*Nanotechnology Perceptions*
*ISSN 1660-6795*
*www.nano-ntp.com*

# Lean Manufacturing in Productivity Improvement in a Food Company, Peru

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The objective of the research was to determine the impact of implementing Lean Manufacturing tools on the productivity of the production area in a food company specializing in the manufacture of Andean cookies in the city of Huancayo. To achieve this, the Lean Manufacturing methodology was used, selecting the Kaizen, 5S, TPM (Total Productive Maintenance), Kanban, and Just in Time (JIT) methodologies. An explanatory research level was employed, using the production processes of an Andean cookie company as the sample. With the implementation of Kaizen, a 30% increase was achieved in the Plan phase, as well as 10% increases in the Do, Check, and Act phases. Similarly, with the application of 5S, a 15% increase was recorded in each of the areas of sorting, ordering, cleaning, standardization, and discipline. The implementation of TPM resulted in a 20.71% increase in reliability. On the other hand, with the implementation of Kanban, a 10% increase in stock control, a 31.11% increase in worker training, and a 30% reduction in activities were observed. Additionally, with the application of JIT, a 20% increase was found in system startup, a 15% increase in process awareness, a 30% increase in control, and a 20% increase in the customer-supplier relationship. Regarding productivity after the implementation of Lean, a 14.9% increase was recorded. In conclusion, the implementation of Lean Manufacturing significantly contributed to the productivity increase of the company.

**Keywords:** Lean Manufacturing, Productivity, Kaizen, TPM.

## 1. Introduction

Globally, in a highly competitive and globalized environment, organizations must meet certain standards in their processes to remain viable and fulfill the quality standards demanded by the market. On this path toward continuous improvement, manufacturing companies adopt Lean Manufacturing, a system that enables them to produce more with fewer resources. This approach systematically organizes processes, leading to greater labor efficiency with fewer personnel, reduced resource usage, and the minimization of waste or defects in production compared to conventional methods [1].

In Europe, the importance of adopting multiple approaches in food systems is emphasized to make them more sustainable, resilient, responsible, diverse, competitive, and inclusive. This involves implementing various actions, such as increasing total production, improving distribution methods and channels, and reducing food waste, among other strategies. The use of tools like 5S and JIT, as well as methodologies like Value Stream Mapping (VSM), is also considered crucial to identify the needs that will enable these objectives to be achieved[2].

At both the European and Latin American levels, small and medium-sized enterprises (SMEs) account for a significant percentage, between 30% and 60% of the Gross Domestic Product in different regions. However, a marked productivity disparity remains between entities in Europe and Latin America. On average, only about 5% of Latin American companies participate in exports. If these companies fail to close this gap through improvements in their processes, management practices, and technology adoption, this disparity will persist over time [3].

In Colombia, competitiveness in the food sector is significant, and the increase in business productivity (65%) is attributed to internal actions that each company can undertake, such as improving the positioning of their products and gaining a larger market share, in addition to enhancing processes and management practices. However, SMEs face challenges that restrict their effectiveness, such as process control, the absence of quality standards, waste generation during production, and inefficient equipment use, which are common problems that have a considerable impact [4].

In this regard, Palange and Dhatrak [5], observed that the implementation of Lean Manufacturing reduced production cycle time, eliminated non- essential activities, and improved order and cleanliness in the workplace, allowing for a smoother production flow, reducing production costs, and increasing productivity. Additionally, the study by Singh et al. [6] demonstrated that implementing Lean Manufacturing resulted in a savings of 242,208 rupees in one year. On the other hand, in the study by Fitriadi and Wijayanti [7], it was identified that after applying the Waste Assessment methodology, the VALSAT model, and Value Stream Mapping, a process cycle efficiency of 67% was achieved. Similarly, Sergeeva et al. [8] assert that the incorporation of Industry 4.0 technologies in industrial companies, such as enterprise resource planning systems, the industrial Internet of Things, automation and robotics, augmented and virtual reality, and radio-frequency identification, not only contribute to more efficient manufacturing by reducing losses but is also the most effective way to eliminate them.

In Peru, many companies opted to implement telecommuting or remote work. However, labor productivity became uncertain because, while telecommuting was promoted with new technologies that accelerated productive growth, its effectiveness was not entirely predictable. It is also noted that productivity is crucial for economic development both in Peru and globally. In recent years, Peru has maintained macroeconomic stability, but other aspects related to productivity have remained relatively low compared to countries like Chile and South Korea [9].

In the food company located in Huancayo, operational inefficiencies, high levels of waste, and considerable operational costs were observed. The lack of optimized processes and the presence of inefficient practices in the production chain directly affect the company's ability

to respond to the growing market demand. Additionally, competition in the food sector demands continuous improvement to remain competitive. Identifying and resolving these issues are crucial elements for the sustainable growth of the company, especially concerning productivity deficiencies. In 2023, a decrease in production quantity was observed compared to 2022, suggesting a loss for the company, given that the same amount of inputs was used. Consequently, this study aims to determine the influence of applying Lean Manufacturing tools on the productivity of the production area of a food company dedicated to manufacturing Andean cookies in the city of Huancayo.

## 2. LEAN MANUFACTURING

Lean Manufacturing is a constant and systematic approach aimed at identifying and eliminating waste or superfluous activities that lack added value in a process, thereby generating costs. The true effectiveness of this approach lies in its ongoing commitment to seeking improvement opportunities within the company, recognizing that there are always wastes that can be eliminated [10].

A. Kaizen

Continuous improvement, also known as Kaizen, has become the fundamental pillar of the drive towards excellence in terms of Quality [11]. This comprehensive approach serves to enhance the efficiency of any production process through the application of various techniques, tools, and methods. This Japanese philosophy, whose meaning is continuous improvement, aims to foster a positive culture of change, stimulate the creative capabilities of human beings, and identify the root causes of problems for resolution. Therefore, when a company adopts this methodology to increase its productivity, it is crucial to continuously maintain and refine its application over time [12]. To do this, it is essential to evaluate the PDCA cycle (Plan, Do, Check, Act). To accomplish this, the following formulas are employed [13].

a) Plan

x100

[12]. For this purpose, the following formulas are employed: [15].

a) Stock control

* 100%

P = Percentage of the fulfillment of planned objectives.

OA = Number of objectives achieved. OP = Number of objectives planned.

b) Do

Percentage of goal implementation.

c) Check

X 100

CL =Percentage of

compliance level in dispatches

DCT = Number of dispatches completed on time.

TDR = Total number of

dispatches required.

d) Act

X 100

CO = Percentage of coverage of observations.

RO = Resolved observations. TO = Total observations.

B. 5´S

The 5'S represent a tool focused on operability, organization, and unifomity in work. Its objective is to create a work environment that promotes high levels of performance in a safe, orderly, and clean environment. This methodology aims to maintain constant consistency to ensure compliance with standards, both internally established and those required by customers, thus facilitating the proper execution of daily tasks [12]. It is important to consider availability; therefore, the following formula is used [14].

x 100

D = Percentage of

disponibility

C. TPM (Total Productive Maintenance)

It is a tool within Lean Manufacturing that investigates how to improve the disposition and reliability of equipment, mechanisms, and systems. Additionally, it focuses on the execution of preventive maintenance plans, organizing scheduled activities according to the time or frequency recommended in the machine manuals, and subsequently recording maintenance tasks [10]. To ensure the reliability of TPM, the following formula is applied [14]:

x 100%

MTBF= Mean Time Between Failures MTRF=Mean Time To Repair Failures

D. Kanban

Kanban, originated by Toyota, emerged as a response to the need to improve productivity by managing both the manufacturing order and the collection of materials and products with suppliers. This system focuses on coordinating and synchronizing these elements in production lines, ensuring precise delivery in terms of type, quantity, and time required within the production process

SC = Stock Control.

SIA = Stock of Items Attended. SIR = Stock of Items Requested.

b) Number of worker training

* 100

WT: Worker Training.

CW = Capacitated Workers. TW = Total Workers.

c) Decrease in activities

* 100

DA = Decrease in Activities.

AKW = Activities in Kanban Warehouse. TAGW = Total activities in General

Warehouse.

d) Visual Control of Kanban System Items

* 100

VCI = Visual Control of Items.

NIE = Number of Inspections Executed. TSI = Total Scheduled Inspections

E. Just in time

It is a work philosophy that establishes the way in which a production system should be perfected. The premise is to manufacture products in precise quantities and times, ensuring maximum quality so that they are ready to be sold or used by the next stage of production [12] [16].

## 3. PRODUCTIVDAD

Productivity is a crucial performance indicator at all economic levels, from industrial environments to commercial enterprises and the economy as a whole. It refers to the efficiency in the use of resources, linking the quantity of inputs, especially labor and capital [10]. Therefore, it is essential to measure effectiveness and efficiency, for which the following formula is used:

a) Quantity of products

Efficacy= ()x 100

b) Reduction of hours

Efficiency = ()x 100

## 4. METODOLOGIA

A. Tipe of invetigation

The type of research conducted was applied, as it aimed to solve the problem of low productivity in the food company. As mentioned by Hernández R. and Mendoza C

[17] applied research involves the prior identification of a problem and seeks to apply knowledge from different specialized areas to address specific needs, offering solutions to problems in social or productive sectors.

B. Level

The level of research applied was explanatory. In agreement with Ruiz C. and Valenzuela M. [18] this approach seeks to understand the why of phenomena, establishing cause-and-effect relationships. It focuses on identifying the underlying reasons for the causes and the consequences affecting the variable under study.

C. Method

The method used was observational, as it allowed the observation of the phenomenon in its natural form. According to Hernández R. and Mendoza C. [17] this approach involves the organized and precise collection of information through direct observation of phenomena, events, or study subjects.

D. Desing

The design was experimental because Lean Manufacturing tools were applied to increase the productivity of a food entity. As mentioned by Hernández R. and Mendoza C. [17] in an experimental design, controlled and deliberate changes are made to one or more variables with the aim of evaluating their impact on another specific variable of interest.

key information from the documents during the research process.

G. Data análisis technique

The T-Student analysis technique was used to identify the variation of means in dependent samples. For this purpose, the SPSS software was used due to its utility as a computer tool in data analysis in areas such as business.

## 5. RESULTADOS

Below are the results obtained from the application of Lean Manufacturing tools.

A. Results of the Kaizen Application

Fig.1 shows the identification of the problems identified in the cookie company that have been causing poor productivity.

O1-------X O2

Where:

X = Implementation of Lean Manufacturing.

O1 = Observation before Lean Manufacturing implementation.

O2 = Observation after Lean Manufacturing implementation.

E. Population and sample

The population was a food company in the city of Huancayo. Similarly, the sample consisted of the production processes, and the sampling method used was non- probabilistic convenience sampling. Cohen N. and Gómez

G. [19] mention that the population refers to a group of human beings or objects that share similar characteristics. Additionally, Bernal C. [20] states that the sample is a representative portion of the total population to be studied. Hernández R. and Mendoza C. [17] explain that convenience non-probabilistic sampling selection is based on accessibility and convenience, rather than following a random or probabilistic method.

F. Data collection technique

The technique employed was the observation of the production processes of the food company. In agreement with Ruiz C. y Valenzuela M. [18] who state that observation involves carefully examining a phenomenon with an analytical approach, with the purpose of obtaining the maximum amount of impartial information possible. Additionally, the documentary analysis technique was used, which allows for the systematic review and evaluation of written documents with the aim of extracting relevant information on a specific topic.

The instrument used was the observation sheet for recording data on the production processes of a food company. As mentioned by Cohen N. and Gómez G. [19] the observation sheet is a research tool that facilitates the organized recording of data collected during an observational study because it helps structure and systematize the information obtained during the research. Additionally, analysis sheets were used to collect and record.

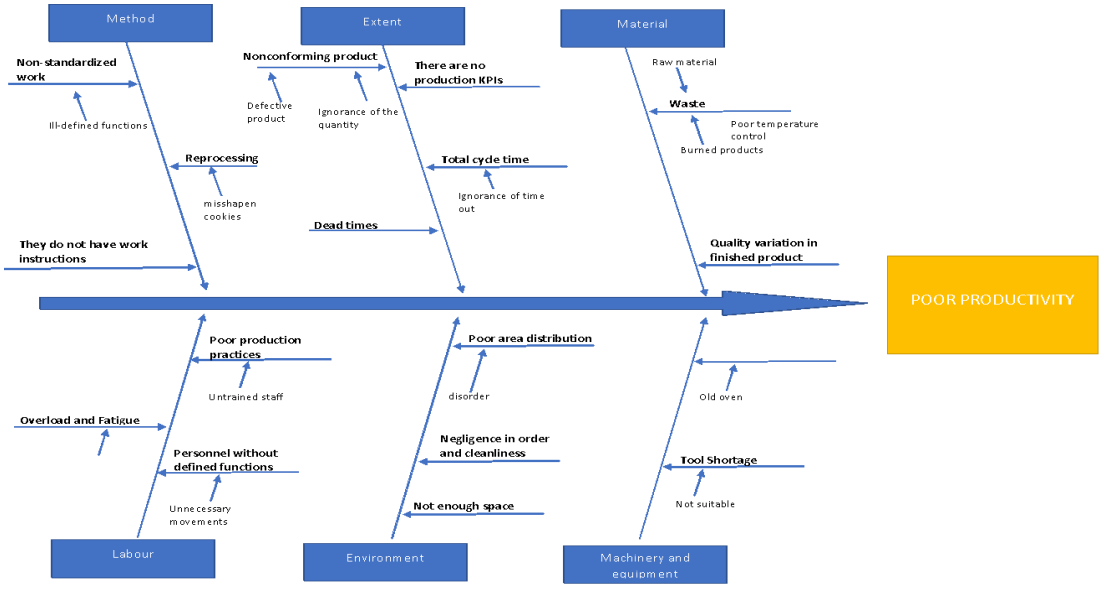



Figure 1. Ishikawa Diagram

In Fig. 2 the Value Stream Map is depicted, illustrating the transformation of raw materials into the final product, in this case, cookies. Firstly, the raw materials are ordered from wholesale stores, with an average daily of 70 bags of flour. Once the raw material arrives at the warehouse, it is transferred to the dosing area, followed by the mixing and kneading process, rolling, baking, cooling, and finally, packaging. Subsequently, the finished product is loaded onto the potential customer's vehicle for its corresponding distribution.

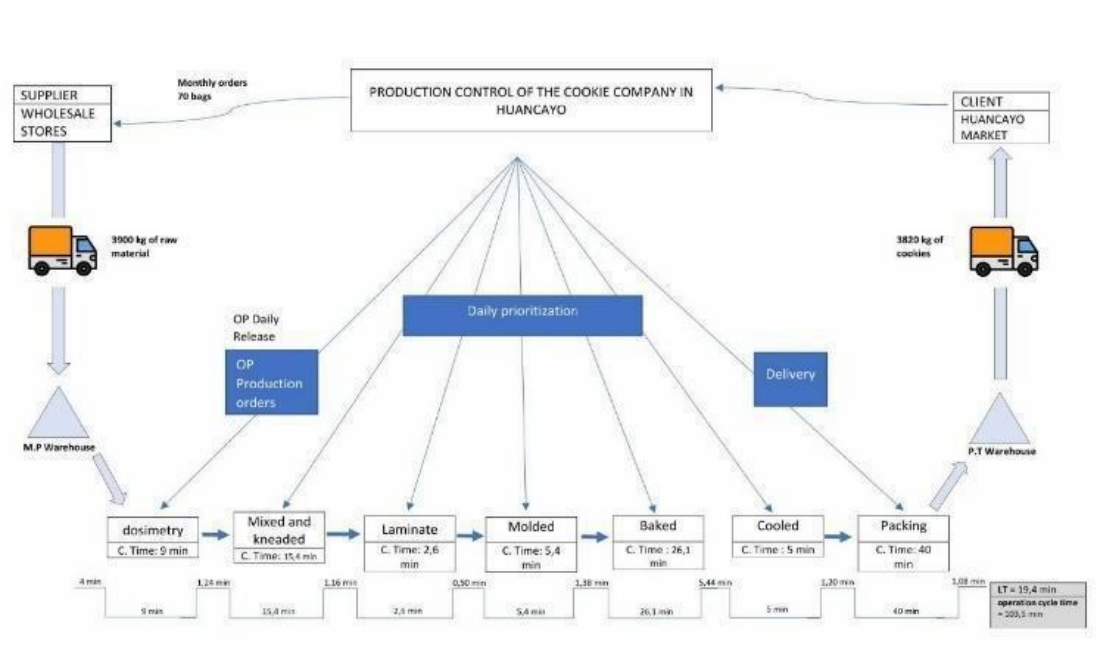



Figure 2. Value Flux Map.

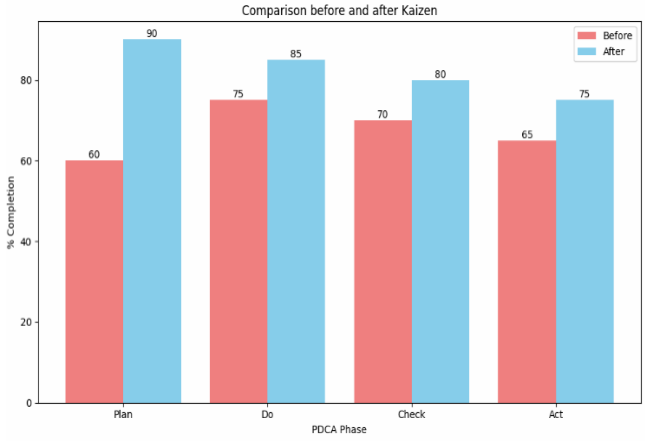



Figure 3. pPaDrtCAo

compliance of the phases of the PDCA cycle (Plan, Do, Check, Act) before and after the implementation of Kaizen. Before implementation, the compliance percentages in the Plan,

Do, Check, and Act phases were 60%, 75%, 70%, and 65% respectively. After implementation, these percentages significantly increased to 90%, 85%, 80%, and 75% respectively. These results indicate that the implementation of Kaizen has improved effectiveness and efficiency in all stages of the PDCA cycle, suggesting an overall improvement in process management and the quality of work performed at the cookie company in the city of Huancayo. These results are consistent with the study by Vargas et al. [21], where it was evidenced that applying Kaizen resulted in an improvement in manufacturing time by up to approximately 2 hours.

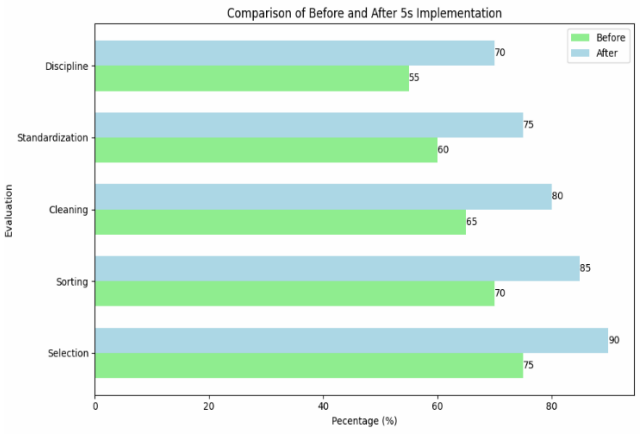



Figure 4. Percentage of Compliance of the 5'S

In Fig. 4, the percentage compliance of the 5'S (Sort, Set in Order, Shine, Standardize, and Sustain) before and after the implementation of the 5'S methodology is presented. The data reveal significant improvements in all areas after implementation: the compliance percentage increased from 75% to 90% in Sort, from 70% to 85% in Set in Order, from 65% to 80% in Shine, from 60% to 75% in Standardize, and from 55% to 70% in Sustain.

These findings suggest that the 5'S methodology has had a positive impact on compliance and process organization, resulting in improved quality and productivity. These findings align with Bravo [22] cuya investigación aplicó las 5'S como parte del Lean whose research applied the 5'S as improvements in the following stages: Sort increased from 25% to 64%, Shine from 20% to 56%, Standardize from 21% to 58%, Sustain from 22% to 57%, and finally, Set in

Order from 21% to 58%. The similarity between this study and Bravo [22] is because both focus on the application of methodologies related to Lean Manufacturing, specifically the 5'S. Both investigations share the objective of improving organization and efficiency in the work environment, demonstrating the relevance and effectiveness of these practices in optimizing processes and increasing productivity despite being carried out in different business contexts.

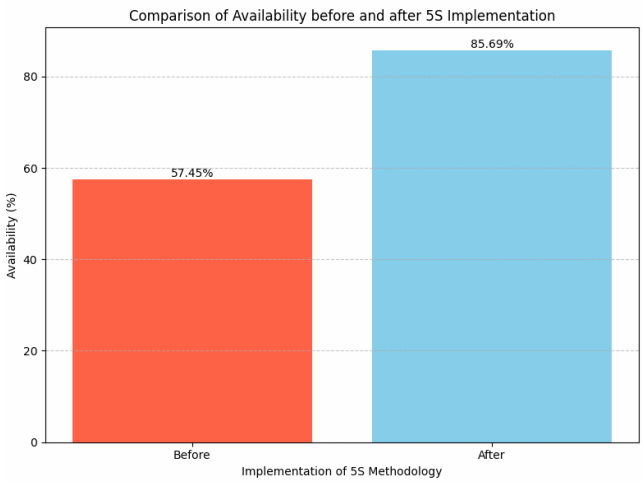



Figure 5. Percentage of Availability of the 5'S.

In Fig.5, it can be observed that before the implementation of the 5'S methodology, the availability was 57.45%. This means that, on average, during the planned working time, approximately 57.45% of the time was being effectively used in the execution of planned activities, while the rest of the time was lost due to various types of waste, such as downtime, rework, waiting, among others. The increase in availability suggests that downtime and waste were reduced, leading to a better utilization of planned working time.

C. Results of TPM (Total Productive Maintenance) application

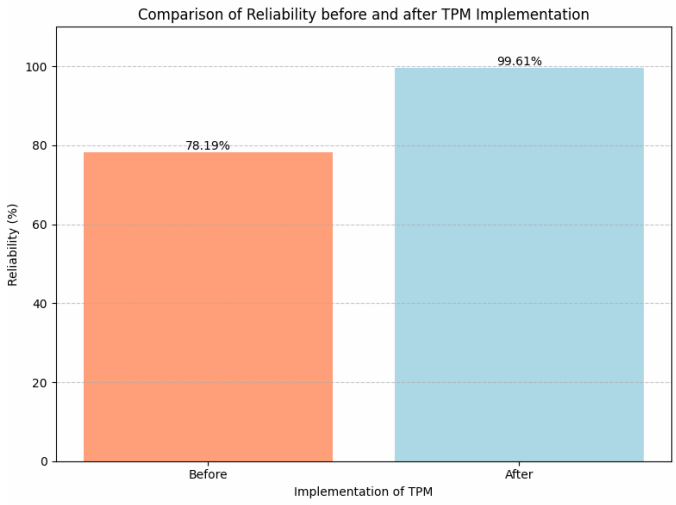



Figure 6. TPM Application.

In Fig. 6, it is observed that the implementation of TPM has been effective in increasing the process reliability from 78.19% to 99.61%, resulting in higher efficiency and reduced downtime. This can lead to a significant improvement in productivity and the quality of the final product. This finding is similar to the study by Canahua [23], where it was evidenced that

the implementation of TPM increased the performance factor from 76.68% to 93.34%. The similarity with the study by Canahua [23] is that both studies demonstrate the effectiveness of TPM in improving the efficiency of production processes. In both cases, the implementation of TPM resulted in significant increases in performance and reliability indicators, highlighting the importance of this methodology in optimizing production and minimizing downtime, with the consequent positive impact on productivity and the quality of the final product.

D. Resultados de la aplicación Kanban

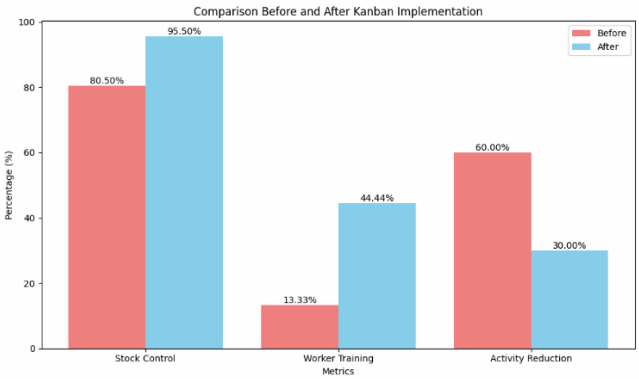



Figure 7. Kanban Application

In Fig. 7, a significant improvement in stock control and worker training is shown after the implementation of Kanban, while the reduction in activities experienced an increase. The level of stock control increased from 80.5% to 95.5%, indicating better inventory management. Worker training also improved significantly, increasing from 13.33% to 44.44%, suggesting a greater investment in personnel development. Additionally, the reduction in activities decreased from 60% to 30%, indicating a decrease in the activities or processes involved after the implementation of Kanban. These results suggest a positive impact on stock control, worker training, and activity reduction. These findings are similar to those of Lazarte et al. [24], quienes en su estudio aplicaron Kanban como herramienta de Lean y lograron mejorar el cumplimiento de los pedidos dentro del plazo establecido.

The similarity between both studies is due to the fact that both employ Lean Manufacturing tools to optimize production processes. In both cases, the implementation of Kanban has proven effective in improving management, highlighting the usefulness of this methodology for increasing efficiency and customer satisfaction.

E. Just in time (JIT)

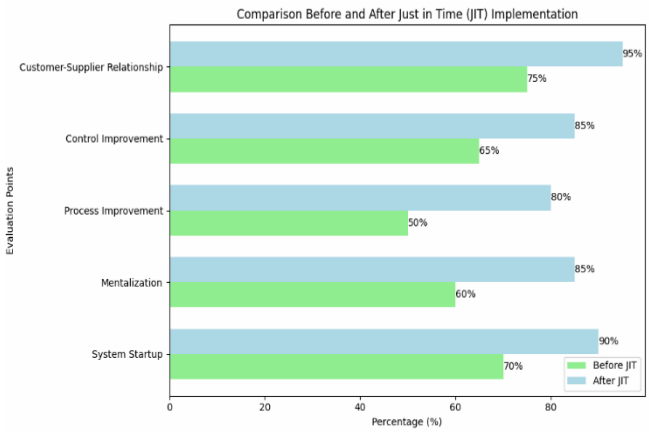
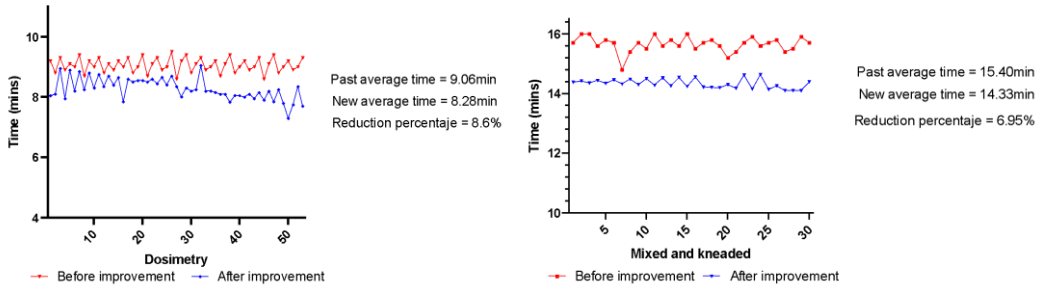



Figure 8. JIT Application

According to Fig. 8, a significant improvement is shown in all evaluation points after the implementation of Just in Time (JIT). For instance, system startup time increased from 70% to 90%, indicating enhanced efficiency in initiating operations. Mindset also improved from 60% to 85%, suggesting a deeper understanding and commitment to JIT principles by the personnel. Furthermore, processes and control experienced substantial enhancements from 50% to 80% and from 65% to 85%, respectively, indicating an overall optimization in operation management and supervision. Lastly, the customer-supplier relationship rose from 75% to 95%, implying increased collaboration and efficiency in the supply chain. These findings signify a positive and widespread impact of JIT implementation on various aspects of the company's operation.

F. Productivity results



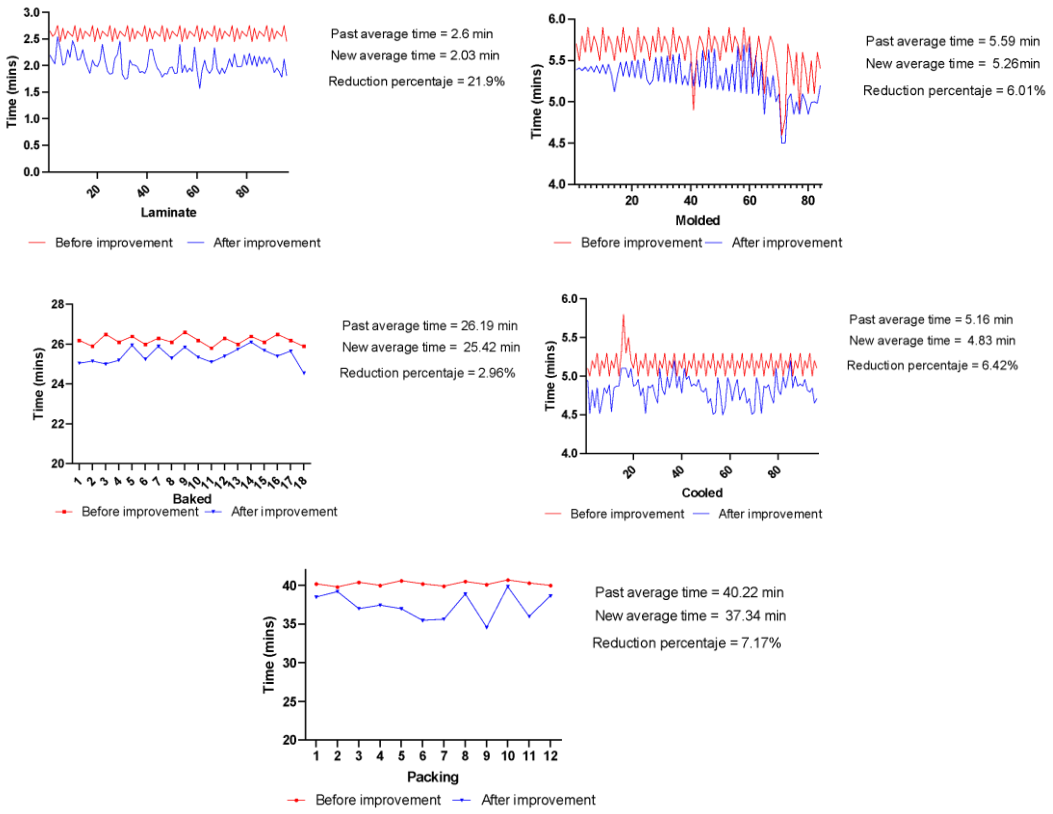



Figure 9. Assessment of Time Before and After Implementation

Fig. 9 illustrates that following the implementation of Lean Manufacturing, there was a noticeable reduction in the processing times for each stage of cookie production. This directly influenced the company's productivity and, consequently, its profitability.

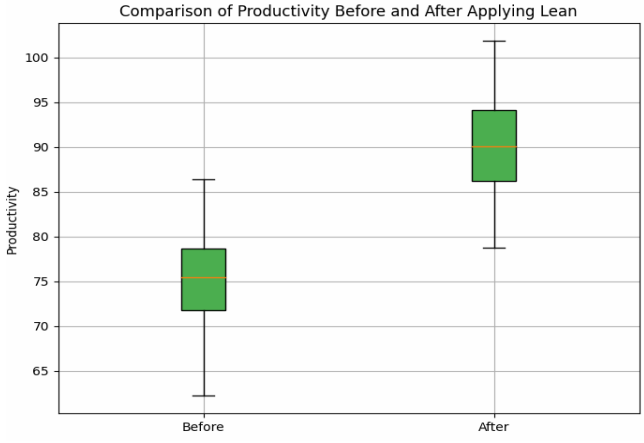



Figure 10. Productivity Increase

The productivity efficiency reached 87%, w[2h]ile effectiveness stood at 84%. Furthermore, significant differences are observed between the means of the evaluated productivity data (75% before and 89.9% after), indicating a 14.9% increase in productivity, as depicted in Fig. 10. This finding is reinforced by the Student's t-test, with a p-value of 0.000, confirming that the implementation of L[3e]an influences the company's productivity.

These findings are consistent with results from other studies. For instance, Mulugeta L.'s study [25] foun[4d] a 16.66% increase in productivity after implementing continuous improvements. Similarly, Edwin R. et al. [26], reported a 19.1% increase in productivity following Lean Manufacturing implementat[i5o]n. Additionally, Ortiz J. et al.'s study [27] identified a 20% increase in productivity after implementing Lean Manufacturing. Finally, results are akin to those[6]of Huaroc C. and Quispe J. [28], who discovered a 134.91% increase in company production after applying Lean.

The resemblance between our study's findings and previous research can primarily be attributed to [7th] e overall effectiveness of Lean Manufacturing in enhancing productivity and operational efficiency across various industrial contexts. This suggests that, regardless of specific differences in implementation and application context, Lean Manufacturing tends to yield consistent results in terms of productivity increments. Moreover, it is plausible that previous studies and ours have employed similar methodologies and assessed productivity in comparable ways, further bolstering the validity and reliability of the obtai[n9e] d results.

## 6. Conclusion

The implementation of various continuous improvem[1e0n]t methodologies, such as Kaizen, 5S, TPM, Kanban, and JIT, has proven effective in increasing efficiency and productivity in different areas of an organization. [1B1]y applying Kaizen, significant improvements were achieved in adhering to the Plan-Do-Check-Act phases, while 5S contributed to better organization and discipline in the workplace. TPM demonstrated an increase in process reliability, whereas Kanban and JIT resulted in notable improvements in inventory control, staff training, and overall operational efficiency. Collectively, these initiatives have led to a significant 14.9% increase in productivity following the implementation of the Lean approach in the organization. These results underscore the importance of adopting a holistic approach to continuous improvement to achieve sustainable enhancements in the company's performance and competitiveness.

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