measures the efficiency of manual processes.

Objective: Increase by 50.75% by obtaining workers with better training.

$$\text{Efficiency (\%)} = (\text{Actual deliveries}/\text{Expected deliveries}) \times 100$$

4) Inventory Record Accuracy (IRA)

It is an indicator that shows the efficiency and accuracy of the registration of goods stored by a company concerning the physical inventory.

Objective: Increase by 27.04%.

$$\text{IRA} = (\text{Quantity of stock in the system}/\text{Quantity of actual stock}) \times 100$$

IV. VALIDATION

This section is the model validation and is divided into three sections: description of the scenario, initial diagnosis and design, and validation results.

A. Scenario description

A validation method known as "simulation" was used to test the proposed solution's effectiveness. The simulation system was based on the order handling process, from the arrival of the waybill to the completion of the order distribution.

B. Initial diagnosis

The logistics area in the company under study has a low rate of on-time and complete deliveries, with an average of 58.56% in 2021. This deficit generated an economic loss amounting to PEN 242,792.84, which represents a margin of 3% concerning sales for the year of the product with the highest demand.

On the other hand, it is essential to mention that the company currently has an average order preparation time of 77.67 min/order and an average picking reception time of 12.63 min/order.

C. Validation design and results

To validate the model, the first step was to request specific information from the company, such as the number of workers and resources for each activity. In addition, a time collection of in-person picking tasks was carried out over three weeks. Finally, this data is fed into the Arena simulation software to validate that using Lean Warehousing tools improves the picking process. The simulation of the improved system is shown in Figure 2. The objective is to increase the OTIF indicator by 9.06%, thus reducing losses due to unfulfilled orders.

D. Improvement Results-Proposal Simulation

The improved scenario resulted in a significant variation in the OTIF indicator, increasing from 62.5% to 87.5%. On the other hand, the IRA indicator increased from 74.78% to 95%. Also, the time to reach the location of the standard product decreased by 58.47%. Similarly, there was an increase in operator efficiency from 59.70% to 71.72%. This is because, by applying work standardization, workers have established the procedures to be carried out, eliminating times that do not add value. Likewise, the implementation of Poka-Yoke not only reduced errors but also, by having a device that allows us to visualize the sequence of activities and instantly register the products, this tool contributed to the reduction of time and therefore contributed to our general OTIF indicator.

TABLE I
RESULTS OF THE INDICATORS STUDIED

	Indicators	Current Value	Expected Value	Improved Value
General	OTIF	58.56%	>=67.62%	87.50%
Poka-Yoke	IRA	74.78%	95%	95.00%
Slotting	Time to reach product location	6.14	4	2.55
Standardized Work	Operator Efficiency	59.70%	90%	71.72%

V. DISCUSSION

Through simulation, it was possible to validate the effectiveness of the proposed improvement proposal to minimize the picking process times and the correct location of the products in the warehouse and eliminate errors in the process. In this area, the results of the research were satisfactory. However, to demonstrate these results' reliability and accuracy, the implementation of this improvement in other scenarios will be analyzed.

For this purpose, three scenarios are proposed, in which a comparison of the current simulation of the first month is made with the following three months. For the first scenario, the results obtained in the first simulation (first month) will be used; for the second, the data obtained when simulating the second month will be used; and finally, the third scenario will be carried out with the data from the previous scenario. In this way, we will have scenarios from the current situation up to the fourth month of simulation.

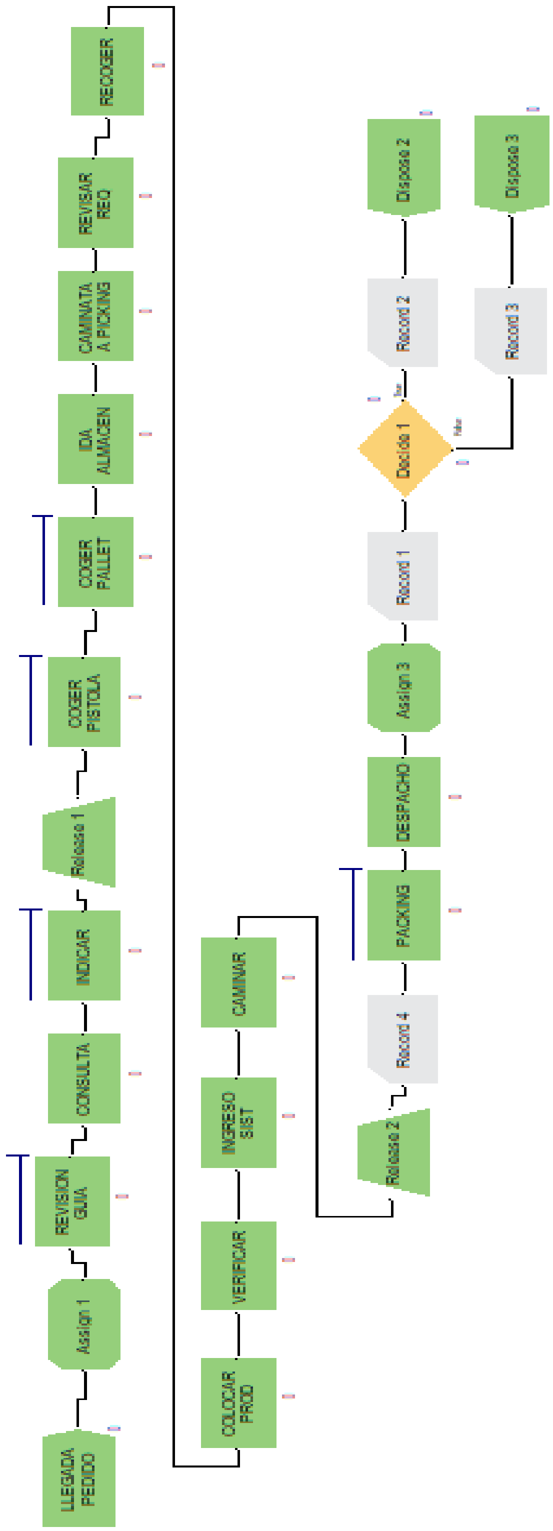

Fig. 2 Simulation of the improved system

1) First scenario:

For this first simulation, the Arena Version 16.1 tool is used again to simulate a second month with the implementation of the proposed improvements of the Lean Warehousing methodology.

TABLE II
RESULTS OF THE FIRST SCENARIO

Indicator	Current Situation	Improved situation	Scenario 1
OTIF	58.56%	87.50%	86.30%
IRA	74.78%	95.00%	95%
Time to reach product location (seconds)	6.14	2.55	2.62
Operator efficiency	59.70%	71.72%	70.87%

As can be seen in Table II, the main indicator (OTIF) rose to 86.5%. Likewise, the time to reach the product location decreased by 57.32%, and operator efficiency in the picking process increased by 11.17 percentage points.

2) Second scenario:

As in the first scenario, the Arena program performs the simulation. In this case, the results of the second month are compared with the first month.

TABLE III
RESULTS OF THE SECOND SCENARIO

Indicator	Current Situation	Scenario 1	Scenario 2
OTIF	58.56%	86.30%	87.11%
IRA	74.78%	95%	95%
Time to reach product location (seconds)	6.14	2.62	2.48
Operator efficiency	59.70%	70.87%	72.27%

In this second scenario, the main indicator (OTIF) rose to 86.94%. In addition, the time to reach the product location went from 6.14 to 2.48, and the operational efficiency in the picking process obtained a value of 72.27%.

3) Third scenario:

Finally, the Arena v16.1 simulator is used again to simulate the third and last month. In this case, the second scenario is compared with the third.

TABLE IV
RESULTS OF THE THIRD SCENARIO

Indicator	Current Situation	Scenario 2	Scenario 3
OTIF	58.56%	86.94%	88.11%
IRA	74.78%	95%	95%
Time to reach product location (seconds)	6.14	2.48	2.59
Operator efficiency	59.70%	72.27%	71.86%

For the last month, the OTIF indicator rose to 88.11%. In addition, the time to reach the product location increased by 4.44%, and the operational efficiency in the picking process obtained a value of 71.86%.

For this purpose, three scenarios are proposed, in which a comparison of the current simulation of the first month is made with the following three months. For the first scenario, the results obtained in the first simulation (first month) will be used; for the second, the data obtained when simulating the second month will be used; and finally, the third scenario will be carried out with the data from the previous scenario. This way, we will have scenarios from the current situation up to the fourth month of simulation.

TABLE V
ECONOMIC IMPACT ON THE IMPROVEMENT

Financial loss	Current Situation	Improved proposal	%difference
Non-fulfillment of orders in quantity and/or on time	S/ 242,792.84	S/ 68,285.49	71.88%

The current situation segment refers to the profit that the company does not obtain for not fulfilling the orders due to a non-fulfillment of the quantity of the standard product and/or for delivering the order out of time. As a result of these problems, the company did not fulfill the products and, therefore, obtained a loss during the year 2021 of S/ 242,792.84. This amount for noncompliance was reduced by 71.78% concerning the current amount, with a value of S/ 68,285.49. Based on those above, it is considered a significant improvement over the current simulation.

The financial indicators were calculated based on cash flows such as Net Present Value (NPV) and Internal Rate of Return (IRR). The NPV with S/15,089,377.45 means that the project is viable; the IRR being higher than the COK (20.6%), so it is profitable.

VI. CONCLUSIONS

This research was able to diagnose that the main problem in the company under study, in the mass consumption sector, is a low OTIF indicator with a value of 58.56% since it represents the company's most significant economic loss. The eloquent impact of this problem was evidenced in the literature. Furthermore, this project has been able to validate the significant impact of causes on the main problem, finding the following: Incorrect product location assignment, the inadequate sequence in picking tasks, and inappropriate registration and tracking of products, which have an impact of 46.38%, 28.84%, and 13.15%, respectively, on the company's breakage.

Based on this diagnosis, this research validates that the original Lean Warehousing model applied to the improvement of logistic processes in a mass consumption company is competent to significantly increase the orders attended on time and completed, obtaining an increase of 28.94% in the OTIF indicator. Likewise, the IRA indicator was increased from 74.78% to 95% thanks to eliminating errors in recording inputs and outputs in the system. It should be noted that, although initially, the main objective was to increase the IRA indicator, the improvement proposal also reduced the recording times by more than 17 times. On the other hand, the operators' efficiency increased by 12.2% more than the initial state of the current situation, and the time to reach the location of the products decreased by more than half. This made it possible to achieve good times to optimize the processes and, in this way, fulfill the main objective of this research. In this area, the effectiveness of the Lean Warehousing model can be demonstrated in a new scenario, the mass consumption sector, as a consequence of the optimal results obtained. Existing this improvement and other similar ones found in the literature, it is evident that the proposed model can be applied in different areas with satisfactory results. Therefore, it is concluded that it is highly effective and far-reaching.

Finally, the present research expands the literature on improving and optimizing logistic processes in the mass consumption sector using Slotting, Standardized Work, and Poka-Yoke tools. However, it is essential to take advantage of the future dissemination of this implementation in other divisions with similar characteristics to the one studied for continuous improvement in the company under study.

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