

Lean Six Sigma for the Optimization of the Operations Area of a Microenterprise in the Alcoholic Beverage Sector

María Alexandra Sarmiento Díaz

Faculty of Industrial Engineering, University of Lima
Lima, Perú
20171453@aloe.ulima.edu.pe

Valeria Velazco Collantes

Faculty of Industrial Engineering, University of Lima
Lima, Perú
20171668@aloe.ulima.edu.pe

Abstract

Nowadays, the efficiency of a company's processes and productivity are critical factors for it to stand out in its field. A methodology that has been highly effective for this purpose is Lean Six Sigma, which is based on data analysis to reduce time, eliminate waste, and enhance product quality. The objective of this study was to design and implement an improvement proposal for the operations area of a microenterprise in the alcoholic beverage sector through the tools of Lean Six Sigma. To develop the proposal, the DMAIC cycle was taken as a reference. The main problem of the company studied was the excessive amount of time that did not add value to the final product. This has resulted in a high lead time, inefficiency in the process, waste of resources, and, consequently, losses for the company. The implemented tools allowed for a 44% reduction in cycle time and a 29% increase in productivity in the operations area. The value of this study lies in the fact that the methodology and tools applied can serve as a guide for future Lean Six Sigma case studies in other micro-enterprises and sectors, benefiting researchers and professionals.

Keywords

Lean Six Sigma, DMAIC, Operations, lead time

1. Introduction

In an increasingly competitive business environment, companies are constantly looking for ways to improve their processes and maximize efficiency. In Peru, microenterprises play a crucial role in the economy. According to the Ministry of Production (2021), 96% of all formal Peruvian companies are microenterprises, which generate a significant portion of the country's employment. However, many of these organizations, especially in Peruvian provinces, have not yet adopted management tools, which limits their growth potential and competitiveness. Álvarez (2018) did research on microenterprises from Cusco. She argues that sustainable development has not been achieved in many microenterprises in this city, given that a critical factor for this lies in the application of appropriate management tools. Unfortunately, despite the fact that 300,000 companies are created each year in Peru, two-thirds of these companies also cease to exist annually. This high rate of companies closing annually is also evident in the city of Cusco, despite its real GDP growth from 2008 to 2013 being higher than that of China, Panama, and India. In addition, the government has implemented initiatives to support the development of companies through program promoters and public-private partnerships, employing various tactics such as business expansion, training, financing, and industrial support. However, management in a company plays a crucial role, as it determines whether there will be successful results.

The Lean Six Sigma methodology, which combines elimination of waste and reduction of variability, is presented as an effective solution to optimize processes, reduce waste, and improve business management. In the context of a microenterprise, the application of Lean Six Sigma not only seeks to optimize production but also to train workers to perform their tasks efficiently and to engage staff in the pursuit of continuous improvement to meet growing demand and contribute to strengthening the company's market position. This article will examine how this methodology has been applied to the case of an alcoholic beverage microenterprise in Cusco, including the challenges encountered and the results achieved.

1.1 Objectives

The primary purpose of this research is to design and validate a proposal for the application of Lean Six Sigma to increase the productivity of the operations area in a micro-enterprise of alcoholic beverages in Cusco.

In addition, it is intended to reduce the variability of the operations area process, design indicators to measure the impact of the application of Lean Six Sigma and identify the aspects that favor the application of Lean Six Sigma in micro-enterprises. The results obtained should bring greater profitability to the company and contribute to future research where the Lean Six Sigma methodology is applied in micro-enterprises or companies in the alcoholic beverages sector.

2. Literature Review

For several years, the use of continuous improvement models has increased mainly based on the concept of improving quality, productivity, reducing waste and increasing strategic performance (Drohomeretski et al., 2014). One of them is Lean Six Sigma, which is the fusion of two methodologies: Lean and Six Sigma. Lean focuses on reducing cycle time to deliver the product to the customer in less time, eliminating activities that do not add value (Dossou et al., 2020); while Six Sigma focuses on reducing the variability of system inputs by identifying the causes of errors or defects in the processes to eliminate them (Ketan and Nassir, 2016). The two philosophies guide improvements and employ different mindsets; however, both share the objective of optimizing process performance, enhancing product value, and enhancing customer satisfaction. Lean Six Sigma, hereafter LSS, is a model not only to be applied in large companies, but also in medium and small ones, as demonstrated by the study by Felizzola and Luna (2014), where it is considered that the application of the LSS methodology benefited the SME under study, since it highlighted the necessary elements to plan and make changes that allowed focusing on improvements in processes, reducing cycle time and eliminating waste.

2.1 Lean Six Sigma

The research found on LSS focuses primarily on the Latin American context, mainly in Brazil, Ecuador and Colombia, since the company chosen in this study is in a similar context. However, there is also research from Turkey, Vietnam, the United Kingdom and Mexico. Likewise, there is both empirical and theoretical background to obtain different approaches to the concepts, methodologies, tools and applications of LSS.

Lean Six Sigma Concept

In the research carried out by Al-Rifai (2024), he indicates that LSS is a critical administrative method that is based on understanding the facts by analyzing data and knowledge to increase productivity, focusing on eliminating defects through improvements in the production process. This concept is complemented by Byrne et al. (2021), who state that the methodology addresses and improves the understanding of the processes by providing tools to effectively identify and implement corrective actions for the root cause of the problems. Simultaneously, Tjahjono et al. (2010) indicate that it could shorten product delivery times by decreasing the total production cycle time, in addition to reducing process variation by offering standardized methods. To achieve this, LSS employs a six-grade scale (1 to 6), where grade 6 represents the highest level of quality (Subirá et al., 2019).

Principles of Lean Six Sigma

Smetkowska and Mrugalska (2018) state that the LSS philosophy is based on fundamental principles focused on customer requirements and needs, making decisions based on accurate data, cooperation and participation of all those involved, continuous improvement and effective management. Similarly, in the study by Chugani et al. (2017) on Lean and Six Sigma methodologies, it is stated that both have principles to deal with quality management and operational activity problems as soon as they are identified. These conclusions are reinforced years later by Timans et al. (2016) in which they point out that both merge the advantages of each and magnify them. However, Powell et al. (2017) found in their literary review of LSS that there is no empirical validity on the fusion between Lean and Six Sigma.

2.2 Other LSS application studies

LSS implementation methodology

LSS uses the DMAIC framework as a work methodology, as demonstrated by different studies carried out in Portugal and Morocco (Costa et al., 2017; Nedra et al., 2019). Similarly, in studies carried out in Ecuador, Brazil and Peru, this same methodology was applied for the continuous improvement and quality of companies (Teran and Alvarado, 2017; Conceição et al, 2019; Mejia and Rau, 2019). According to the studies, the framework must go through 5 stages to implement LSS: define, measure, analyze, implement and control. However, the survey carried out by Felizzola and Luna (2014) uses 4 phases that consist of preparing the company with actions that guarantee the conditions for successful implementation, defining the improvement focuses and projects, executing where the DMAIC framework is used and finally the evaluation of results.

Applied cases of LSS

Given the success of LSS development and application in organizations, it is essential to adapt this method to the specific characteristics of small and medium-sized companies to achieve positive results. In the study by Felizzola and Luna (2014) they implement LSS in a small company that manufactures wooden furniture where a positive impact was obtained in the operational and financial aspects, however, critical factors were considered such as the interrelation of LSS with the company's strategy, the capabilities to manage projects, commitment of management and workers, training. Likewise, other applied cases such as that of Terán and Alvarado (2017) and Daroczi et al. (2020) obtained improvements such as the reduction of defective products and the cycle time of the processes and Gutiérrez et al. (2017), in which the methodology is applied to identify the most relevant problems and opportunities for improvement, as well as to generate greater customer satisfaction.

2.3 Background of the Case Study

This case study investigates the production process of the sweet anise liqueur line of the company Flor de Anis S.R.L., located in the city of Cusco. It was founded eight years ago, starting with a single type of aniseed; however, it now offers four types of drinks and plans to launch two more in 2026. Its main clients are two wholesale companies responsible for distributing products in the city of Cusco, the region's provinces, and other cities in Peru. The star product produced by Flor de Anis is dry anise liqueur and sweet anise liqueur, which come in two presentations: 750 ml and 250 ml bottles.

As a micro-enterprise with an artisanal process and no specific control points, it presents some challenges which will be explored in this article.

3. Methods

The research consisted of a case study with a pre-test and post-test design, where observations and records were taken both before and after the implementation of the Lean Six Sigma program in the company to measure its impact on productivity. The research carried out was of an applied type, as it focused on solving practical needs and problems using the theoretical knowledge obtained from the literature review.

On the other hand, the scope of this research work was exploratory and descriptive, since it is aimed at examining and describing the phenomena and events of the case; it is not intended to establish a relationship between variables (Behar, 2008). Likewise, the approach is qualitative, as it focuses on studying an individual case that is representative not from a statistical standpoint, but for its unique qualities. Additionally, the results obtained were reported using qualitative tools and were refined as the research progressed.

The methodological proposal is based on the DMAIC cycle, which consists of 5 stages (Define, Measure, Analyze, Improve, and Control). Additionally, a preliminary preparation stage was introduced, during which actions were taken to ensure the necessary conditions for successfully implementing LSS in a microenterprise, as certain factors were identified that could hinder the process. Table 1 below summarizes what was done in each phase and the techniques and tools used (Hernández, 2014).

Table 1. Methodological proposal

| Stage | Scope | Techniques | Tools |
|---------|---|--|---|
| Prepare | Training in LSS of the team involved | In-person training | Visual presentation |
| | Obtain the commitment of management and workers to provide us with information and actively participate in the process | Interview | Simulation Game Printed material |
| | Define project activities, roles and responsibilities | Work Breakdown Structure | Gantt Diagram |
| Define | Know and describe the process | Interview | Interview Guide Process Activity Diagram Process Operations Diagram |
| | Identify waste and activities that do not add value | Process Mapping | VSM (initial), Spaghetti Diagram (initial) |
| | Identify customer needs | Customer profiling | CTQ Tree, Voice of Customer |
| Measure | Measure the current variation of the process and define the product specification limits | Statistical Process Control | Control Charts, Process Capability Index (Cpk) |
| | Measure the times of each operation and identify downtime | Time Study | Record Format (standard time, cycle time) |
| Analyze | Identify the main problem of the process | Problem Prioritization | Pareto Diagram |
| | Analyze the root causes of the main problem | Root Cause Analysis | Ishikawa Diagram, 5 Whys |
| Improve | Propose creative solution alternatives to address the root causes found | Collaborative generation of ideas | Brainstorming |
| | Select and prioritize solutions based on 3 criteria: Positive impact for the organization, effort required, and potential risks | Error Prevention Methods | Poka-Yoke |
| | | Project Prioritization | Impact, Effort and Risk Matrix |
| Control | Analyze the indicators obtained after implementing the improvement to validate the effectiveness and sustain the results. | Analysis and comparison of indicators | VSM, Spaguetti Diagram, Control Charts, Capability Index, Record format (final) |
| | Monitor the measured indicators and observe whether non-value-added times or the number of defects has been reduced. | Quality Control and Process Efficiency | Check sheets (data record and process times) |
| | Set new quality standards after the improvement project. | Quality control | Product data sheet |

A pre-test and post-test were conducted to compare the results and assess the behavior before and after applying the methodology. For the study, four dimensions of the study topic on the efficiency of the company's operations area were considered, in addition, the control of the tests was carried out with reference indicators of the authors Evans and Lindsay (2010) and Tetteh and Uzochukwu (2015), which consider essential indicators of the Six Sigma methodology as such and process quality control. Table 2 shows the dimensions and indicators of this study.

4. Data Collection

The research was conducted in a microbusiness located in the city of Cusco, Peru, which produces three varieties of artisanal liquors. For the implementation of the LSS methodology, the area of operations where the production of the anise liquor line is carried out was considered. The process of this product was chosen for the study because it represents nearly 80% of the total bottles produced by the company. Below is the data collected at each stage of the project.

4.1. Prepare

To avoid resistance to change among employees and managers, a pre-DMAIC cycle phase was implemented. During this phase, staff were informed about the importance of applying the methodology and promoting a culture of continuous improvement to achieve good results. Visual materials and printed brochures were used, and a "snippet" exercise was conducted. The objective of this exercise is to demonstrate how waste in a process affects efficiency and productivity. The materials used were scissors, paper, and a stopwatch. The steps of the exercise are explained below:

1. Preparation: Participants were divided into two teams and provided with scissors and a set of instructions to cut specific shapes out of paper.
2. First Round: Each team must cut the shapes following an inefficient process (e.g., using too many motions, not organizing their workspace properly, etc.). The time taken was recorded.
3. Analysis: After the first round, each team was asked to analyze their process and discuss the challenges they faced and the waste they identified (waiting, unnecessary movement, etc.).
4. Second Round: The teams were asked to improve their process by applying Lean principles, such as organizing space, reducing movement, and improving workflow, and the time was retaken.
5. Results: Finally, the results were discussed. Each team shared their feelings about implementing the changes and what they learned about the importance of continuous improvement.

This dynamic was very helpful in engaging the operators with the Lean philosophy, promoting their commitment to process improvement.

4.2 Define

To obtain a general view of the area and processes studied, an operations diagram of the process was made. This is shown in Figure 1. The process begins with the reception of the alcohol in the mixing tank, where it is mixed with water, sugar, and anise in the quantities necessary for the production batch. Then, the liquor goes to the filtering section, where the operation is carried out using 1-micron filters placed in columns. At the exit of the filters, the liquor is bottled, and an operator carries out a visual control, discarding bottles that contain liquor with impurities. The corks are then placed in the bottles and labeled. Afterwards, another operator cleans the outside of the bottle while again inspecting that it does not contain impurities; if so, the bottle is discarded. Finally, the bottles are placed in boxes of 12 units and stored in the finished product warehouse.

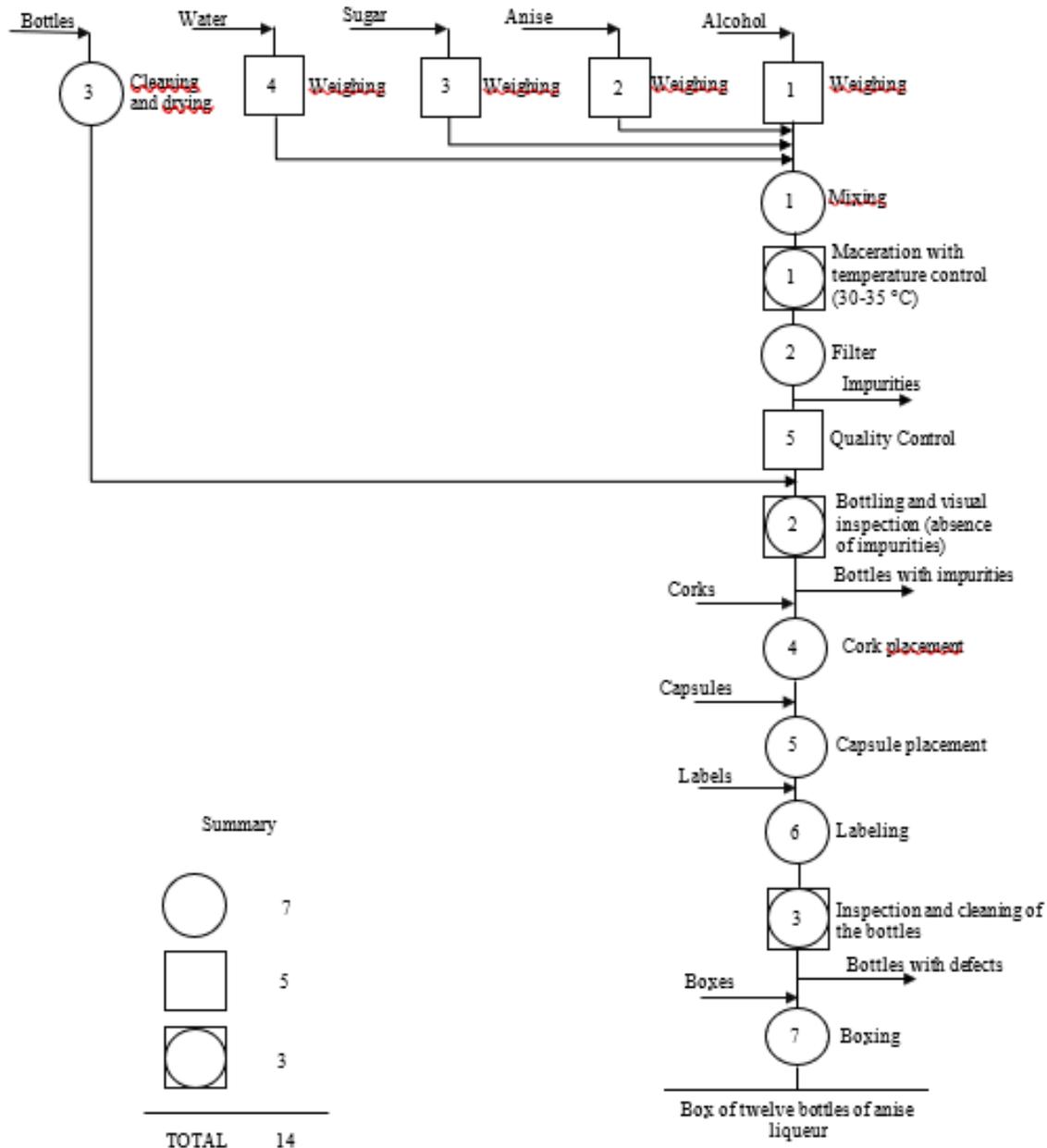


Figure 1. Anise Liquor Process Operations Diagram

To create the diagram, an interview was conducted with managers and operators. The production process at the plant was also observed during a workday. The following problems were identified during the interview and visit to the plant:

- Limited capacity to meet high demand: Inability to respond to sales peaks (e.g., high season or tourist events).
- Unproductive time for operators and machines: In many moments of the week, operators are just waiting for the maceration process to be complete, and machines are not working while operators do the manual process.
- Leaks and losses during bottling: Shortage of alcohol, bottles, or anise at critical moments that halt production.
- Variability in product quality: Differences in flavor, aroma, or alcohol content due to a lack of process standardization.

4.3 Measure

Regarding the first problem mentioned, namely the company's inability to meet demand, it is necessary to identify the bottleneck in the process. To this end, the time required for each stage of the process was measured, and the takt time was also calculated. Furthermore, Figure 2 illustrates the anise liqueur flow chart, while Table 2 presents the calculation of takt time.

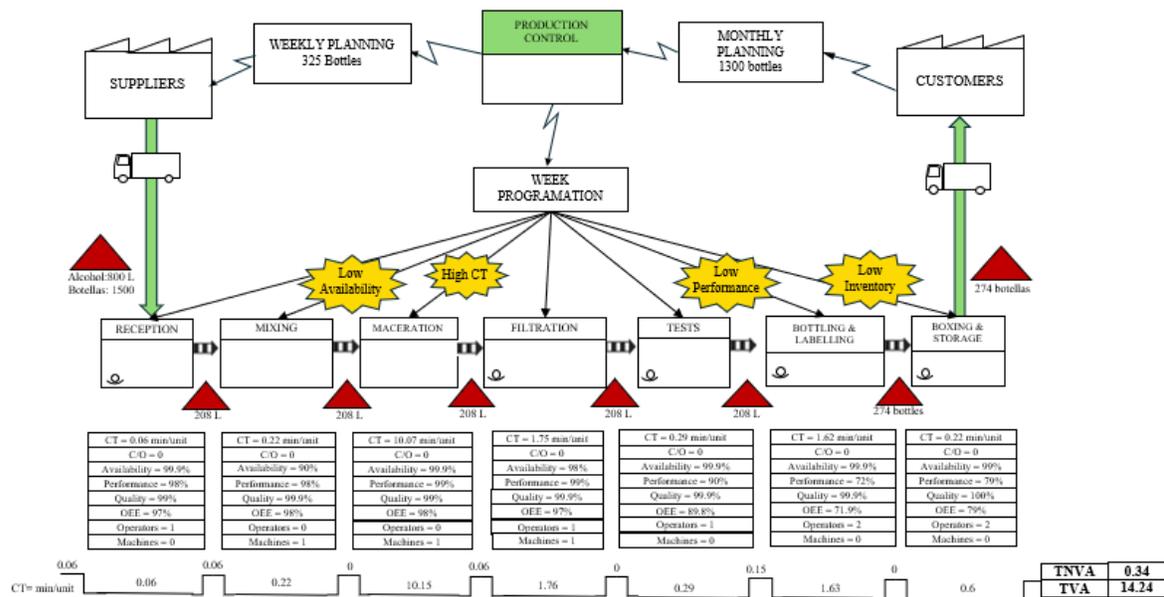


Figure 2. Flow Process Chart

Table 2. Takt Time Calculation

| Variable | Quantity | Unit of measurement |
|------------------------------------|-------------|-----------------------|
| Max monthly demand | 1300 | Bottles/month |
| Working days per month | 22 | days |
| Daily demand | 60 | Bottles/day |
| Shifts per day | 1 | |
| Effective working time per day (h) | 9 | hours/day |
| Effective working time per day (m) | 540 | minutes/day |
| Takt Time | 9.04 | minutes/bottle |

It was identified that cycle time is greater than takt time, which explains why the demand cannot be met, and the bottleneck operation is maceration. This is because two batches are produced weekly, utilizing the full capacity of the maceration tank. However, during the site visits, it was observed that this maceration tank remains idle most of the time. While operators are engaged in other activities, such as filtering, testing, and bottling, this machine can run simultaneously to produce an additional batch per week.

4.4 Analyze

The objective of this phase was to identify the problems that impact the most on the company's results (Table 3). After analyzing the data collected, a Pareto chart was created to prioritize the identified issues (see Figure 3).

Table 3. Problems Prioritization

| Problem | Annual Incidence Ratio (Frequency) | Frequency x Economic Impact (\$) | Percentage | % Accumulated |
|--|------------------------------------|----------------------------------|------------|---------------|
| Limited capacity to meet high demand | 12.1% | 66,255 | 55.2% | 55.2% |
| Unproductive time for the operators/machines | 5.1% | 28,000 | 23.3% | 78.6% |
| Leaks and losses during bottling | 3.0% | 16,380 | 13.7% | 92.2% |
| Variability in product quality | 1.7% | 9,333 | 7.8% | 100.0% |

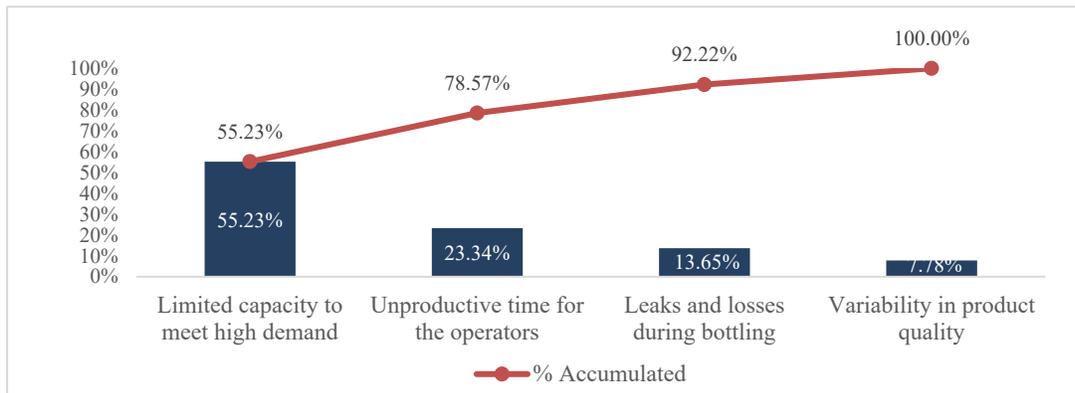


Figure 3. Pareto Chart

As shown in the chart, the problems that currently have the most significant impact on the operations area are the limited capacity to meet high demand and the unproductive time of the operators.

4.5 Improve

Considering the results of the analysis phase, the following solutions were proposed for the most impactful problems:

- chase higher capacity machines Pur
- define a weekly schedule per operator Def
- redistribute the plant layout Red
- apply the 5S methodology Ap

These solutions were then prioritized based on three criteria: positive impact, required effort, and potential implementation risks, using an IER matrix (Table 4).

Table 4. IER Matrix

| Project description | | Impact | | | | Effort | | | | Risk | | | Score | Rank |
|---------------------|---------------------------------------|-------------------|----------------------|--------------------------|--------------|----------|----------|------|--------------|----------------|----------------|-------------|-------|----------|
| | | Capacity Increase | Cycle Time Reduction | Productive Time Increase | Total Impact | Manpower | Economic | Time | Total Effort | Financial Risk | Operative Risk | Total Risk | | |
| Weight | | 35% | 35% | 30% | 100% | 20% | 50% | 30% | 100% | 50% | 50% | 100% | | |
| P1 | Proposal for plant redistribution | 2 | 5 | 4 | 3.65 | 3 | 4 | 3 | 3.5 | 4 | 4 | 4 | 11.2 | 3 |
| P2 | 5S Application | 2 | 5 | 4 | 3.65 | 4 | 5 | 3 | 4.2 | 5 | 5 | 5 | 12.9 | 2 |
| P3 | Weekly schedule per operator | 4 | 2 | 5 | 3.6 | 5 | 5 | 4 | 4.7 | 5 | 5 | 5 | 13.3 | 1 |
| P4 | Purchase of higher capacity machinery | 5 | 1 | 1 | 2.4 | 5 | 1 | 4 | 2.7 | 1 | 3 | 2 | 7.1 | 4 |

The IER matrix evaluates proposals by assigning higher scores to those with greater positive impact, lower required effort, and lower associated risk. In this matrix, we observed that proposals 1, 2, and 3 received high scores and were therefore implemented following the ranking order. It was decided to implement the three proposals with the highest scores to improve the efficiency and organization of the company's production area.

Weekly schedule per operator:

According to the interview, two batches are produced per week; however, there was no weekly production planning. During the visits, it was observed that operators had a large amount of unproductive time, so that the weekly batch count could be increased from 2 to 3 or even 4 batches per week. This is expected to help meet demand during peak months. Therefore, the following weekly schedule is proposed for each operator.

Operator 1

| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|----------|---|--|--|--|--|----------|
| 9-10 am | Weighing and charging ingredients/ Check mixing machine | Transfer to filter/Mixing tank cleaning | Boxing/ Transport to warehouse | Transfer to filter/Mixing tank cleaning | Material reception/ Dispatch of finished products | |
| 10-11 am | Bottle cleaning | Supervise Filtering/Inventory check | Weighing and charging ingredients/ Check mixing machine | Supervise Filtering/Inventory check | | |
| 11-12 pm | | | Bottle cleaning | | | |
| 12-1 pm | | | | | | |
| 1-2 pm | | Lunch | Lunch | Lunch | | |
| 2-3 pm | | Transport to bottling station | Organoleptic and chemical tests | Transport to bottling station | Organoleptic and chemical tests | |
| 3-4 pm | | Bottling and impurity check (both) | |
| 4-5 pm | | Corks & Capsules placement (parallel)/ Transport to labelling area | Corks & Capsules placement (parallel)/ Transport to labelling area | Corks & Capsules placement (parallel)/ Transport to labelling area | Corks & Capsules placement (parallel)/ Transport to labelling area | |
| 5-6pm | | Labels & Inspection (parallel) /Cleaning | |

Operator 2

| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|----------|--------|--|--|--|--|---|
| 9-10 am | | Weighing and charging ingredients/ Check mixing machine | Transfer to filter/Mixing tank cleaning | Boxing/ Transport to warehouse | Transfer to filter/Mixing tank cleaning | Boxing/ Transport to warehouse |
| 10-11 am | | Bottle cleaning | Supervise Filtering/Inventory check | Weighing and charging ingredients/ Check mixing machine | Supervise Filtering/Inventory check | General cleaning of the production area |
| 11-12 pm | | | | Bottle cleaning | | |
| 12-1 pm | | | | | | |
| 1-2 pm | | Lunch | Lunch | Lunch | Lunch | |
| 2-3 pm | | Organoleptic and chemical tests | Transport to bottling station | Organoleptic and chemical tests | Transport to bottling station | |
| 3-4 pm | | Bottling and impurity check (both) | |
| 4-5 pm | | Corks & Capsules placement (parallel)/ Transport to labelling area | Corks & Capsules placement (parallel)/ Transport to labelling area | Corks & Capsules placement (parallel)/ Transport to labelling area | Corks & Capsules placement (parallel)/ Transport to labelling area | |
| 5-6pm | | Labels & Inspection (parallel) /Cleaning | |

Caption:

| |
|---------|
| Batch 1 |
| Batch 2 |
| Batch 3 |
| Batch 4 |

Figure 4. Weekly Schedule

5S's Implementation

The 5S tool was implemented in the operations area to keep all items organized and thus avoid issues such as delays and errors in the process. Below is the proposal for implementing this tool in the company Flor de Anis.

Seiri (Sort): In this stage, a joint effort was carried out with production operators to classify all workshop materials, tools, and items. Items were categorized as functional, repairable, or obsolete/unusable. A visual labeling system was used: red stickers for unusable items, yellow for obsolete ones, and green for recoverable materials. Items in poor condition were formally discarded. Additionally, a temporary quarantine zone was created to store items that are infrequently used, with a defined evaluation deadline. A minimum inventory list was also developed to ensure critical supplies are always available for production.

Seiton (Set in Order): The workspace was reorganized based on the frequency of use of tools and materials, placing them strategically for easy access. Color-coded labels and visual workshop maps were implemented to indicate the location of resources. A shadow board system was also installed for the most-used tools, allowing for quick identification of any missing items. These measures helped reduce search times and improve process flow.

Seiso (Shine): A structured weekly cleaning plan was established, including desks, shelves, equipment, cabinets, and common areas. Zones were assigned cleaning responsibilities, so each operator became responsible for a specific location. Visible checklists were posted in the work areas, and a report log was introduced to record issues such as leaks, equipment wear, or safety risks observed during cleaning routines.

Seiketsu (Standardize): With the support of workers, clear labels and signage were placed on workstations, machines, and storage areas. Visual standards were defined for each workshop zone, including reference photos of how each area should look under optimal conditions. A practical printed 5S guide was created for employee access, and a system of rotating monthly roles was implemented to oversee compliance with standards.

Shitsuke (Sustain/Discipline): To maintain long-term improvement, self-discipline was promoted through regular 5S self-evaluations using a structured form. Additionally, brief monthly team meetings were scheduled to gather suggestions, review progress, and reinforce commitment. A visual performance indicator system (rated 1 to 5) was introduced for each zone, along with a symbolic recognition program to highlight the worker or area with the best performance in order and cleanliness. Hands-on refresher workshops were also planned every 3 to 6 months to reinforce the methodology's principles.

Plant Redistribution:

A Spaghetti diagram was created to analyze the movement of operators within the work areas, identifying unnecessary movements and zones with high traffic. In this case, Figure 4 (initial diagram) shows that the area marked with a star had the highest level of congestion, increasing the likelihood of incidents. Figure 5 (final diagram) shows the proposed layout, which eliminates unnecessary transport routes.

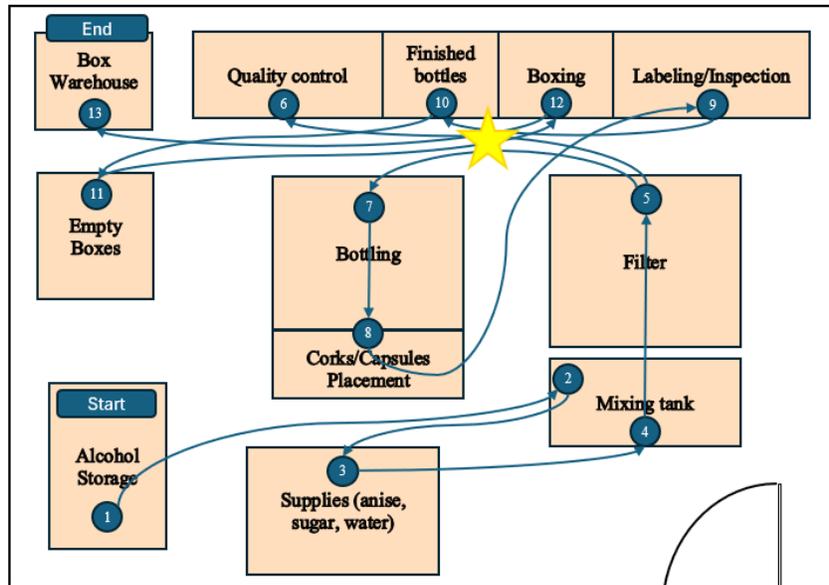


Figure 4. Initial Distribution

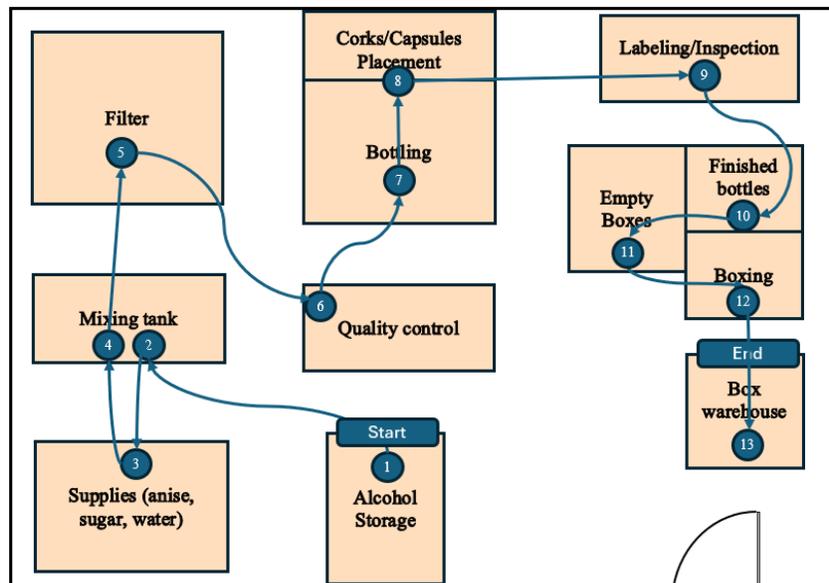


Figure 5. Plant Redistributi

4.6. Control

After implementing the proposed improvements from the previous stage, a control plan was developed to monitor the indicators defined during the measurement phase, to validate the impact of the implemented improvements. As shown in the following Table 5, lead time is the indicator with the highest percentage of improvement, at 15%, followed by productivity with an 8% increase. This confirms that the improvements implemented in the company yielded positive results.

Table 5. Indicators Post Test

| Indicator | Pretest | Post Test | % improvement |
|-----------------------|----------------------|---------------------|---------------|
| Productivity (weekly) | 272 bottles | 350 bottles | +29% |
| Time No Added Value | 0.34 minutes/bottle | 0.12 minutes/bottle | -5.9% |
| Time Adds Value | 14.24 minutes/bottle | 8.01 minutes/bottle | -44% |
| Cycle Time | 14.58 minutes/bottle | 8.13 minutes/bottle | -44% |

5. Conclusions

Implementing Lean Six Sigma in the operations of a small alcoholic beverage business proved highly beneficial. By applying the DMAIC cycle, we identified key issues that impacted productivity, including wasted time and insufficient production to meet demand. With targeted improvements—such as establishing a weekly schedule for operators, reorganizing the plant, and implementing the 5S methodology—we were able to reduce cycle time by 44% and increase productivity by 29%.

These outcomes demonstrate that even smaller companies with limited resources can effectively implement continuous improvement techniques if they tailor the approach to their specific situation. Plus, having staff involved and fostering a culture of ongoing improvement were crucial to the project's success. The results of this study can serve as a valuable guide for other microenterprises seeking to improve their processes. They can also lay the groundwork for future research on Lean Six Sigma in similar environments.

Based on what we found and analyzed, here are a few recommendations to keep the improvements going and make them scalable:

- Set up a simple monitoring system with control charts and dashboards to keep an eye on key metrics like lead time, productivity, and DPMO. This way, any process issues can be spotted early, helping maintain the gains made.
- Create standardized work instructions for every stage of production and ensure all operators receive proper training and refresher courses. This will help reduce quality variations and maintain consistency, particularly as the business grows or adds new products.
- Expand the Lean Six Sigma approach to other areas like inventory management or distribution. Taking a broader view can create synergies between departments and better prepare the company to handle increased demand or enter new markets.

References

- Alcaide Muñoz, C., & Gutierrez, L. Six Sigma and organisational ambidexterity: A systematic review and conceptual framework. *International Journal of Lean Six Sigma*, 8(4), 00–00, 2017, <https://doi.org/10.1108/IJLSS-08-2016-0040>
- Al-Rifai, M. H. *Lean Six Sigma: Una hoja de ruta DMAIC y herramientas para la implementación exitosa de mejoras*. Productivity Press, Taylor & Francis, 2024, <https://doi.org/10.4324/9781032688343>
- Álvarez Mantilla, S. S. *Gestión empresarial y competitividad para el desarrollo sostenible de las pequeñas y medianas empresas del ámbito alimentos en el centro arqueológico de la ciudad de Cusco* (Tesis de licenciatura). Universidad Inca Garcilaso de la Vega, 2018, <https://hdl.handle.net/20.500.11818/4076>
- Behar Rivero, D. S. *Metodología de la investigación* (A. Rubeira, Ed.). Sharlom, 2008.
- Byrne, B., McDermott, O., & Noonan, J. Aplicación de la metodología Lean Six Sigma a una planta de fabricación farmacéutica: Un estudio de caso. *Processes*, 9(3), 550, 2021, <https://doi.org/10.3390/pr9030550>

- Chugani, N., Kumar, V., Garza-Reyes, J. A., Rocha-Lona, L., & Upadhyay, A. Investigating the green impact of Lean, Six Sigma and Lean Six Sigma: A systematic literature review. *International Journal of Lean Six Sigma*, 8(1), 7–32, 2017, <https://doi.org/10.1108/IJLSS-11-2015-0048>
- Conceição, R. S., Gama, R. C., & Santos, J. P. Lean Six Sigma: Implementation of improvements to the industrial cost management. *Independent Journal of Management & Production*, 10(1), 131–151, 2019, <https://doi.org/10.14807/ijmp.v10i1.996>
- Costa, L. B. M., Godinho Filho, M., Fredendall, L. D., & Ganga, G. M. D. Lean, Six Sigma and Lean Six Sigma in the food industry: A systematic literature review. *Trends in Food Science & Technology*, 82, 122–133, 2018, <https://doi.org/10.1016/j.tifs.2018.10.002>
- Daróczy, M., Tran, T.-A., Luu-Nhan, K., & Rajab, G. The use of Lean Six Sigma tools in the improvement of a manufacturing company – Case study. *Production Engineering Archives*, 26(7), 36–41, 2020, <https://doi.org/10.30657/pea.2020.26.07>
- Dossou, P.-E., Pereira, R., Salama, C., & Chang, J. J. How to use lean manufacturing for improving a healthcare logistics performance. *Procedia Manufacturing*, 51, 1657–1664, 2020, <https://doi.org/10.1016/j.promfg.2020.10.232>
- Drohmeretski, E., Gouvea da Costa, S. E., Pinheiro de Lima, E., & Garbuio, P. A. Lean, Six Sigma and Lean Six Sigma: An analysis based on operations strategy. *International Journal of Production Research*, 52(3), 804–824, 2014, <https://doi.org/10.1080/00207543.2013.842015>
- Evans, J. R., & Lindsay, W. M. *Managing for quality and performance excellence* (8th ed.). Delmar Cengage Learning, 2010.
- Felizzola Jiménez, H., & Luna Amaya, C. Lean Six Sigma in small and medium enterprises: A methodological approach. *DYNA (Colombia)*, 81(184), 62–69, 2014, <https://doi.org/10.15446/dyna.v81n184.39769>
- Hernández Sampieri, R., Fernández Collado, C., & Baptista Lucio, P. *Metodología de la investigación* (6ª ed.). McGraw-Hill Interamericana, 2014.
- Ketan, H., & Nassir, M. Aluminium hot extrusion process capability improvement using Six Sigma. *Advances in Production Engineering & Management*, 11(1), 59–69, 2016, <https://doi.org/10.14743/apem2016.1.210>
- Mejía Carrera, S., & Rau Álvarez, J. Análisis y propuesta de mejora para la implementación de herramientas de manufactura esbelta en la línea de confecciones de una empresa textil. In *Proceedings of the 17th LACCEI International Multi-Conference for Engineering, Education, and Technology*. Latin American and Caribbean Consortium of Engineering Institutions, 2019, <https://doi.org/10.18687/LACCEI2019.1.1.106>
- Ministerio de la Producción. *Decreto Supremo N.º 013-2013-PRODUCE: Definición de características de la micro, pequeña y mediana empresa en Perú*. Gobierno del Perú, 2013, <https://www.gob.pe/institucion/tuempresa/noticias/898863-micro-y-pequenas-empresas-representan-el-99-2-del-tejido-empresarial-peruano>
- Nedra, A., Yassine, C., Néjib, S., & Morched, C. A new Lean Six Sigma hybrid method based on the combination of PDCA and DMAIC to improve process performance: Application to a clothing SME. *Industria Textil*, 70(5), 459–466, 2019, <https://doi.org/10.35530/IT.070.05.1595>
- Powell, D., Strandhagen, J. O., Tommelein, I. D., Ballard, G., & Formoso, C. T. A new set of principles for Lean production. *Proceedings of the 25th Annual Conference of the International Group for Lean Construction (IGLC25)*, 413–420, 2017, <https://doi.org/10.24928/2017/0266>
- Smętkowska, M., & Mrugalska, B. Using Six Sigma DMAIC to improve the quality of the production process: A case study. *Procedia – Social and Behavioral Sciences*, 238, 590–596, 2018, <https://doi.org/10.1016/j.sbspro.2018.04.039>
- Subirá Conceição, R., Pariz, M. C., de Genaro Chirolí, D. M., & Velozo, F. Lean Six Sigma: Implementation of improvements to the industrial cost management. *Independent Journal of Management & Production*, 10(6), 2023–2045, 2019, <https://doi.org/10.14807/ijmp.v10i6.929>
- Tetteh, E. G., & Uzochukwu, B. M. *Lean Six Sigma approaches in manufacturing, services, and production*. IGI Global, 2014, <https://doi.org/10.4018/978-1-4666-6477-9>
- Terán, P., & Alvarado, A. Mejoramiento de la competitividad en empresas PYMES del Ecuador aplicando Lean Six Sigma: Caso de estudio. *Gaceta Sansana*, 4(1), 5–18, 2017.
- Tjahjono, B., Ball, P., Vitanov, V., Scorzafave, C., Nogueira, J., Calleja, J., Turner, C., Araujo, C., & Srivastava, A. Six Sigma: A literature review. *International Journal of Lean Six Sigma*, 1(3), 216–233, 2010, <https://doi.org/10.1108/2040146101107501>

Biographies

María Alexandra Sarmiento Díaz holds a bachelor's degree in industrial engineering from Universidad de Lima, Peru (2022), graduating in the top 20% of her class. She is currently pursuing a diploma in Leadership and Strategy in the Era of Artificial Intelligence at the University of Navarra and holds a certificate in Executive Talent Development from Universidad de Piura. Her professional experience focuses on designing and implementing process improvement and operational efficiency projects, applying Lean Six Sigma principles and tools. She has led initiatives in resource optimization, predictive modeling, and the automation of performance reporting. She has contributed to the development of resource allocation and client distribution models that enhance productivity and maximize profitability, as well as to benchmarking analyses aimed at identifying opportunities for improvement and cost reduction. Her work combines data analysis with strategic planning to deliver sustainable, result-oriented solutions.

Valeria Velazco Collantes holds a bachelor's degree in industrial engineering from Universidad de Lima, Peru (2022), where she graduated in the top 10% of her class. She currently serves as Pricing Manager at Banco de Crédito del Perú (BCP), leading initiatives to optimize pricing strategies and profitability. She previously served as Deputy Manager of Pricing and Projects at BCP and worked as a *Pricing & Revenue Management Analyst* at Belcorp, where she contributed to the design of pricing strategies and revenue management in highly competitive markets. During her academic years, she was actively involved at CEDICE, Universidad de Lima, holding positions such as Deputy Director of Finance and Management, General Coordinator, and Coordinator of Studies and SME Incorporation, gaining valuable experience in project management and organizational leadership. Her career combines expertise in pricing, revenue management, innovation, and operational efficiency, with a strong focus on strategic decision-making to achieve sustainable results.