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Original Article

Enhancement of Productivity and Efficiency through a Service Model with Lean Service Tools - Case Study

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Abstract *- This research aims to enhance productivity in the preparation and presentation of hamburgers at an artisanal category restaurant. The goal is to increase productivity and efficiency while reducing reprocessing rates during practice. This article introduces an innovative operational model that integrates Facility Layout Design (FLD), Standardized Work (STW), and autonomous maintenance under the Plan-Do-Check-Act (PDCA) cycle framework to address the suboptimal utilization of workstations and the current layout, as well as the high error rates in the preparation process and the lack of preventive maintenance for the machines involved in the operation. The model is divided into four phases. The first phase consists of diagnosing the initial situation of the company. The second phase encompasses the implementation of Lean Service and FLD tools. Subsequently, a 12-week implementation phase took place. Finally, the implemented improvements were assessed, and pre-and post-implementation indicators were compared. Statistical validation of the improved indicators was performed using Minitab Statistics V21 software. The results confirmed an 18% increase in productivity and a 27% increase in efficiency. Additionally, reprocessing was reduced by 50%. This article serves as a reference for better decision-making for managers and entrepreneurs within the artisanal food cluster seeking to enhance productivity and efficiency and reduce reprocessing rates in similar small and Medium-Sized Enterprises (MSE).*

Keywords *- PDCA, Facility Layout Design, Standardized Work, Autonomous maintenance, Productivity, Rework.*

1. Introduction

In Peru, one of the economic effects stemming from the COVID-19 pandemic has been a growth of 2.68% in the Gross Domestic Product (GDP) compared to the previous year. This increase can be attributed to the development across various market industries, including the gastronomic sector. Within this context, the category of hamburgers stands out, experiencing a 22% rise owing to consumer preference [1].

The most significant issue highlighted in the reviewed literature within the gastronomic industry is productivity-related. Increasing this indicator leads to reduced preparation times. Another problem involves unnecessary worker movements due to inadequate space in line with product demand, leading to bottlenecks and high production costs. A further problematic factor emphasized in the sector is the lack of standardized tasks, directly impacting the final product [2].

Likewise, another contributing factor is the absence of preventive maintenance on the machines involved, as their deterioration affects product preparation. Therefore, for most companies in this industry, measuring productivity, efficiency, and reprocessing across all operational processes is essential, as it reflects product quality and a high level of customer service. From the literature analysis, it has been observed that few studies refer to the application of Lean Service tools in companies of the artisanal gastronomic sector. Therefore, it is necessary to validate the application of these tools to optimize productivity in Small and Medium-sized Enterprises (SMEs) in this gastronomic sector. This would represent the first validation in this specific sector, which could serve as a knowledge base for managers and entrepreneurs within this gastronomic cluster.

Consequently, the objective of this article is to propose the implementation of the Lean Service-FLD methodology in an artisanal hamburger restaurant by combining the tools of facility layout design, standardized work, and autonomous maintenance through the PDCA cycle to enhance indicators of productivity, efficiency, and reprocessing. Given the scarcity of studies on this topic evident in the literature review, there is justification and motivation to present a management model to improve these indicators in small and medium-sized enterprises within the gastronomic sector.

While much of the literature primarily focuses on manufacturing sectors, it is our new model to be adapted as support for application within the service sector. The proposed model will effectively fill the service sector efficiency improvement research gap.

2. Literature Review

The following section provides a literature review of the tools utilized in the management model.

2.1. Facility Layout Design

According to facility layout design, the tool focuses on structuring the location and arrangement of units or sections at the production department level [3]. Other researcher described it as the dilemma of organizing the placement of facilities and determining their location [4].

On the other hand, recent research has determined that FLD is the best method to address facility layout design problems [5]. For this reason, a plant with an inefficient layout can experience adverse effects such as high production costs, low yields, unnecessary delays, and low revenue generation [6].

With FLD, it is possible to analyze the entire layout and improve the production line's performance. This aims to reduce downtime, bottlenecks, and material handling costs and improve the utilization of labour, equipment, and space [7]. A study in the manufacturing industry that combined FLD with standardized work successfully eliminated 66% of unnecessary operator movements and increased production by 63.2%, achieving greater efficiency [8].

Based on previously evaluated case studies, it is demonstrated that facility layout design can address facility layout design problems, reducing unnecessary operator movements and greater efficiency in productivity. Despite the scarcity of studies on FLD, especially in the context of restaurants, the authors' stance does not mention limitations for applying this tool in any service-providing company. From this perspective, confirming and disseminating the benefits of FLD in the restaurant industry is vital.

2.2. Autonomous Maintenance

Autonomous maintenance focuses on enhancing workers' technical skills so they can perform minor activities on equipment while leaving more complex repairs to maintenance specialists [9].

With this, the fundamental purpose of autonomous maintenance is to anticipate defects and failures in the machinery involved in the production process, given the deterioration and lack of cleanliness of its components. All of this is achieved through providing basic principles to operators, such as daily checks, cleaning, replacing essential elements, and making simple repairs, among other actions [10]. Autonomous maintenance is applied in an automotive company that uses milling machinery, achieving a significant reduction of 97% in defective item production and a 10% increase in productivity [11]. Likewise, their application noted other articles where non-conforming products and unforeseen machinery stoppages were an issue. After implementation, efficiency increased by 23% and 36%, respectively, and productivity indicators rose by 25% [12].

According to previous research, the autonomous maintenance tool has been implemented in various organizations across different sectors, yielding noteworthy results. However, there are few studies on its application in the restaurant industry. Despite this, autonomous maintenance offers various advantages to businesses, including increased availability and optimal performance of machinery used in production.

2.3. Standardized Work

STW is a powerful but underutilized strategy for process improvement initiatives. Additionally, STW documents the flow of process activities in sequential tasks, guiding daily execution [13]. The sequence of standardized work is the most accredited approach to acting, offering the operator a clear guide for task execution. Consequently, standardization is critical for maintaining organized and coherent processes [14].

Design work, part of STW, is characterized by increasing process efficiency and productivity through modifications that optimize the workspace. Similarly, area limitations and operator interaction should be considered before making changes to ensure optimal workstation conditions [15].

It was stated that to reduce cycle times and increase efficiency in various tasks, it is necessary to eliminate or adjust non-standardized activities and ensure proper plant distribution [16].

Additionally, it was pointed out that appropriate implementation of the standardized work tool can provide multiple advantages, such as creating a comprehensive learning platform for individuals and organizations, establishing a baseline for continuous improvement (Kaizen method), identifying anomalies and opportunities for progress, enhancing stability and quality of results by referring to process steps sequentially [17].

In this context, it found that implementing STW in an SME dedicated to tire manufacturing reduced the number of defective parts by 97%, translating to a decrease from 230 defective parts to only five elements, in addition to confirming an over 9% increase in productivity, going from 230 parts/h to 255 parts/h.

Another case study executed the standardized work strategy in a chassis production factory, showing process improvements with a 44% reduction in time and a 51% increase in efficiency [18]. Additionally, it asserts that implementing STW reduces variability in tasks performed by operators during the automotive exhaust system manufacturing process, resulting in a 76.35% reduction in inconsistency or error resolution [19]. Consequently, the authors emphasize that standardized work applies to companies of any size, whether small or medium, as it seeks to simplify control, reduce variability, and optimize the quality of operational processes. Furthermore, researchers highlight that despite its origins in a manufacturing environment, there is literature supporting its successful implementation in the service sector.

2.4. PDCA

The PDCA is a tool that can be used to analyze significant problems using various tools and engineering studies to determine and prioritize causes, all to solve them optimally [20]. The application of this tool is made in stages to plan and ensure the most suitable implementation, evaluate achieved results, and determine methods for further improvements. In a study with a bottleneck in a manufacturing company, a significant improvement was achieved in daily production, going from 264 to 304 units, resulting in increased productivity and thus satisfying customer demand [21]. In a case study in the food industry, losses in the sauce were reduced by 86.75%, leading to increased operational efficiency and decreased production costs [22].

The PDCA cycle is divided into four steps. The first is ‘Plan,’ which involves defining the company’s main problems, identifying the causes, prioritizing them, and then developing an action plan with the necessary sequence to achieve the desired objectives. The second step is ‘Do,’ which involves implementing the tools defined in the previous stage and continuously monitoring to ensure proper application [23]. The third step, ‘Check,’ involves executing a pilot with standard methods, team training, and progress monitoring [24]. Finally, the fourth step is ‘Act,’ where the success of tool implementation is verified, which is done through crucial indicators evaluating the ‘As Is’ and ‘To Be’ states [25]. Therefore, it is concluded that the PDCA cycle enables increased productivity and efficiency in operational processes, reducing costs. However, it is highlighted that there is limited research on applying the PDCA cycle to support operational process improvements in companies.

3. Methodology

According to the described sector study, restaurants face various production-related issues that hinder business growth. This is why efforts were made to implement Lean methodologies that suit the needs and ensure the achievement of set objectives. The management model encompasses appropriate tools to address unnecessary operator movements, such as FLD, suboptimal use of workstations, the absence of a standard work diagram for STW, and autonomous maintenance for preventive maintenance management. Table 1 shows the articles that have contributed to the proposed model.

3.1. Proposed Model

The proposed model was based on research covering the methodologies and limitations of using Lean Service-FLD tools. While most articles focus on the manufacturing industry, no restrictions prevent their application in service sector companies. Tools such as Value Stream Mapping (VSM), ABC Analysis, Time Studies, Line Balancing, Failure Mode and Effects Analysis, and Problem Trees were utilized to diagnose the company’s issues.

Notably, VSM was highlighted for exposing value-added and waiting times in the preparation process, including the Spaghetti Diagram to record operator movements graphically. These tools were used to determine the execution plan for optimizing each problem. The conducted diagnosis identified recurring issues in the restaurant industry, including productivity, efficiency, and operational rework.

Table 1. Comparative matrix of state of the art vs The causes of the research problem

Causes / Articles	Poor Layout	Inefficient Use of the Workstation	High Rate of Errors in Preparation	No Record of Preventive Maintenance
[8]	FLD	STW		
[11]		STW		Autonomous Maintenance
[12]			STW	Autonomous Maintenance
[15]	FLD		STW	
Proposal	**FLD**	**STW**	**STW**	**Autonomous Maintenance**

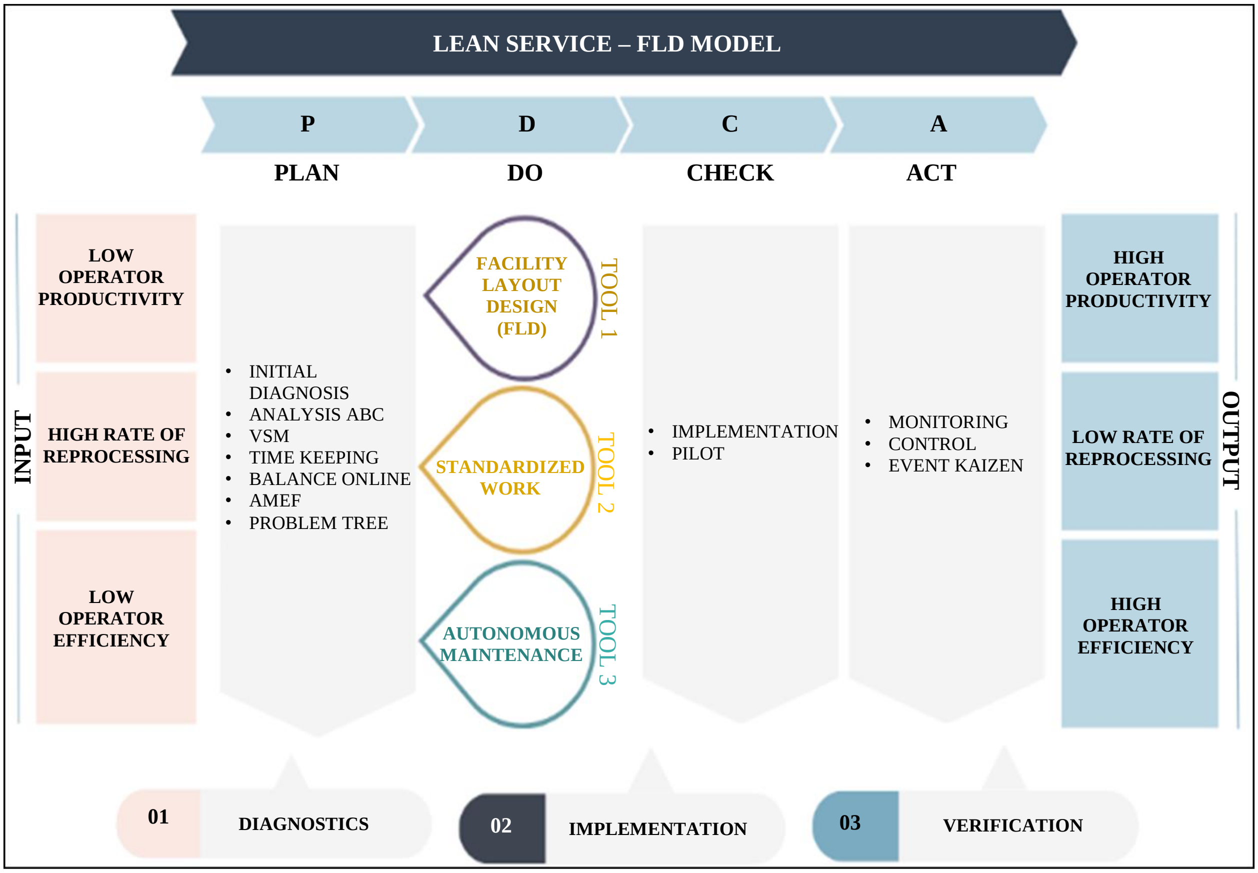

Fig. 1 Proposed model

Therefore, an innovative model was developed with three critical inputs for developing and implementing FLD, STW, and autonomous maintenance. Firstly, FLD was implemented to define work zones; secondly, STW was executed to achieve optimal workstation usage and establish work methods.

Finally, autonomous maintenance was employed to prevent major machinery failures. The achieved results were improved indicators following the PDCA model, depicted in Figure 1. This model was applied to bridge the literature gap by implementing lean service in an understudied sector with significant room for exploration, namely the restaurant industry. Apart from contributing to optimizing operational processes in the sector, it primarily aims to enhance customer service levels, resulting in increased company profitability.

3.2. Model Components

The model is divided into 4 phases corresponding to the PDCA framework:

3.2.1. Phase I: Plan

In this initial stage of the management model, the company's current situation was diagnosed using performance indicators. Various analysis methodologies were employed to identify the central problem and its causes and establish objectives.

3.2.2. Phase II: Do

During this second stage, the implementation of the tools from the proposed model was carried out. The first introduced tool was FLD. To accomplish this, a Spaghetti diagram was created in advance, mapping the complete route of operators and identifying bottlenecks. Then, travel times and machinery distribution were analyzed based on usage frequency to achieve an efficient layout. For the second tool, standardized work was executed, aiming to enhance workstations and establish standardized processes for use by any operator.

First, the process was analyzed based on the new layout and workstation constraints. Then, the redesigning of machine infrastructure was performed with the aid of design work, and a time study was conducted, capturing fields such as activities, operators, start time, end time, and tools used, among others. Finally, an average of each action performed by operators was generated to establish a preparation manual with precisely defined activities, determined times, instruments for each activity, the author, the approval date, and the person who approved it.

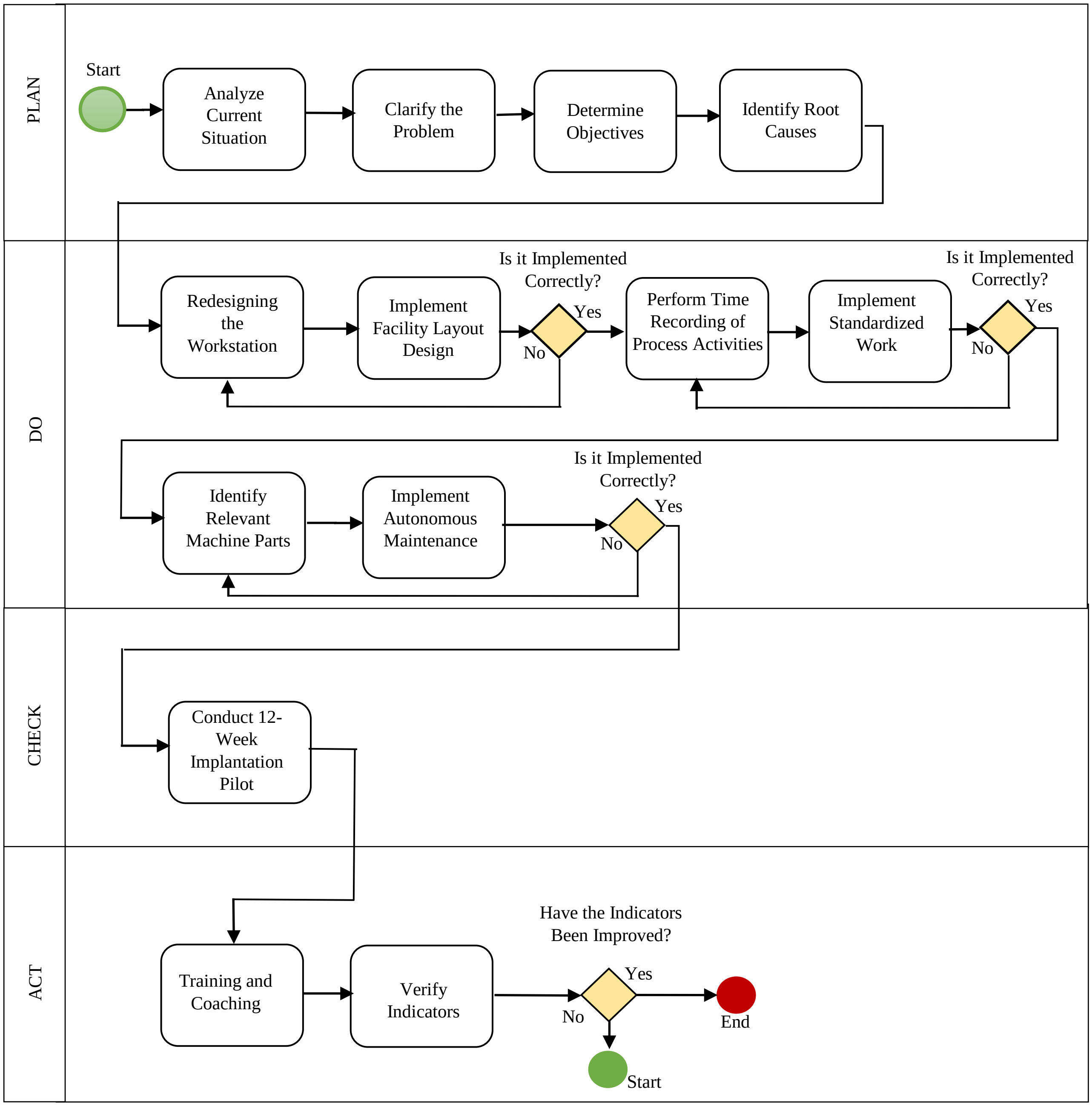

Fig. 2 The flow of the proposed method

Ultimately, autonomous maintenance was carried out. Its purpose was for operators to identify and prevent breakdown points in critical machinery components vital to operational processes. An independent maintenance manual was established since negligence in these components would directly impact company operations.

This outlined the activity, features, materials, time, and frequency. Ongoing training and supervision by the company's technical expert ensured proper understanding and application of autonomous maintenance.

3.2.3. Phase III: Check

During this third stage, a 12-week pilot, including the new layout, standardized documents, and manuals, was executed. Daily monitoring was established through time studies to verify the correct implementation of the tools.

3.2.4. Phase IV: Act

In this final stage, results obtained from the implementations were verified. Monitoring and comparison of key indicators before and after execution were conducted. Additionally, the Kaizen event was used to identify continuous process improvements for rapid implementation.

3.3. The Flow of the Proposed Model

A visually organized presentation of activities conducted in the Lean Service-FLD management model is sought, specifically within the 4 phases of the PDCA cycle. This is intended to enhance the three proposed input indicators and simultaneously achieve previously set objectives. Figure 2 shows the implementation method of the proposed model.

3.4. Model Indicators

3.4.1. Productivity

The key indicator that measures the company's resource utilization in relation to the quantity of production generated. This indicator is presented as burgers/Peruvian soles.

$$\text{Productivity} = \frac{\text{Produced units}}{\text{Used resources}} \quad (1)$$

3.4.2. Efficiency

This indicator measures the average time of produced hours against the total working hours of an operator, maximizing production within the shortest possible time. This indicator is expressed in percentage.

$$\text{Efficiency} = \frac{\text{Produced hours}}{\text{Total working hours}} \quad (2)$$

3.4.3. Reworks

This indicator measures an operator's rework time during product preparation, comparing it to the actual working hours. This indicator is expressed in percentage.

$$\text{Reworks} = \frac{\text{Rework hours}}{\text{Total working hours}} \quad (3)$$

4. Results

4.1. Initial Diagnosis

To conduct the initial diagnosis of the artisanal burger restaurant, the first step was to identify the most critical product line in the company. This turned out to be the preparation of the Classic Smash Burger, which generates the highest income and profits, at 31%, compared to other company products.

Upon inspecting the activities, it was discovered that the main problems in the preparation process were low productivity and efficiency, measured at 0.049 burgers/sol and 59%, respectively. Additionally, there was a high rework rate, accounting for 24% of working hours. Figure 3 shows the problem tree summarizing the diagnosis made in the case study.

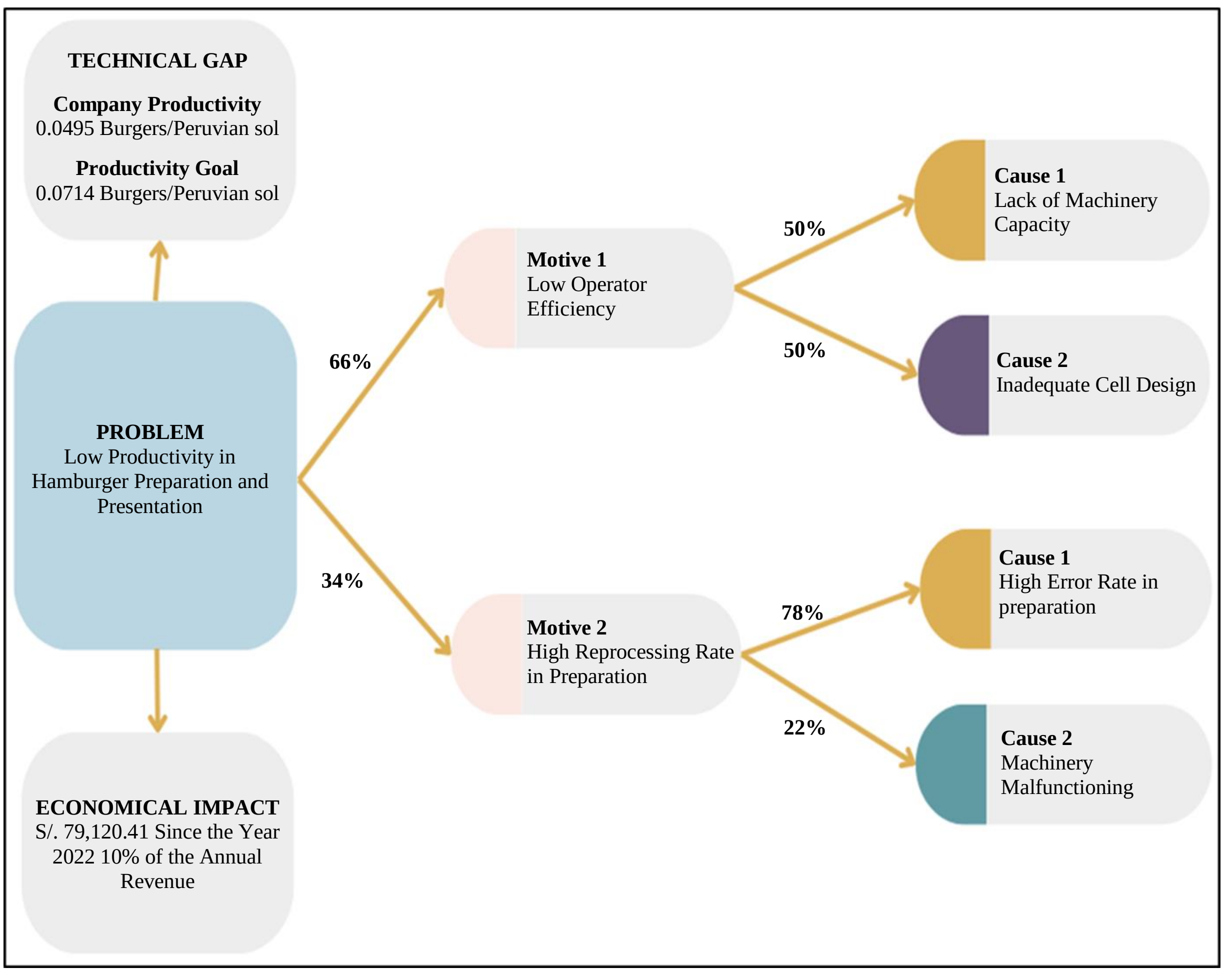

Fig. 3 Problem tree

4.2. Validation Diagnosis

Two validation techniques were implemented to confirm the behaviour and improvement of productivity, efficiency, and rework variables: a 12-week pilot and the statistical tool Minitab. Furthermore, critical indicators mentioned in the previous section were established to monitor and control the implementation of the lean service.

4.3. FLD Methodology

When validating with the Minitab tool, an Excel spreadsheet was initially used to establish 30 random samples from the preliminary and post-implementation stages. The collected observations were input into Minitab to verify significant indicator variations.

It's important to note that a normality test was conducted for each indicator to determine the type of statistics to use, resulting in a P-value greater than 0.05. Consequently, parametric statistics were employed. Following this, a hypothesis test was conducted, working with the following scenarios:

Null hypothesis = 0, meaning the difference between the previous and post-implementation situations equals 0. Alternative hypothesis ≠ 0, the difference between the last and post-implementation situations is not equal to 0. A Student's T-test was performed to accept one of the two hypotheses presented, resulting in a P-value less than 0.05 for all indicators, rejecting the null hypothesis.

Therefore, statistically, it was validated that a significant improvement was achieved in the productivity, efficiency, and rework indicators.

Pilot: Based on the previous analysis, the Spaghetti diagram shown in Figure 4 was created as the first step to identify the zones of each operator:

Grill Zone: The work area of the "grill" operator, whose primary function is to fry the burgers. This zone uses the primary and secondary grills.

Assembly Zone: Work area of the "assembly" operator whose primary function is to assemble the burgers and toast the buns. This zone utilizes the toaster and the assembly table.

Subsequently, the FLD implementation revealed that the fryer had a lower usage frequency than the grill and toaster. Additionally, it was observed that the fryer led to more significant operator movement from the assembly zone to the toaster and vice versa. Therefore, the fryer was relocated beside the stove to reduce the extra travel generated by the equipment for the operators. Figure 5 shows the spaghetti diagram with the relocation of the fryer. Afterwards, the secondary grill was implemented on one of the burners. This involved placing a tray made of 1.5 millimetres thick stainless steel, which expands the workspace of the main grill, as shown in Figure 6.

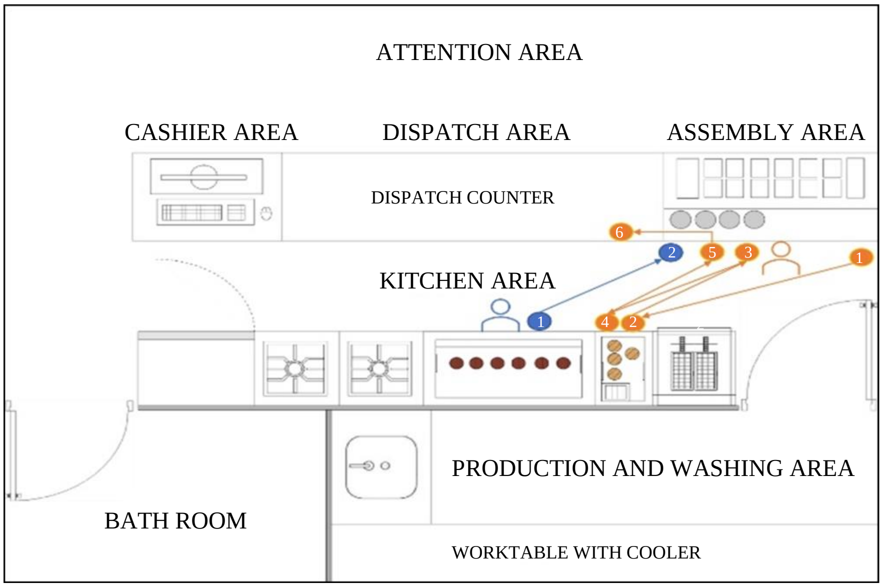

Fig. 4 Spaghetti diagram before implementations

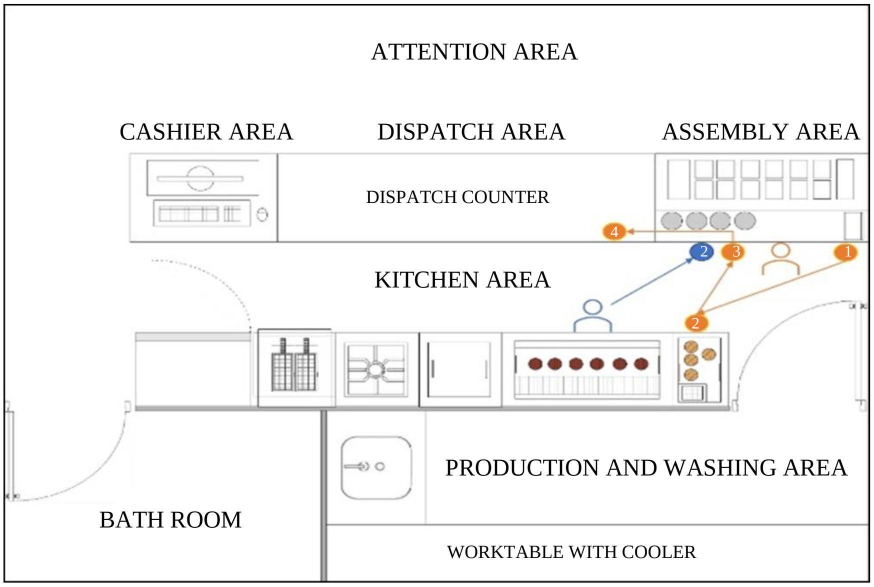

Fig. 5 Spaghetti diagram after implementation

Fig. 6 Second grill

Fig. 7 Main grill with warming racks

As a third step, standardized work was executed, explicitly using the design work approach. During this, it was identified that the worker in the assembly area was encountering a reprocessing step by placing the bread lid back into the toaster to warm it. This is crucial as it needs to be at the optimal temperature for assembling the burgers. For this reason, two-tier equipment was added above the base of the grill to keep the ingredients warm and eliminate the need for the worker to transfer back and forth. The two tiers serve the following purposes: Tier 1 is a resting place for meats and bread, and Tier 2 is a space for placing grilling utensils.

Figure 7 shows the redesigned station with the two levels established in the improvement, and Figure 8 shows the case study. Subsequently, the production manager implemented standardized work, requiring initial training on utilizing the meat and bread warming rack. Additionally, fixed positions were established for grilling utensils and spices. Following that, training for the new preparation process was conducted, which involved tools such as a laser thermometer and oil dispenser, among others. After this, time measurements were taken to establish and highlight the time improvements in the standardized work diagram.

Ultimately, an average time for activities of both the grill operator and assembly operators' activities was calculated. It's important to note that different products were involved in the time measurements; hence, a unification was necessary using the equivalent unit's method. Below is the standardized work diagram with average times, along with the approval by the responsible individual, date of analysis, and review- conducted by the production manager.

Finally, autonomous maintenance aims for the operators to perform simple activities such as cleaning and daily monitoring. In Figure 9, the main parts of each machine are shown, the maintenance of which was controlled and prioritized by the responsible operational staff. For the cleaning process, it was essential to have the appropriate materials, specifications, time, and frequency for proper cleaning.

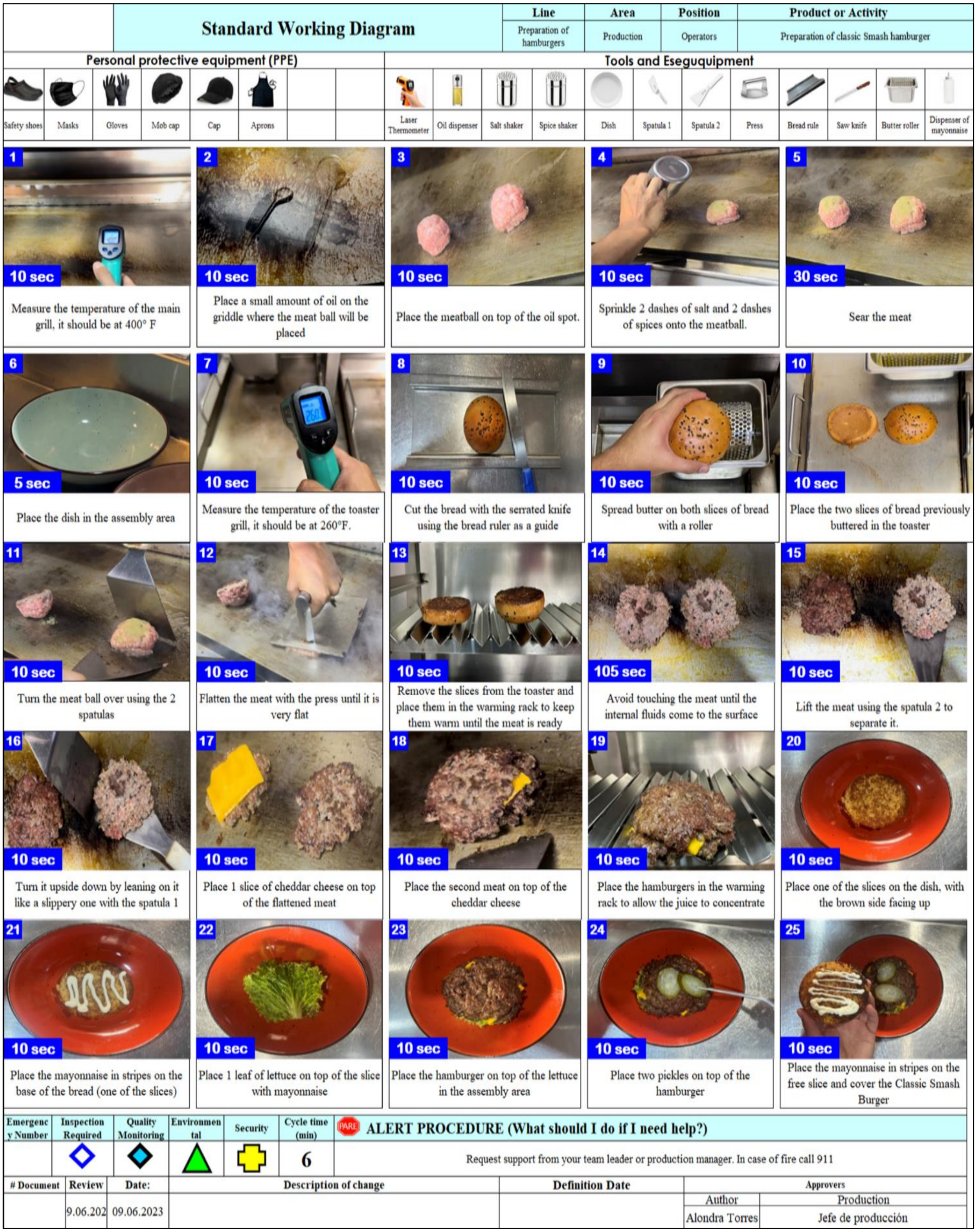

Fig. 8 Standard working diagram

		
Inside of Gas Grill	Inside of Toaster	Gas Hoses

No.	Component	Method	Corrective Action	Tool	Specification	Time	Frequency
1&3	Burner	Visual	Machine Interior Cleaning	1 Litre of Water 1/2 Cup Degreaser, 1/4 Cup of Detergent, Brush and Microfiber Cloth.	With the mixture already prepared, spray it onto the affected area. Use a brush and scrub the greasy or burnt areas over the gas vents until you reach the Steel colour. Finally, wipe all clean rooms with a microfiber cloth to achieve a polished shine.	10 Minutes	3 Times per Week
2	Pilot	Visual	Machine Interior Cleaning	1 Litre of Water 1/2 Cup Degreaser, 1/4 Cup of Detergent, Swab and Microfiber cloth.	With the mixture already prepared, spray the microfiber cloth until it becomes damp. Then, gently rub the outer area of the pilot until all the grease or bunt residue is removed. Also, use a wet swab to clean the inner part of the pilot. Finally, wipe all clean areas with a microfiber cloth to achieve a polished shine.	5 Minutes	3 Times per Week
4	Hosses	Visual	Machine Gas Connection Cleaning	1 Litre of Water 1/2 Cup Degreaser, 1/4 Cup of Detergent and Microfiber Cloth.	With the mixture prepared, spray a stream onto the microfiber cloth until it becomes damp. Rub along the entire length of the hose to remove all accumulated grease. Finally, use another dry cloth to polish and achieve a shine.	5 Minutes	2 Times per Week

Fig. 9 Autonomous maintenance manual

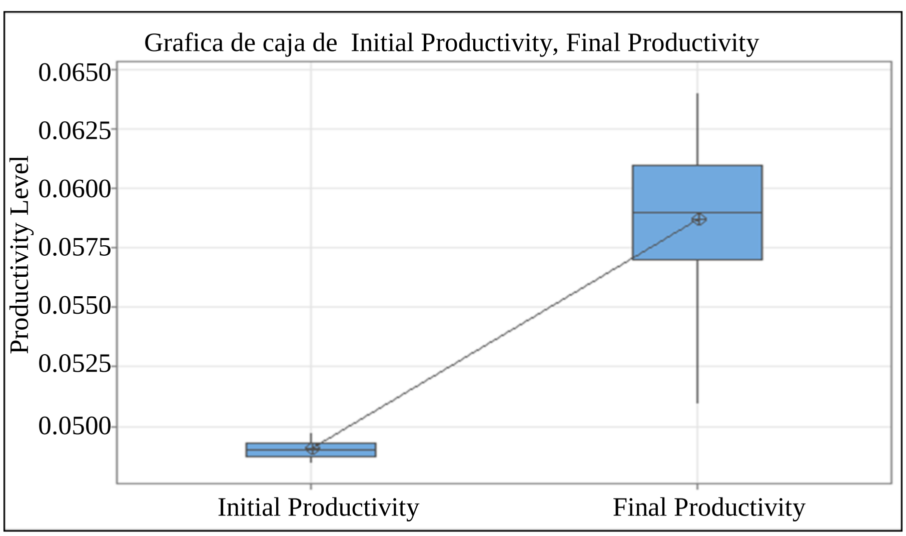

Fig. 10 Results of T-test

The autonomous maintenance manual began its implementation with training provided by the company's technician, who explained the procedure to be followed, the combination of materials, and the frequency at which each activity should be performed. Additionally, the expert technician conducts quarterly visits to gain a more in-depth assessment of its proper functioning. The proposed autonomous maintenance manual is presented below. When conducting the 12-week implementation pilot, the following parameters were considered: 8 hours of work per shift, one shift per day, six days a week, and a capacity of 2 operators in the hamburger preparation process. To illustrate the improvement of the indicators, the statistical software Minitab Statistics V21 was used, taking as input a representative sample of the initial and post-implementation situations.

For the initial position, historical indicators and company time data were obtained, while for the post-implementation problem, the method of measuring time during the pilot was used with Student's t-test; the test results are shown in Figure 10. Table 2 shows the results of the situation before and after applying the Lean Service-FLD tools in the pilot.

Table 2. Comparison of indicators before and after implementation

Indicators	Pre-Pilot Situation	Post-Pilot-Situation
Productivity	0.049 Burgers / Peruvian Sol	0.059 Burgers / Peruvian Sol
Efficiency	59%	75%
Rework	24%	12%

As shown in Figure 10, the results of the t-Student statistical test show a significant increase in the productivity index after implementing the model proposed in the case study.

5. Discussion

The research problem focuses on improving productivity, efficiency, and rework in preparing and presenting artisanal burgers. The management model's most significant contribution lies in applying tools from the Lean Service-FLD methodology. This aims to enhance these indicators and consequently design optimal operational processes. Effective resource management is crucial in the restaurant industry, highlighting productivity as a critical indicator for study. In the pre-pilot situation, the hand yielded a result of 0.049 burgers/Peruvian sol, while the subsequent case increased to 0.059, marking an 18% growth. Implementing lean service tools and techniques can lead to a 25% increase in productivity.

Similarly, the authors in reference also report a 10% increase. Therefore, the elevation of the indicator is consistent with previous findings. It also assures to improve the rework indicator by 97% upon executing standardized work, which involves defining a specific recipe and autonomous maintenance [11].

The authors state that the implementation of standardized work reduces the variability of the activities performed by the operators, which is reflected in a reduction of 76.35% in rework indicators. Therefore, by establishing uniform work methods and outlining a cleaning procedure for key machinery components, including materials, specifications, cleaning frequency, and times to pre-empt malfunctions, the rework rate is reduced by 50%. This improvement aligns with what the authors previously stated .

Similarly, modifying workstations and expanding the central griddle's workspace led to a 27% increase in the efficiency indicator, raising the preliminary value from 59% to 75%. The study managed to eliminate 66% of unnecessary operator movements, validating improvements by implementing design work and FLD [8].

However, the research is confined to studying the preparation of a single product, the most significant one for the company, generating the highest demand and income of about 31% in 2022. The scope of this study encompasses the preparation stage, excluding pre-production and the state of inputs. Thus, only the workflow of two operators in the skillet and assembly areas is evaluated, concluding at the product's dispatch in the kitchen.

For future work, there are areas for improvement that could be addressed in subsequent research:

- Investigate applying available technologies with lean service tools to automate operational areas.
- Quantify customer service-related indicators through Lean Service tools, such as waiting times and satisfaction.
- Explore the impact on supply chain indicators upon implementing lean service tools, including inventory management and supply.
- Evaluate the impact of lean service on financial metrics in diverse industries.
- Assess companies in other sectors that have utilized the lean service methodology and compare successful implementations and experiences.

6. Conclusion

Comparing the post-implementation situation of lean service tools-specifically FLD, STW, and autonomous maintenance across the 4 phases of the PDCA cycle with the initial position reveals improvements in production processes, reflected in key indicators.

- Productivity and process efficiency show 18% and 27% improvements, respectively.
- There is a 50% reduction from the initial 24% to 12% regarding rework.
- While the targeted productivity increase is 44%, considering the pilot's three-month duration, it's expected to achieve the goal over time.
- Additionally, because of the implementations, operational costs were reduced from 88% to 79%, contributing to increased profitability for the company.
- It can be concluded that the application of Lean Service-FLD in an artisanal burger company has been feasible and successful.

The methodology, rooted in successful research in the artisanal burger restaurant, has been effectively implemented. While much of the literature primarily focuses on manufacturing sectors, it has been adapted as support for application within the service sector.

Ultimately, this management method is a reference for future service sector studies aiming to enhance productivity and efficiency and reduce rework in operational development. Especially within the small and medium-sized enterprises in the culinary industry, there is a significant knowledge gap regarding lean service tool applications despite being a rapidly growing market.

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