Picking Optimization in a Peruvian SMEs Based on Lean Warehousing Techniques

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Abstract

Picking is a basic process within warehouse management, comprising the activities carried out since the order is received until the products are located in the warehouse and are ready for dispatch. The objective of this study was to optimize the productivity of the picking process in a Peruvian food company. For this purpose, a pre-test and post-test methodology was designed with a qualitative and descriptive approach in order to suggest an innovative proposal. Lean Warehousing techniques, such as 5s and Systematic Layout Planning (SLP) were utilized, as well as an inventory record automation model and ADKAR, a change management model. The proposal was validated through pilot tests and a simulation in the Arena software (16.1 version), proving its effectiveness in increasing productivity by more than 36%. The value of this study lies in that it can be applied both in companies in the same sector or other areas that have their own warehouse and want to increase its productivity.

Keywords
Productivity, Picking, Lean Warehousing and Warehouse.

1. Introduction
Nowadays, companies have been forced to meet the particular needs demanded by customers. The market trend has changed; it is no longer the company that decides which products to sell, but rather, it is the company that must adapt to offer the products that are in demand. The situation becomes more complicated when it is necessary to ensure fluency in the chain, from the moment the customer's need is identified until it is met. For an efficient supply chain, productivity levels must be guaranteed and constantly demanded to be improved at each stage. For this reason, this study will consider one of the determining elements in the performance of the chain: management of the picking area in the warehouse.

Picking is a basic process within warehouse management, which comprises the activities that take place from the moment the order is received until the products are placed in the warehouse and are prepared for dispatch. It is estimated that the management of this area represents 55% of the total operating expense of the warehouse, which means that any inefficient performance directly affects productivity and operating costs of companies (de Koster et al. 2007).

The main reason why picking management becomes complex is because it is usually a process that requires a lot of organization so that the use of resources, such as intensive labor and machinery, are used efficiently. Likewise, companies must seek to maximize storage space and, simultaneously, minimize handling and moving operations of all stored products to improve productivity.

In order to maximize storage space, many companies opt for accumulative or compact racks, which are excellent for taking advantage of limited space, since the aisles between shelves are eliminated and the space is used for the storage of goods. However, if these types of warehouses are not properly organized, the handling of goods can become complex, directly affecting productivity, as well as picking operations in critical dispatch times (Roodbergen and Vis 2006).

As stated by the authors Fontalbo et al. (2017) keeping control over productivity is fundamental in companies in order to be competitive and measure their performance in the globalized world. One way to increase the productivity of a company is through the application of continuous improvement techniques, which, as mentioned by Bonilla et al. (2010), consist in applying methodologies that allow optimizing the behavior and results of the different processes, increasing their efficiency and effectiveness.

1.1 Objectives

The objective of the study was to increase productivity in the picking area throughout an innovative program inspired by Lean Warehousing techniques applied in a Peruvian food company. It was demonstrated, in a practical way, that the techniques used, allowed an increase in productivity in the picking area. The study presents multiple methodological benefits, since by demonstrating its validity, it serves as a starting point for future interventions in companies of different sectors that would like to improve the management of the picking area of their warehouses.

2. Literature Review

In Chile, a methodological proposal was developed to increase integration and collaboration in inventory management following logical steps. This methodology starts from collaborative planning, in order to integrate key processes and then proceed to implement and verify the performance of the proposal developed (Salas-Navarro et al. 2017). This methodology was similar to the one developed in Cuba, which, in order to reduce inefficiencies in warehouse logistics management, used a systemic model to relate key elements and perform a diagnosis to then propose improvement actions (Calzado-Girón 2020).

However, other researchers opted for a different methodology. Such is the case of those conducted by Salgado (2018) and Uárez et al. (2021), in Ecuador and Peru respectively, which use the 5s methodology to improve the performance of two companies. However, while the one conducted in Peru has a non-experimental design, the research in Ecuador did implement the tool in the company, managing to increase productivity by 26%. Another research that has a semi-experimental design was conducted in India and showed that the implementation of Lean principles managed to decrease the operation time of most activities by 40% (Baby et al. 2018).

Both Cardona et al. (2018) and Huguet et al. (2016), authors of research conducted in Colombia and Venezuela, respectively, used ABC classification in manufacturing companies to propose improvements in warehouse distribution. Baby et al. (2018) also employed this methodology; however, they applied it in a sale warehouse of a manufacturing company located in India, achieving quantifiable improvements.

In terms of improvements in the picking area, research conducted in Poland showed that the application of the Kaizen method and Lean techniques managed to increase productivity in a sewing machine Factory successfully, decreasing picking time by more than 22% (Srisuk and Tippayawong 2020). Similarly, Prasetyawan et al. (2020) used Lean techniques, specifically Lean Warehousing to improve the performance of a warehouse by maximizing space. Silva et al. (2020), on the other hand, solved problems related to warehouse planning and order picking by using a heuristic method with scheduling models.

In Turkey, research showed that the correct design of a warehouse is crucial for companies in the food sector, through the case of a company that managed to reduce its costs by 80% (Sayin and Barman 2020). Another study in the food industry is the one from Bastos et al. (2019), which determines the optimal inventory policy for picking activities, relying on simulation.

Quintana et al. (2020) conducted a study in Argentina, in which they determined that the best way to implement an improvement within a Company, was through the ADKAR change management model, where, through a series of stages, members involved where made aware of the need for change, instead of imposing it, in order to ensure greater commitment from the employees. Similarly, Carranza and Yuptón (2019), in an investigation conducted in Peru, managed to get a school to adapt to the change imposed by the government by applying the steps of the model, carrying out a series of trainings.

3. Methods

The research presented is a case study with a pretest and post-test design. A previous analysis of the problem was carried out in order to propose an innovative proposal with the purpose of improving the current situation of the warehouse. The approach was qualitative with an exploratory and descriptive scope, with a purposeful intention. The methodological design was validated by experts in the topics analyzed. The four phases of the proposed methodology were inspired by the Deming cycle, a continuous improvement tool.

In the first phase, an analysis was carried out to identify the main problem, after reviewing the root causes using different tools such as Pareto, problem tree and VSM diagram. Subsequently, in the second phase, the innovative proposal was designed, applying Lean Warehousing techniques, specifically 5s and Systematic Layout Planning (SLP), as well as a change management model and the automation of inventory records. In the third phase of the methodology, the proposal was validated using pilots and a simulation with Arena software version 16.1, according to the techniques used. Finally, in the fourth phase, the results and the contribution of the proposal were discussed; both for the company and for the sector. The phases mentioned before are summarized in Table 1 below:

Table 1. Phases of the proposed methodology

Phases	**Scope**	**Tools**	**Techniques**	**Validation**
1. Initial Analysis	Information was gathered to identify the main problem and perform a root cause analysis.	Observation, Root cause analysis	VSM Diagram Pareto Problem Tree	Warehouse manager and management control manager
2. Innovative proposal	The improvement proposal was designed and developed applying Lean Warehousing techniques.	Check List	5s SLP Inventory register automation model ADKAR	Chief Executive Officer
3. Proposal validation	The proposal was validated by performing a simulation in Arena software version 16.1 and pilot projects.	Statistical techniques	Pilots Arena simulation model	Chief Executive Officer
4. Final analysis	The results were discussed	Analysis of results	Graphic material	Chief Executive Officer

4. Data Collection
The case study company began its operations in the city of Lima in 2008, manufacturing canned products to contribute to the nutrition of vulnerable populations. Nowadays, the company has a processing plant and its own warehouse from which it manages all its operations.

The warehouse is compact and contains finished products (quarantined and released), materials and supplies that do not require refrigeration, logistic units (crates), and machinery. This cumulative warehouse is made up of 3 blocks, 2 of which are attached, separated from each other by a corridor that provides access only to blocks 2 and 3. To access block 1, there is a second corridor. It should be noted that the aisles have been designed to optimize the storage area to the maximum, leaving only space for stacker maneuvers.

Each block is 6 levels high and has 15 rows numbered from letter A to letter O. Blocks 1 and 3 have 3 positions deep, while block 2, located in the middle of the warehouse, has 4 positions. A map of the warehouse is shown below in Figure 1.

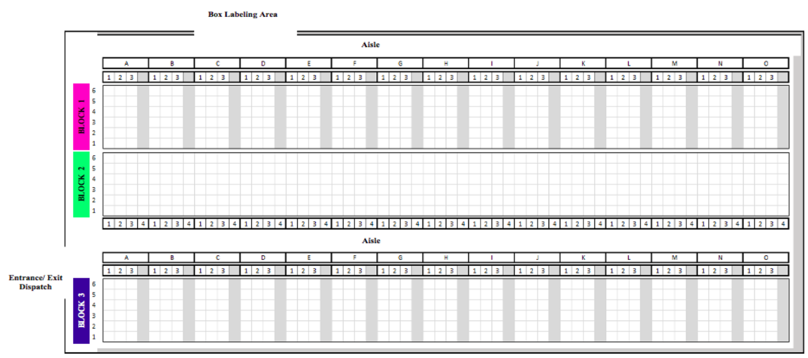

Figure 1. Compact warehouse map

The warehouse management process starts with the reception and discharge of the boxes coming from the manufacturing area. These are transferred to the reception area. Subsequently, with the help of a stacker, the boxes are stored in the accumulative racks. This process is carried out without respecting any zoning policy, they are placed in the spaces that are empty at that moment or that are most accessible.

After the arrival of orders, the pallets are searched in the different positions of the warehouse using a manual guide, to verify the stock and the position. Then, with the help of the stacker, the operators in charge, look for the best way to access the position and remove the requested pallet. As this is an accumulative warehouse, if the product is in the second deep position, the operator must remove everything below and in front of it in order to reach it. After removing the pallet from its respective position, the operator places the pallets in the aisle for quality control. After quality control, an operator is in charge of palletizing the boxes for its later transfer to the dispatch area. Finally, using a waybill, the boxes are authorized for shipment and the truck is loaded for dispatch.

4.1 Initial Analysis
The initial analysis of the case study was carried out by collecting both qualitative and quantitative information as part of a pre-test design. First, a VSM diagram was made, with the objective of mapping and identifying the non-value-adding times of the following warehouse management activities: receiving, storage, picking, quality control and dispatch. As seen in Figure 2, the picking activity was the one that presented the longest time of all the previously mentioned activities, thus demonstrating that the implementation of an improvement was highly necessary.

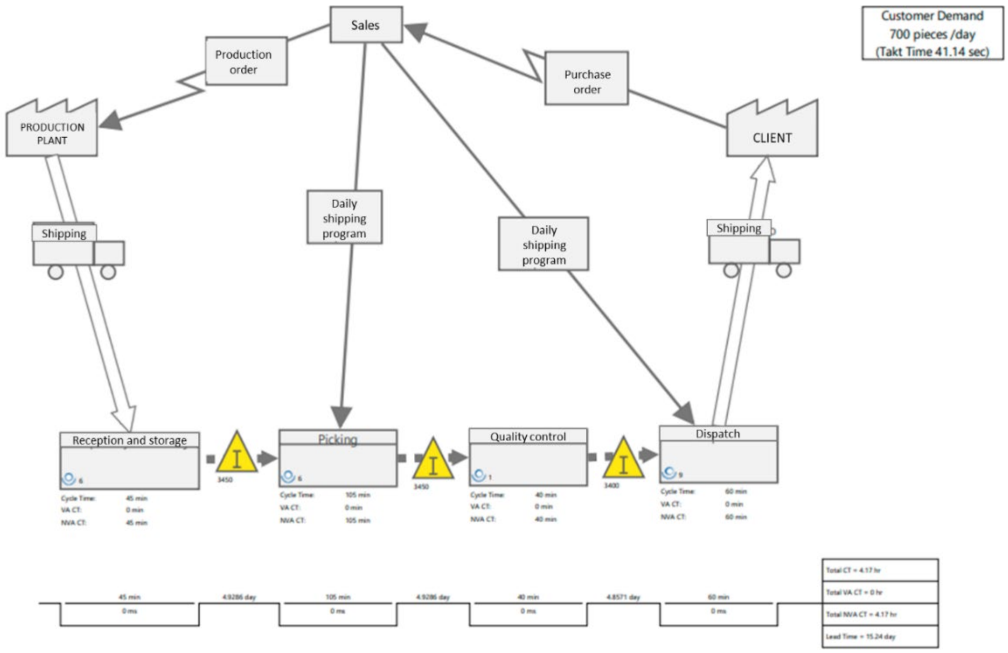

Figure 2. VSM diagram

Once the area that is going to be improved is identified, we sought to determine the average productivity of the picking area of the company, comparing it with the optimal productivity of the sector, as shown in Figure 3. The picking process has an average productivity of 132.5 packages/hour, which is 26.7% below the sector standard of 180 packages/hour.

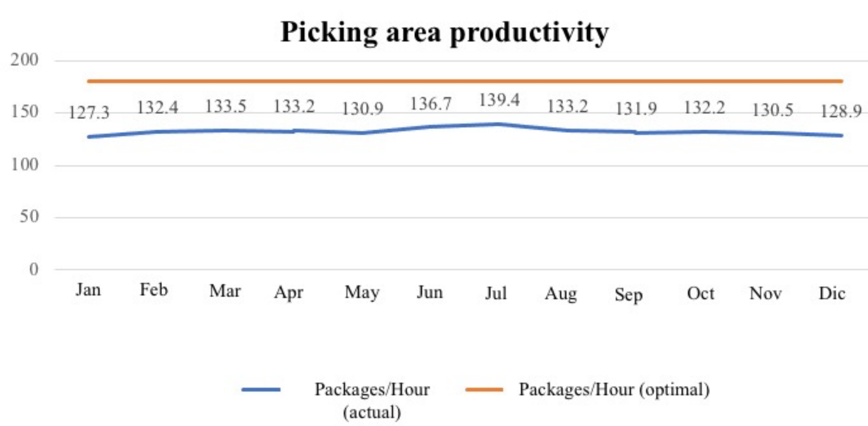

Figure 3. Picking area productivity

A detailed cost analysis was also carried out to show the economic impact of inefficiencies in picking activities, which are reflected in the cost of overtime. 67% of the total overtime in the warehouse corresponded to the picking process, amounting to S/. 119,043.2 and representing 1% of the total profit for 2019.

Then, we proceeded to investigate the different reasons that caused the low productivity index in the picking process. Among these, the disorder of the warehouse, as well as the lack of knowledge of product locations, were significant reasons. Likewise, the lack of trained employees, lack of knowledge of the free warehouse spaces and the presence of products without rotation in the warehouse, were the causes of the problem.

The following Pareto diagram shows the prioritization of these reasons according to the time that does not add value for the company.

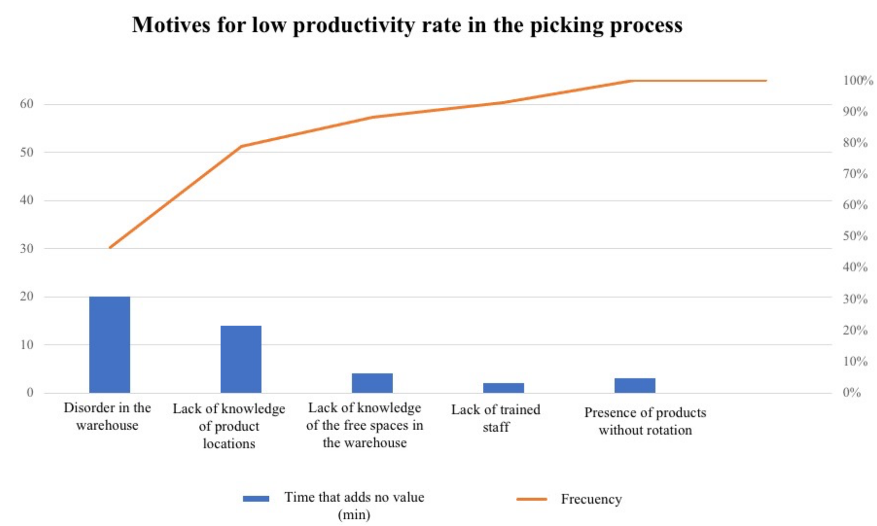

Figure 4. Pareto diagram

As shown in Figure 4, disorder in the warehouse and lack of knowledge of product locations were the main reasons contributing to the problem. To identify the root causes of the main reasons, a problem tree diagram was created and is presented below in Figure 5.

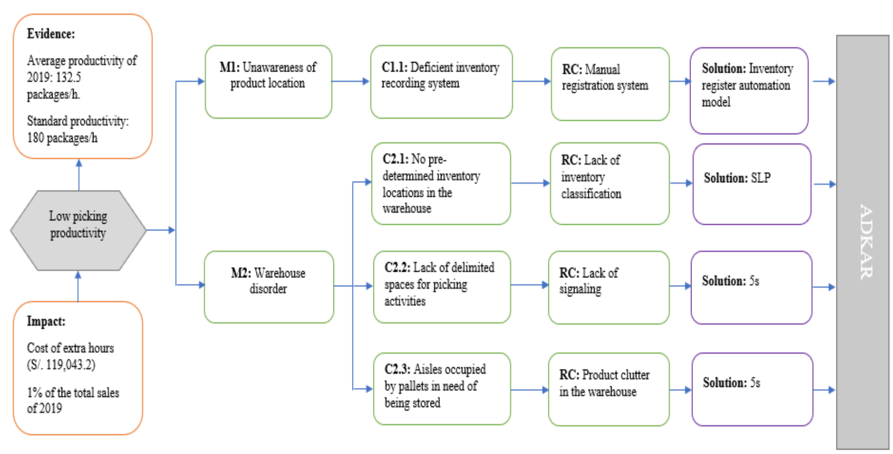

Figure 5. Problem Tree

The main problems in picking management were the lack of knowledge of product locations and disorder in the warehouse. Regarding the lack of knowledge of product locations, the root cause was the poor inventory recording system, which was caused by a manual recording system. The inadequate inventory control in the warehouse increased the possibility of human error since the warehouse clerk relied only on a manual guide to locate a product at the time of dispatch.

On the other hand, the disorder in the warehouse was caused by the inexistence of predetermined inventory locations, the lack of delimited spaces for picking activities and the halls occupied by pallets waiting to be stored, resulting in excessive handling and transfer operations of the stored products, which generated subsequent delays in dispatch.

The following key indicators were established to analyze the actual situation of the picking process and compare it to the industry standards, which were set as the objective. These are shown below in Table 2.

Table 2. Key indicators

Indicators	Current situation	Objective
Picking productivity	132.5 packages/hour	180 packages/hour
Picking time	20.4 min/order	16 min/order
Inventory Record Accuracy (IRA)	84%	100%
Location Record Accuracy	81%	100%
Internal audit 5s	62%	100%

4.2 Innovative proposal

The proposed model consists of applying Lean Warehousing techniques to improve the productivity of the warehouse picking area. The proposal has 3 sequential stages, in which different tools were implemented to improve the main problems identified in the initial analysis. In the first stage, the 5s tool was applied, with the objective of determining the base guidelines and obtaining an initial stability.

Then, in the second stage, we proceeded to use the Systematic Layout Planning (SLP) tool and an inventory register automation model in order to reorganize and redefine the warehouse locations to reduce distances and increase productivity. Finally, in the third stage, the ADKAR change management model was applied, with the aim of achieving a successful change within the organization, where all employees generate awareness and are integrated into it in the best possible way.

After reviewing the literature, it became evident that there was a lack of research on improvements applied using Lean Warehousing techniques in collaboration with a change management model. Therefore, it was decided to apply the previously mentioned techniques with the objective of assuring the success of the proposed improvement and its permanence over time, as shown in Figure 6.

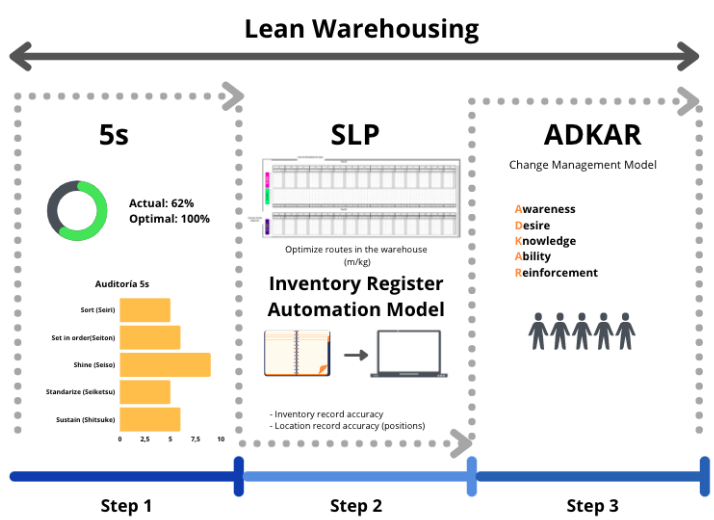

Figure 6. Innovative proposal summary

5. Results and Discussion

5.1 Results

Next, the improvement proposal will be presented, which will be validated through the implementation of a pilot and a simulation in the Arena software. As for the pilot, it will be implemented to validate the 5s tool, as well as the inventory register automation and ADKAR. On the other hand, the simulation will help to validate the SLP tool, quantitatively demonstrating the feasibility of the proposal.

5.1.1 Stage 1: 5s

A checklist was used for each of the 5s in order to identify those that required improvement. Out of a maximum score of 10, the 5s obtained the following scores, as shown in Figure 7.

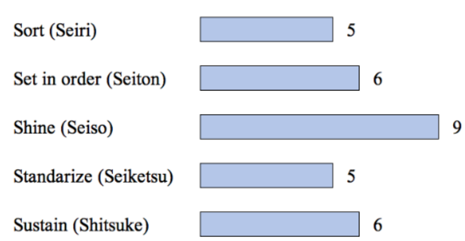

Figure 7. 5s Evaluation

Except for Shine (Seiso), all components needed improvement. Regarding Sort (Seiri), the main problems identified were disused materials, such as machinery, which hindered the work environment; unorganized and unlabeled work tools, as well as boxes stacked in the passageway, which impeded the correct flow of picking activities. With respect to Set in order (Seiton), the warehouse did not have access paths, determined storage and picking areas, nor location and direction indicators. Regarding Standarize (Seiketsu), there were no clear procedures for the implementation of improvements, so there was no culture of continuous improvement. Finally, the main problems found with respect to Sustain (Shitsuke) are the lack of procedures for inspections and deficient reporting standards, as well as incomplete training of warehouse personnel. The result of the audit was 31 points out of a total of 50 possible points, representing 62% compliance.

After evaluating the current situation, a schedule for the implementation of the pilot program was determined. It was established and coordinated with the warehouse collaborators in order to carry out the following improvement proposals. First, an inventory of unneeded materials was made to determine whether they should be discarded or relocated to another area. For disused machinery, it was decided to relocate it in rack positions with lower turnover and difficult access, so as not to interfere with the daily logistics of the warehouse. Then, the shelves were labeled, determining defined positions for the storage of tools. In addition, specific areas for storage and picking activities were delimited, and a flow direction was defined to avoid unnecessary movements.

Finally, procedures for picking activities were established and a checklist was given to each employee. In addition, inspection reports were standardized, a specific time was established for their periodic review, and all warehouse personnel were trained. After two months, the audit was carried out again and a score of 50 points was obtained, reaching 100% compliance, and thus completing the first stage.

5.1.2 Stage 2: SLP and Inventory register automation model

The SLP tool was applied in order to reorganize the warehouse and determine positions according to the type of inventory in order to reduce handling and extensive trips through the warehouse. The new positions were determined based on inventory turnover, placing machinery and supplies with low turnover in positions that were difficult to access, while priority was given to finished products and raw materials, which were assigned to the most accessible locations. The current situation and the proposed improvement are shown in Figure 8.

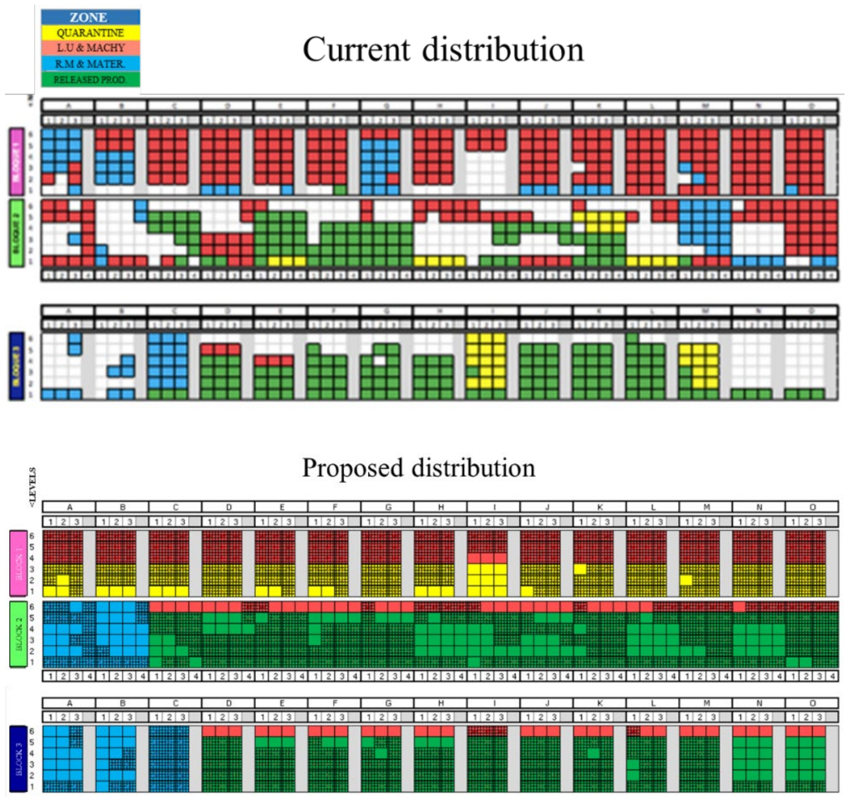

Figure 8. Current and proposed warehouse distribution

Once the new layout was obtained, it was necessary to implement an automatic inventory registration model to optimize the search for lots and keep a correct control of it. Having only manual records increased the probability of human error, as well as picking time, directly affecting the productivity of the area. Therefore, after several meetings with the warehouse manager and operators, the main problems were identified.

For inventory control, there was a manual Kardex, in which the current receipts, issues and balances were recorded by type of product. There was also a manual system for recording items, which made searches difficult because it was very extensive and disorderly. Both documents were updated by certain operators in charge, who were the only ones who understood it, while the rest had not been trained to use it. The accuracy of the inventory and location records did not meet industry standards, being 84% and 81% respectively. This was due to the fact that the operators in charge relied on their memory and often failed to record certain movements.

After analyzing the problems previously mentioned, working together with the warehouse manager, a proposal was made to develop a model for automating the inventory register. This consisted of an Excel macro with the following sections, shown in Table 3.

Table 3. Model sections

Sections	**Description**
Input	Registers the inputs, considering the zone in which they must be stored (quarantine, raw material and materials, released product, or logistic units and machinery). Depending on the type of zone selected, the macro will indicate in which block of the warehouse it can be located, also taking into account availability.
Transfer	It is used when it is necessary to relocate inventory from one position to another.
Outflow	Records the inventory outflows from the warehouse.

Kardex	Indicates the number of units that have entered and exited by product type, as well as the balance.
Positions	Displays the warehouse map, according to the layout determined after the SLP, and indicates the occupied and available positions, as well as the percentage of availability of each block and each zone.
Stock	Displays the amount stored of each product, as well as the position in which it is located.

In order to validate both the SLP tool and the inventory register automation model, a simulation was conducted using Arena, a simulation software for discrete events modeling, that enables an easier analysis of possible scenarios. The simulation was made to quantitatively measure the improvement of both tools. For this purpose, the times of the order search activities in the inventory register and the extraction of the merchandise from the shelves were reduced by -52% and -28% respectively. The model was run with 20 replications, and, with a 95% confidence level, the margin of error was 6%.

Figure 9 shows the simulation model in Arena, validated by experts in the topic.

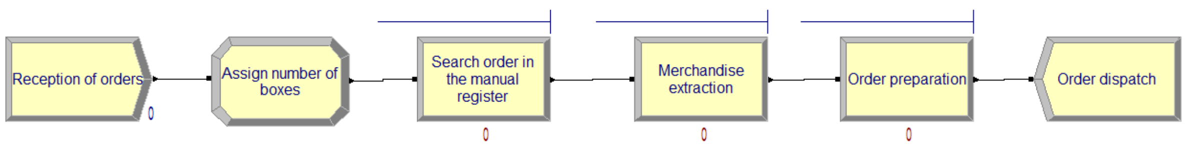

Figure 9. Arena Simulation

The times of each picking activity were measured by means of a time study and then analyzed in Input Analyzer to determine the distribution to which they were adjusted, as shown in Figure 10. The simulation also included information about the working hours of the personnel and the number of operators involved per activity.

Process - Basic Process

	Name	Type	Action	Priority	Resources	Delay Type	Units	Allocation	Minimum	Value	Maximum	Expression
1	Search order in the manual register	Standard	Seize Delay Release	Medium(2)	1 rows	Triangular	Minutes	Value Added	1	2	3	1
2	Merchandise extraction	Standard	Seize Delay Release	Medium(2)	1 rows	Triangular	Minutes	Value Added	6	8	11	1
3	Order preparation	Standard	Seize Delay Release	Medium(2)	1 rows	Expression	Minutes	Value Added	.5	1	1.5	0.1 * Number of boxes

Figure 10. Basic Process

Finally, it could be concluded that the simulation in Arena showed that the application of the tools decreased picking time by 26.9%, as shown in Table 4.

Table 4. Arena Simulation

Measurement	**Picking time**
Current simulation	20.4 min / order
Improvement proposal	14.91 min / order

5.1.3 Stage 3: ADKAR

In order to ensure that the improvement implemented is sustainable over time and has a positive impact on both the company and its employees, it was decided to apply the ADKAR change management model. This consists of the development of 5 elements to ensure the correct recognition, acceptance, and implementation of change. The model was validated through a pilot, which lasted one month and consisted of several trainings to the warehouse personnel about the proposed changes (5s, inventory register automation and SLP), ensuring that the 5 elements are correctly fulfilled, as seen in Table 5.

Table 5. ADKAR trainings

Stage	Detail
Awareness	The benefits of the change were detailed, as well as the risks of not implementing it, with the objective of making the operators aware of the need for it.
Desire	Once the personnel have understood the importance of change, it is necessary to generate the desire to actively participate in it and support it, emphasizing the benefits for both the company and the employees themselves.
Knowledge	Once the employees are motivated, they are trained in the improvement proposals, providing them with the necessary information, resources, and knowledge, so that they can face the change successfully.
Ability	Personnel are supported during the learning process so that they can continue to improve their skills.
Reinforcement	Continuous monitoring and reinforcement of what has been learned is provided to ensure that the change is maintained in the long term and that there is no return to previous practices.

Once the training was completed, a survey was conducted to evaluate the satisfaction of the collaborators in each stage of the change management model. This consisted of 5 questions for each stage, where each of them was evaluated quantitatively with a scale from 1 to 5, where 1 was "Strongly disagree" and 5 was "Strongly agree". Out of a maximum score of 125, 114 points were obtained, with an average score per question of 4.56, which indicates that the training was very satisfactory and that a successful change was implemented in the organization. Table 6 below shows the values of the main indicators after the implementation of the improvements.

Table 6. Indicator's comparison

Indicators	Current situation	Improved situation	Objective
Picking productivity	132.5 packages/hour	180.7 packages/hour	180 packages/hour
Picking time	20.4 min/order	14.91 min/order	16 min min/order
Inventory Record Accuracy (IRA)	84%	100%	100%
Location Record Accuracy	81%	100%	100%
Internal audit	62%	100%	100%

5.2 Discussion

The overall objective of the study was to increase productivity in the picking area, based on an innovative program inspired by Lean Warehousing techniques applied in a Peruvian food company. These techniques were also applied in the research of Srisuk and Tippayawong (2020), with the purpose of reducing non-value-added times and/or eliminating deficient procedures, thus reducing picking time.

With respect to the methodology, which was inspired by the Deming cycle, it consisted of 4 sequential stages that served as a basis to achieve a correct diagnosis, a successful formulation of the innovative proposal, as well as its validation and the final analysis of the results. Similarly, the methodology applied in the research conducted by Salas Navarro et al. (2017) was also inspired by the Deming cycle, by defining a sequence of 5 steps starting from the definition and planning, and then measuring the main indicators that allowed the development of action plans.

First, the 5s made it possible to create a culture of order, cleanliness, and standardization, serving as a starting point for the following improvements. As for the second stage, the SLP tools and the inventory register automation system were applied, which directly influenced the reduction of picking times. Finally, for the improvements applied to be sustainable over time and to generate employee commitment, the change management model, ADKAR, was applied.

An initial analysis was carried out in order to diagnose the main problems in the warehouse. As a result, it was found that productivity in the picking area was 26.8% below the industry standard. Then, the main causes were identified, which were the deficient inventory registration system, the lack of predetermined inventory locations in the warehouse, the lack of delimited spaces for picking activities and the aisles occupied by pallets pending storage.

As for the results obtained, the 5s allowed to increase the compliance of the audit performed from 62% to 100%, by applying different organizational techniques related to the components of the tool: sort, set in order, shine, standardize, and sustain. The same happens in the research by Salgado Heredia (2018) where they applied the 5s tool with the purpose of reducing activities that did not add value, thus increasing productivity. Likewise, the research conducted by Uárez Eleorraga et al. (2021) coincides with the study conducted, since during the process of introducing the tool, they considered that the collaboration of the personnel was fundamental to obtain better results, as well as the subsequent training to ensure a correct implementation of the 5s.

On the other hand, the simulation in Arena of the SLP tool and the automation of the inventory registration system showed that a 26.9% reduction in picking time was achieved, by reducing both the product search time and the product handling movements. This case is similar to that of Silva et al. (2020), where they also carried out a reordering of the warehouse, since both studies agree that a fundamental problem in the picking area is the lack of predetermined locations for product allocation. Another similar case is that of Prasetyawan et al. (2020) since, in both studies, one of the main causes of inefficiency in warehouse activities is the inaccuracy of the manual inventory management system. However, while in the study in question such a system was automated as a solution, in the research in comparison labeling and sorting techniques are used to decrease the company's waste and consequently achieve information accuracy.

Finally, the application of the change management model, ADKAR, allowed the applied improvements to be sustainable over time, generating awareness of the need for change, desire for participation, knowledge to face change, constant support for the development of skills, and continuous accompaniment to reinforce what has been learned. This model is also applied in the study conducted by Carranza and Yuptón (2019), where a Peruvian school sought to adapt to the changing environment using a questionnaire technique to analyze the dimensions of the model and to know the direct opinion of the collaborators.

6. Conclusion

The improvement proposal was effective in demonstrating that the different tools applied significantly increased the productivity of the picking area, achieving the objectives initially set. The application of the 5s made it possible to increase compliance with the audit from 62% to 100%, by applying different organizational techniques related to the tool's components. The implementation of the Systematic Layout Planning (SLP) and the inventory register automation model, validated by means of the Arena software, allowed reducing the average time of picking activities by 26.9%, after reducing the time of the search of the register order and the extraction of the merchandise. The change management model, ADKAR, validated through training and a pilot questionnaire, showed that a successful change could be implemented in the organization, obtaining an average score of 4.56 per question, out of a maximum of 5 points. The integration of the previously mentioned tools successfully increased the productivity of the picking area by 36.5%, obtaining a productivity of 180.7 packages/hour and successfully reaching the industry standards. Finally, the transferability of this study lies in the possibility of being applied in other SMEs in the sector and other industries, as well as in logistics companies seeking to increase the productivity of the picking area. To this effect, the reports detailed throughout this study facilitate that the methodology can be replicated in other contexts.

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