1st World Congress on Industrial Engineering and Operations Management
October 9-11, 2024
Publisher: IEOM Society International, USA DOI:10.46254/WC01.20240040
Published: October 09, 2024

A Lean Manufacturing Case Study: Enhancing Efficiency and Reducing Waste in Latin American Food Production

Alexandra Katherine Rojas-Valverde
Bachelors in industrial engineering
Facultad de Ingeniería, Universidad de Lima, Peru
20171356@aloe.ulima.edu.pe

Claudia Alexandra Muñoz-Briceño
Bachelors in industrial engineering
Facultad de Ingeniería, Universidad de Lima, Peru
20163362@aloe.ulima.edu.pe

Abstract

The biscuit manufacturing sector in Latin America, particularly in Peru, plays a significant role in the region's economy by contributing to the GDP and providing employment opportunities. However, the sector faces challenges such as low production efficiency, high waste levels, and frequent product defects, impacting profitability and competitiveness. Addressing these issues is crucial for sustainability and growth. This study proposed a Lean Manufacturing-based model incorporating Poka Yoke, Center lining, and Total Productive Maintenance (TPM) to enhance production efficiency and reduce waste. The model focused on preventing and correcting production defects, standardizing and controlling key operational parameters, and maximizing equipment effectiveness through preventive and predictive maintenance. Key findings from the model's implementation showed significant improvements in production efficiency. The Overall Equipment Effectiveness (OEE) increased from 83% to 86.7%, machine availability improved to 95.1%, the performance rate reached 95%, and the quality rate of finished products rose to 95.9%. Additionally, the scrap rate was reduced from 15% to 4%, demonstrating the model's effectiveness in addressing the sector's critical challenges. The academic and socioeconomic impact of this research is significant. The model offers a practical solution to improve efficiency and reduce waste in biscuit manufacturing, contributing to Lean Manufacturing literature and benefiting companies and consumers in Latin America. This study encourages further research to integrate advanced technologies with Lean Manufacturing principles to drive continuous improvement and innovation in the biscuit manufacturing sector.

Keywords
Lean Manufacturing, Efficiency Improvement, Waste Reduction, Food Industry, Production Optimization.

Introduction
The biscuit manufacturing sector is a significant contributor to the economy of Latin America, including Peru, playing a crucial role in the region's GDP and providing employment opportunities (Ventura 2023). Biscuit companies in Latin America are integral to the manufacturing sector, driving economic growth and industrial development (Goda et al. 2021). The growth of this industry has been essential for the region, contributing to economic stability and employment (Diao et al.2019). The presence of biscuit manufacturers in Latin America, particularly in Peru, is vital for the economic fabric of the region (Grinberg 2022). These companies not only foster economic growth but also shape the industrial landscape of the region (Lebdioui et al. 2020). Despite the importance of biscuit manufacturers in Latin

America, these companies encounter various production challenges that affect their efficiency and profitability. One of the primary issues these manufacturers face is the low efficiency of production lines, leading to high levels of waste and inefficiencies (Mercado et al. 2019).

These inefficiencies result in increased costs due to product defects, reducing competitiveness in the market (Blyde & Fentanes 2019). Additionally, high levels of unproductive time during production further compound the challenges faced by biscuit manufacturers, impacting their overall productivity and profitability (Rodríguez 2022). These challenges, including waste, product defects, and unproductive time, pose significant obstacles to the sustainability and growth of biscuit manufacturing companies in Latin America (Porras-Arena & Román 2023). Addressing these production challenges is crucial for the long-term success and competitiveness of biscuit manufacturers in the region (Cordero & Rodríguez 2022). Resolving the production challenges faced by biscuit manufacturers in Latin America is crucial for the sustainable growth of the industry and the overall economy. By enhancing production line efficiency and reducing waste, companies can improve their competitiveness and profitability (Alderman & Goodwin 2022). Addressing issues such as product defects and unproductive time can result in cost savings and enhanced product quality, benefiting both companies and consumers (Langer 2024). Moreover, optimizing production processes can drive innovation and technological advancement within the industry, positioning biscuit manufacturers as market leaders (Yakovlev 2022). Successfully overcoming these production challenges can have wide-ranging effects, benefiting individual companies and contributing to the economic development of Latin America (Pariza 2024).

Despite the significance of addressing production challenges in the biscuit manufacturing sector, there is a notable gap in the literature regarding effective solutions to these issues. Current research lacks comprehensive studies proposing practical methodologies to enhance production efficiency and reduce waste in biscuit manufacturing companies in Latin America (Baquero et al. 2023). To address this gap, this research aims to develop a production model based on Lean Manufacturing principles, incorporating tools such as Poka Yoke, Centerlining, and Total Productive Maintenance (TPM) (Jung & Melguizo 2022). By utilizing these Lean Manufacturing tools, companies can streamline their production processes, minimize defects, and optimize resource utilization, leading to improved efficiency and profitability (Reisman 2022). This research seeks to contribute to the existing knowledge by offering a practical and effective model for tackling the production challenges faced by biscuit manufacturers in Latin America, ultimately fostering sustainable growth and competitiveness in the industry (Aquino-Rojas et al.2022).

2. Literature Review

2.1 Lean Manufacturing in the Production Process of Biscuit Manufacturers

Lean manufacturing, a methodology focused on waste reduction and continuous improvement, has been widely applied in various industries, including the food sector. Research by Olu-Lawal (2024) emphasizes the global prominence of Lean Manufacturing, derived from the Toyota Production System, for its principles centered on efficiency enhancement. This methodology has been instrumental in improving productivity and customer satisfaction, as highlighted by (Goshime et al. 2019), who developed a new conceptual model based on identified gaps in existing research. Furthermore, the integration of Lean Manufacturing with Industry 4.0 technologies has been explored by (Kumar et al. 2023), showcasing the potential for simplified and decentralized structures to enhance operational strategies.

In the context of biscuit manufacturing or similar industries, the application of Lean Manufacturing principles has shown significant promise. Bouhannana (2023) demonstrated in a study in Morocco the positive impact of lean practices on both operational and environmental performance within the food supply chain. Additionally, Silva & Warnapura (2021) conducted research in the Sri Lankan food industry, confirming the substantial positive influence of Lean Manufacturing practices on operational and business performance. These studies collectively underscore the effectiveness of Lean Manufacturing in enhancing efficiency and overall performance within the food manufacturing sector.

2.2 Implementing Poka Yoke Methodology in Biscuit Production

Poka Yoke, a methodology aimed at error-proofing processes, has also found relevance in the manufacturing sector. In the context of biscuit production or similar industries, the application of Poka Yoke principles can significantly enhance quality and efficiency. Dănuţ-Sorin et al. (2021) discussed the various tools associated with Lean Manufacturing, including Poka Yoke, emphasizing their role in ensuring error prevention and process improvement. Moreover, the study by Ghaithan et al. (2021) highlighted the impact of Industry 4.0 and Lean Manufacturing on sustainability performance, showcasing how innovative technologies can be integrated to enhance operational processes. The integration of Poka Yoke methodology in biscuit manufacturing processes aligns with the industry's continuous pursuit of quality improvement and error reduction. By implementing error-proofing mechanisms, companies can streamline their production processes and minimize defects. This approach not only enhances product quality but also contributes to overall operational efficiency and customer satisfaction.

2.3 Center lining Methodology in Enhancing Production Processes of Biscuit Manufacturers

Center lining, a methodology focused on optimizing processes for consistent performance, holds significant potential for improving production processes in the biscuit manufacturing industry. While specific studies on center lining in biscuit production may be limited, the broader application of this methodology in manufacturing settings underscores its effectiveness. The study by Ghobadian et al. (2020) examined the interplay between innovation, Lean Manufacturing, and sustainability, emphasizing the need for optimized processes to drive incremental change. In the context of biscuit manufacturing, the implementation of center lining methodology can lead to standardized processes, reduced variability, and enhanced product quality. By identifying and maintaining optimal process settings, manufacturers can achieve consistent output and operational excellence. While further research directly focusing on center lining in biscuit production may be warranted, the principles of this methodology align with the industry's goals of efficiency and quality enhancement.

2.4 TPM Methodology for Improved Production in Biscuit Manufacturing

Total Productive Maintenance (TPM), a methodology focused on maximizing equipment effectiveness, plays a crucial role in ensuring smooth production processes in the biscuit manufacturing industry. While direct studies on TPM in biscuit production may be limited, research in similar manufacturing sectors highlights its significance. Negrão et al. (2019) tested the S-curve theory concerning Lean Manufacturing and business performance, emphasizing the importance of addressing infrastructural challenges and skilled labor shortages. In the context of biscuit manufacturing, the implementation of TPM principles can lead to enhanced equipment reliability, reduced downtime, and improved overall productivity. By prioritizing proactive maintenance and involving all employees in equipment care, manufacturers can optimize their production processes and achieve sustainable operational performance. While further research specific to TPM in biscuit manufacturing may be beneficial, the broader principles of this methodology align with the industry's focus on efficiency and reliability.

3. Methods

3.1 Basis of the Proposed Model

Figure 1 shows the production model based on Lean Manufacturing philosophy, applied to the cookie production line. This model was designed with the objective of increasing production efficiency through the implementation of three key components. The first component, Poka Yoke, focused on preventing and correcting production defects, ensuring that errors were detected and corrected before affecting the final product quality. The second component, Center lining, concentrated on monitoring and parameterizing the adjustable components of the process, ensuring that machines operated within optimal parameters and reducing variability in production. The third component, Total Productive Maintenance (TPM), aimed to increase machine efficiency through preventive and predictive maintenance, minimizing downtime and improving the operational availability of equipment. Together, these three components integrated a systematic and disciplined approach to continuous improvement, promoting waste elimination and resource optimization in the cookie production process, aligned with the fundamental principles of lean manufacturing.

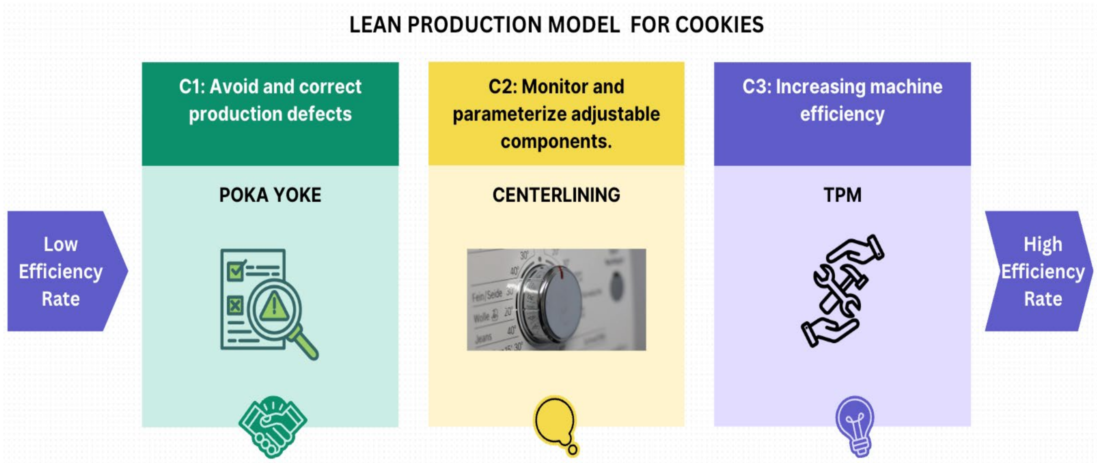

Figure 1. Proposed Model

3.2 Description of the model components

The Lean production model for the biscuit industry proposed in this paper was based on the philosophies and principles of Lean Manufacturing. This approach sought to eliminate waste and improve the efficiency of the production process by integrating three key components: Poka Yoke, Centerlining, and Total Productive Maintenance (TPM). The implementation of these principles has proven effective in various industries, contributing significantly to the existing literature on improvements in quality and operational efficiency. In particular, the model addresses the need to avoid defects in production, monitor and parameterize adjustable components, and increase the efficiency of machines. These practices were aligned with the principles of continuous improvement and error prevention, fundamental pillars of Lean Manufacturing. Through the implementation of this model, a transition from a low to a high-efficiency rate was achieved, optimizing biscuit production and reducing operational costs. The contribution of this study to the literature was to demonstrate the effectiveness of integrating these tools in a specific context such as the biscuit industry.

C1: Avoiding and Correcting Production Defects with Poka Yoke

The first component of the model, Poka Yoke, focused on preventing and correcting production defects from the root. Poka Yoke, meaning "error-proof" in Japanese, was introduced by Shigeo Shingo as a technique to prevent human error in manufacturing processes. In the context of biscuit production, the implementation of Poka Yoke devices allowed the immediate detection of anomalies, preventing defective products from advancing on the production line. This approach not only reduced the amount of waste, but also improved the quality of the final product. Previous studies have shown that applying Poka Yoke in manufacturing environments can significantly reduce defects and improve customer satisfaction (Shingo, 1986). Poka Yoke's integration into the proposed model was based on identifying critical points in the production process where errors were most likely and implementing simple but effective mechanisms to prevent such errors.

C2: Monitoring and Parameterization of Adjustable Components by Center lining

The second component of the model, Centerlining, involved monitoring and parameterization of the adjustable components of the production process. Centerlining is a technique used to standardize and control key operational parameters, ensuring that processes are kept within specific limits to avoid variations and defects. In biscuit production, this meant establishing and maintaining optimal parameters for critical variables such as oven temperature, cooking time and ingredient mixes.The literature has extensively documented the benefits of centerlining for process stability and variability reduction (Montgomery, 2012). The implementation of this technique in the proposed model allowed for greater consistency in product quality, reducing the need for rework and waste. The use of statistical process control (SPC) tools was crucial for continuous monitoring and identification of deviations that could affect production.

C3: Increasing Machine Efficiency by TPM

The third component of the model, Total Productive Maintenance (TPM), focuses on increasing machine efficiency. TPM is a comprehensive methodology that seeks to maximize equipment efficiency through a preventive and predictive maintenance approach. This methodology was developed in Japan and has been widely adopted in various industries for its ability to reduce machine downtime and improve overall productivity. In the context of biscuit production, TPM implementation included operator training in basic equipment maintenance, regular preventive maintenance planning and the use of predictive monitoring techniques to anticipate and prevent failures. Literature has shown that TPM can significantly increase the operational efficiency and life of equipment (Nakajima, 1988). In the proposed model, TPM contributed to greater machine availability and reliability, resulting in smoother production and fewer interruptions.

The Lean production model for the biscuit industry, based on Poka Yoke, Centerlining, and TPM, presented an effective integration of tools that, when applied together, offered substantial improvements in the efficiency and quality of the production process. The contribution of this study to existing literature focused on practical demonstration of how these principles can be adapted and applied in a specific context to achieve significant results. Reducing defects, standardizing critical parameters, and improving machine efficiency were key achievements that highlighted the importance of a holistic and structured approach in implementing Lean Manufacturing.

3.3 Model Indicators

To assess the effectiveness of the proposed storage model, specific metrics were created to monitor and manage its outcomes within the case study. These metrics provided a structured approach to performance evaluation, ensuring that all critical aspects of the production process were comprehensively measured and analyzed. This enabled a detailed assessment of the model's impact on order fulfillment and delivery compliance.

Overall Equipment Effectiveness (OEE): OEE measures the overall efficiency of manufacturing operations, combining availability, performance, and quality rates to provide a comprehensive overview of machine effectiveness.

$$\text{Fill Rate} = Availability \times Performance \times Quality \tag{1}$$

Rate of Availability of Machines: This indicator reflects the percentage of time that machines are available for production, excluding downtime for maintenance or failures.

$$\text{Availability} = \frac{Operating\ Time}{Planned\ Production\ Time} \times 100 \tag{2}$$

Rate of Performance of Machines: This metric measures how well machines perform during operation, comparing actual output to the maximum possible output under ideal conditions.

$$\text{Performance} = \frac{Actual\ Outputs}{Standard\ Outputs} \times 100 \tag{3}$$

Quality Rate of Finished Products: This indicator measures the percentage of products that meet quality standards without requiring rework or rejection.

$$\text{Quality} = \frac{Goods\ units\ produced}{Total\ units\ produced} \times 100 \tag{4}$$

Scrap Rate: Scrap rate indicates the percentage of materials that are wasted or rejected during the manufacturing process, highlighting inefficiencies.

$$\text{Quality} = \frac{Scrap\ Quantity}{Total\ Quantity} \times 100 \tag{5}$$

4. Validation

4.1 Initial Diagnosis

Figure 2 shows the problem tree developed to identify the reasons and root causes affecting the efficiency of the cookie production line in the case study. The philosophical model used is based on breaking down the main problem, low efficiency in the cookie production line, which has an efficiency rate of 83%, below the industry standard of 95%. The economic impact of this inefficiency was estimated at 84,000 PEN annually, equivalent to 5.58% of revenue. At the first level, three main reasons were identified: a high rate of decline (55%), a high rate of defective products (25%), and elevated unproductive times (20%). At the third level, the root causes were further detailed as clogging of cookies in conveyor belt chutes (55%), product fragility (13.5%), inadequate sealing of packaging (11.5%), and conveyor belt failures (20%). This detailed analysis provided a comprehensive understanding of the factors contributing to low efficiency, offering a solid foundation for implementing process improvements aligned with the principles of continuous improvement and waste reduction within the context of lean manufacturing.

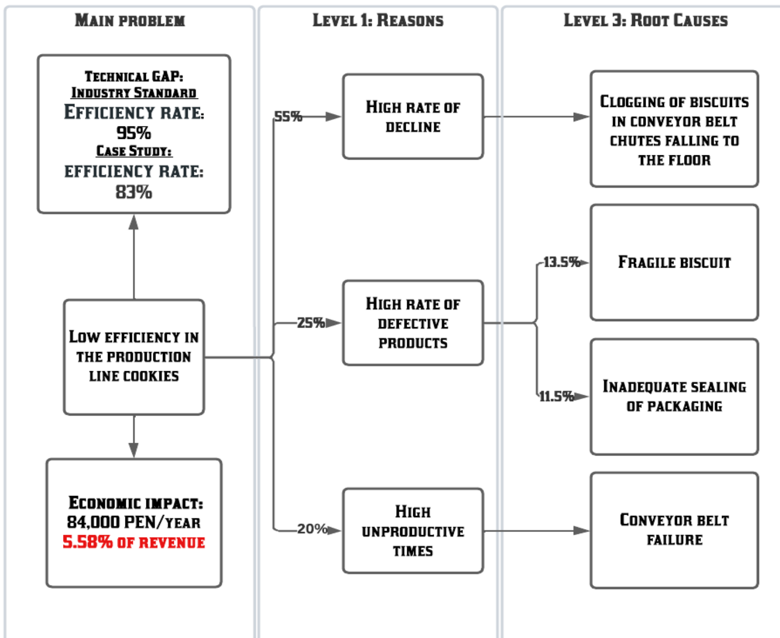

Figure 2. Problem Tree

4.2 Implementation of the model in the case study

Implementation of Component 1: Avoiding and Correcting Production Defects with Poka Yoke

The implementation of Component 1 involved addressing two major issues in the cookie production process: the obstruction of cookies in conveyor channels and the poor design of the primary packaging sealer. The first improvement was changing the design of the guides in the channels to provide more space, preventing obstructions. This change reduced cookie wastage significantly. Additionally, a One-Point Lesson procedure was developed for the proper cleaning and maintenance of these guides. The second improvement addressed the short length of the brush in the primary packaging machine, which caused instability in sealing and cutting the packages, leading to defective products. A new brush, 12 cm longer and made with food-grade specifications, was manufactured and installed. These modifications resulted in a substantial reduction in product defects and waste, with data showing a decrease in cookie wastage from 500 kg per month to negligible amounts and improved sealing efficiency, leading to fewer defective packages. This validated the effectiveness of the proposed Lean production model for cookie manufacturing.

Figure 3 shows the improvement in the design of the gutters in the cookies production line. In the "Before improvement" image, there is an accumulation of cookies in the gutters due to an inadequate guide design, causing blockages and waste. The "After improvement" image displays the enhanced guide design with "Y" shaped corners, preventing blockages and ensuring proper stacking of cookies. This modification significantly reduced product waste and increased the efficiency of the production process.

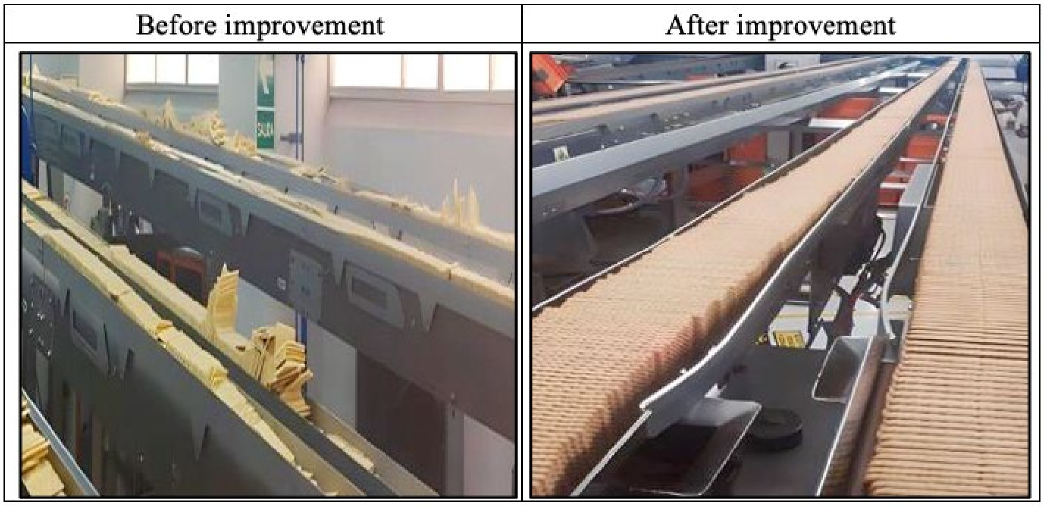

Figure 3. Improvement in the design of the gutters of the cookies production line

Figure 4 shows the improvement of the primary packaging machine squeegee. In the "Before improvement" image, the original squeegee, which is shorter by 15 cm, provided insufficient stability during the sealing and cutting process, resulting in defective packages. The "After improvement" image illustrates the installation of a longer squeegee with a 15 cm extension, designed according to food-grade specifications. This enhanced squeegee provides better grip and stability during the sealing process, significantly reducing the number of defective packages and improving the overall efficiency of the packaging operation.

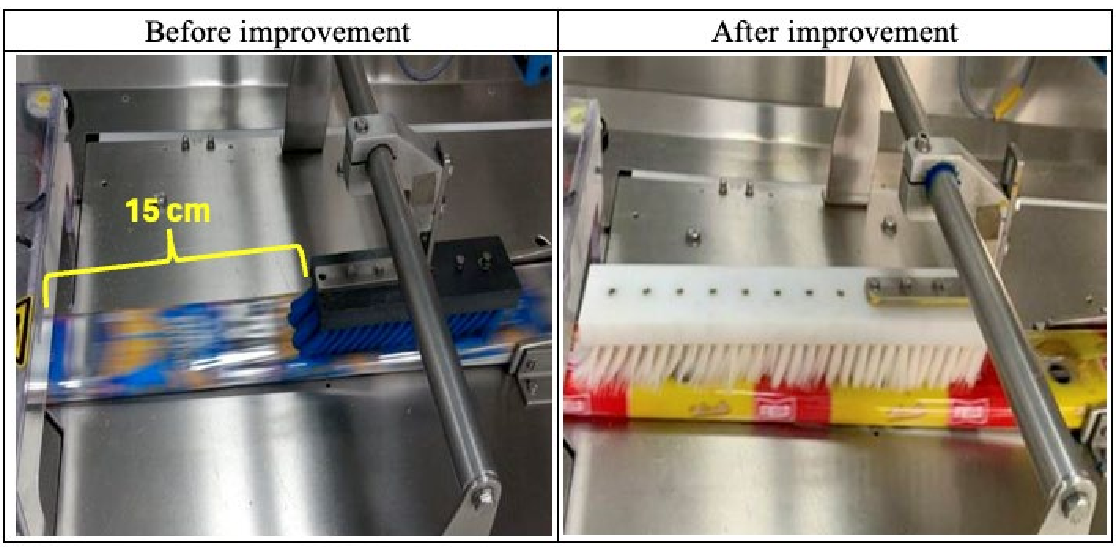

Figure 4. Improved primary packaging machine squeegee

Implementation of Component 2: Monitoring and Parameterization of Adjustable Components by Centerlining

The implementation of Component 2 aimed to address the fragility of the cookies. Initially, operators were trained to measure dough texture using a line texturometer, and an operational procedure for dough texture measurement was developed and deployed. Data on the texture of cookie dough D were collected for one month, and the adjustment parameters for the rollers were compared with the cookie's fragility at the oven exit. As a result, the dough texture parameter was adjusted to a range of 110 to 125 grams force (gf). The optimal roller adjustment parameters were

identified as follows: the first calibrator roller separation set to 215 mm, roller speed to 4.5 m/min, and exit belt speed to 4.5 m/min. The second calibrator roller separation was set to 155 mm with similar speed settings. Finally, the third calibrator roller separation was set to 150 mm with the speed maintained at 4.5 m/min. This systematic approach improved the production process and reduced the fragility of the cookies, ensuring consistent quality.
Table 1 shows the adjustment parameters for the dough rolling roller equipment, focusing on three main rollers.

Table 1. Dough Rolling Roller Equipment Adjustment Parameters

Description	**Centerline**			
	Unit	**LI**	**Target**	**LS**
Separation of gauge rollers 1	mm	210	215	230
Speed of Gauge Roller 1	m/min	4	4.5	5
Output band speed	m/min	4	4.5	5
Separation of gauge rollers 2	mm	150	155	160
Speed of Gauge Roller 2	m/min	4	4.5	5
Output band speed	m/min	4	4.5	5
Separation of gauge rollers 3	mm	145	150	144
Speed of Gauge Roller 3	m/min	4	4.5	5
Output band speed	m/min	4	4.5	5
Pactuala	m/min	1	1.5	2

Implementation of Component 3: Increasing Machine Efficiency by TPM

Component 3 of the implementation included the creation of an autonomous and planned maintenance program to resolve the conveyor belt breakdown. The mechanical drive system on belts 27 and 29 was found to have an accumulation of biscuits and dust due to the lack of an inspection and cleaning checklist by the operators. A weekly checklist was implemented for mechanical drive system inspection activities on all conveyor belts, ensuring that the problem did not recur. In addition, planned maintenance included maintenance of the drive belts, and checking the correct tensioning of the synchronous belts with tensioning equipment. The technical staff was trained in the use of this device and the respective monitoring of this activity was carried out.

Post-implementation indicators showed a significant improvement: line availability reached 95.1%, finished product quality was 95.9%, line throughput reached 95.0% and the shrinkage rate was reduced to 4%. This reflected the fact that the implemented improvements were able to solve problems of scrap, defective products and downtime. The OEE of the biscuit type D production line increased from 83% to 86.7% after the implemented improvement, which showed an improvement in operational efficiency and a reduction of waste and downtime in production.

Figure 5 shows the OEE (Overall Equipment Effectiveness) of the production line after the improvement. In the first quarter, the OEE was 79.6%, increasing to 83.1% in the second quarter and 83.4% in the third quarter. In the fourth quarter, the OEE reached 85.7%, surpassing the 85% target. In the first quarter of the following year, the OEE further increased to 86.7%. These increases reflect continuous improvement in the production line's efficiency following the implementation of the proposed enhancements.

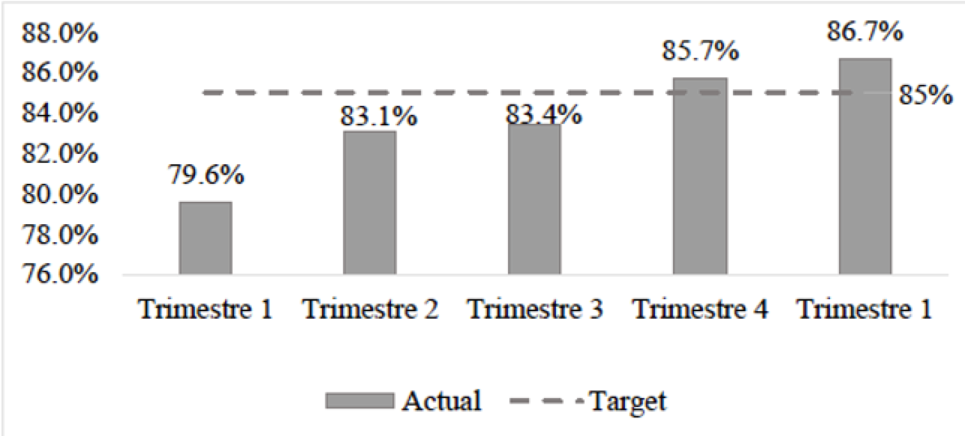

Figure 5. OEE of production line after improvement

5. Results

In Table 2, the key results of the validation of the proposed Lean production model for cookie manufacturing are shown. It was observed that OEE improved from 83% to 86.70%, machine availability from 91% to 95.10%, and machine performance rate from 89% to 95.00%. Additionally, the quality rate of finished products increased from 91% to 95.90%, and the scrap rate decreased from 15% to 4.00%.

Table 2. Results of validation of the proposed model

Tool	Indicator	As-Is	To-Be	Results	Variation
TPM	OEE	83%	95%	86.70%	4.46%
TPM	Rate of availability of machines	91%	95%	95.10%	4.51%
TPM	Rate of performance of machines	89%	95%	95.00%	6.74%
Centerlining	Quality rate of finished products	91%	95%	95.90%	5.38%
PokaYoke	Scrap rate	15%	5%	4.00%	-73.33%

6. Conclusions

The main findings of the study demonstrate that implementing the Lean Manufacturing-based production model, which incorporates Poka Yoke, Centerlining, and TPM, resulted in significant improvements in the efficiency of the cookie production line. OEE increased from 83% to 86.7%, machine availability improved to 95.1%, the performance rate reached 95%, and the quality of finished products rose to 95.9%. Additionally, the scrap rate was reduced from 15% to 4%, indicating a substantial reduction in defects and waste.The importance of this research lies in its ability to address the critical issues affecting the competitiveness and sustainability of the cookie manufacturing sector in Latin America. By improving production line efficiency and reducing waste, companies can achieve significant cost savings and enhance the quality of the final product. This benefits not only individual companies but also positively impacts the regional economy, promoting economic growth and job creation.

This study makes notable contributions to the field of industrial engineering. It provides a practical and effective model for applying Lean Manufacturing principles in the food industry, an area that had been underexplored in existing literature. The integration of Poka Yoke, Centerlining, and TPM not only enhances operational efficiency but also establishes a framework for continuous improvement and sustainability. Thus, this study expands knowledge on the application of Lean tools in specific contexts, offering a holistic approach to addressing production issues.
Final observations suggest that, although the results are promising, further research is needed to explore the integration of advanced technologies such as Industry 4.0 with Lean Manufacturing principles. This could lead to additional improvements in production efficiency and quality. Moreover, it is recommended to conduct longitudinal studies to assess the long-term impact of the proposed improvements and their adaptability to other food industries. The study

also highlights the need to train more personnel in predictive and preventive maintenance techniques to ensure the sustainability of the implemented improvements. In conclusion, this research underscores the importance of adopting innovative and systematic approaches to improve manufacturing efficiency and sustainability, inviting future researchers to continue exploring and expanding these findings.

References

Alderman, J., & Goodwin, G. (Eds.). , The social and political life of Latin American infrastructures. University of London Press, Centre for Latin American and Caribbean Studies, Institute of Modern Languages Research, School of Advanced Study, University of London, 2022. https://doi.org/10.14296/gljm4371

Aquino-Rojas, D., Rodriguez-Paz, E., & Quiroz-Flores, J. , Ergonomic redesign model to reduce musculoskeletal disorders in a cluster of smes in the clothing accessories sector, 2022. https://doi.org/10.18687/laccei2022.1.1.51

Baquero, S., Montes, F., Stankov, I., Sarmiento, O., Medina, P., Slesinski, C., … & Roux, A. (2023). Assembling the puzzle for conducting research through the lens of diversity and cohesion: the salurbal experience. https://doi.org/10.21203/rs.3.rs-2395438/v1

Blyde, J. and Fentanes, O. , The heterogeneous impacts of import competition on mexican manufacturing plants, 2019. https://doi.org/10.18235/0002048

Bouhannana, F. (2023). Application of lean practices in food supply chain: the case of morocco. Advances in Science Technology and Engineering Systems Journal, 8(4), 101-110. https://doi.org/10.25046/aj080412

Cordero, D. and Rodríguez, G. , Merger of network graph indicators to estimate resilience in latin american cities. Ieee Access, 10, 81071-81093,2022. https://doi.org/10.1109/access.2022.3195894

Diao, X., McMillan, M., & Rodrik, D. (2019). The recent growth boom in developing economies: a structural-change perspective., 281-334. https://doi.org/10.1007/978-3-030-14000-7_9

Ghaithan, A., Khan, M., Mohammed, A., & Hadidi, L.,Impact of industry 4.0 and lean manufacturing on the sustainability performance of plastic and petrochemical organizations in saudi arabia. Sustainability, 13(20), 11252, 2021. https://doi.org/10.3390/su132011252

Ghobadian, A., Talavera, I., Bhattacharya, A., Kumar, V., Garza-Reyes, J., & O'Regan, N. (2020). Examining legitimatisation of additive manufacturing in the interplay between innovation, lean manufacturing and sustainability. International Journal of Production Economics, 219, 457-468. https://doi.org/10.1016/j.ijpe.2018.06.001

Goda, T., García, A., & Dominguez, C. ,Sectoral real exchange rates and manufacturing exports: a case study of latin america. SSRN Electronic Journal, 2021. https://doi.org/10.2139/ssrn.3867806

Goshime, Y., Kitaw, D., & Jilcha, K.,Lean manufacturing as a vehicle for improving productivity and customer satisfaction. International Journal of Lean Six Sigma, 10(2), 691-714, 2019. https://doi.org/10.1108/ijlss-06-2017-0063

Grinberg, N.From populism to neoliberalism: the political economy of latin american import-substitution industrialization: argentina, brazil, mexico and colombia in comparative perspective. Latin American Perspectives, 49(2), 183-206,2022. https://doi.org/10.1177/0094582x211063503

Jung, J. and Melguizo, Á. , Rules, institutions, or both? estimating the drivers of telecommunication investment in latin america. Journal of Cyber Policy, 7(1), 5-23,2022. https://doi.org/10.1080/23738871.2022.2034910

Kumar, N., Singh, A., Gupta, S., Kaswan, M., & Singh, M. (2023). Integration of lean manufacturing and industry 4.0: a bibliometric analysis. The TQM Journal, 36(1), 244-264. https://doi.org/10.1108/tqm-07-2022-0243

Langer, E. , New methodologies for a latin american economic history on the 19th century: the south-central andes. RHEAL, 1(I),2024. https://doi.org/10.62467/rheal/01.01.04

Lebdioui, A., Lee, K., & Pietrobelli, C. (2020). Local-foreign technology interface, resource-based development, and industrial policy: how chile and malaysia are escaping the middle-income trap. The Journal of Technology Transfer, 46(3), 660-685. https://doi.org/10.1007/s10961-020-09808-3

Mercado, E., Pierola, M., & Sanchez-Navarro, D. (2019). The impact of import competition from china on firm performance in the peruvian manufacturing sector. https://doi.org/10.18235/0002079

Montgomery, D. C. ,Introduction to statistical quality control (7th ed.). John Wiley & Sons. ISBN: 978-1-118-14681-1,2013.

Nakajima, S. (1988). Introduction to TPM: Total Productive Maintenance. Productivity Press. ISBN: 0-915299-23-2.

Pariza, T. Food safety in latin american informal food establishments. Frontiers in Sustainability, 4,2024. https://doi.org/10.3389/frsus.2023.1325060

Porras-Arena, M. and Román, Á. The correlation between unemployment and economic growth in latin america – okun's law estimates by country. International Labour Review, 162(2), 171-198, 2023. https://doi.org/10.1111/ilr.12398
Reisman, L. Local philanthropy and the transformation of culture in oaxaca, mexico. International Journal of Cultural Property, 29(1), 63-80, 2022. https://doi.org/10.1017/s094073912200008x
Rodríguez, D. (2022). Covid-19 in colombia: repercussions on the economy. Summa Revista Disciplinaria en Ciencias Económicas Y Sociales, 4(1). https://doi.org/10.47666/summa.4.1.04
Shingo, S. (1986). Zero quality control: Source inspection and the poka-yoke system (A. P. Dillon, Trans.). Productivity Press. (Original work published 1985).
Silva, C. and Warnapura, H. ,Impact of lean manufacturing practices on operational and business performance: evidence from sri lankan food industry. Sri Lanka Journal of Social Sciences and Humanities, 1(2), 69-76, 2021. https://doi.org/10.4038/sljssh.v1i2.39
Ventura, M. (2023). An overview of service design education in latin america. https://doi.org/10.3384/ecp203017
Yakovlev, P. The trends changing the economies of latin america. Herald of the Russian Academy of Sciences, 92(S9), S865-S877, 2022. https://doi.org/10.1134/s1019331622150114

Biographies

Alexandra Katherine Rojas-Valverde holds a bachelor's degree in industrial engineering, with expertise in the mining sector, related to commercial sales and marketing processes, continuously committed to enhance growth strategies development for the drilling Peruvian market. She is currently working at a transnational company, specializing in data analysis focused on managing tender's implementation, leading market costs in each of the product lines for better efficient results.

Claudia Alexandra Muñoz-Briceño holds a bachelor's degree in industrial engineering with experience in the retail and operations sector, related to expense control and management. She currently works as a Professional Retail Operations Intern in a Peruvian company specialized in home improvement focused on the Peruvian retail market, looking for the best opportunities to optimize customer satisfaction by accompanying them to have their dream home.