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PROPOSAL OF PRODUCTION MODEL BASED ON LEAN AND CONTINUOUS IMPROVEMENT TO IMPROVE THE PRODUCTIVITY IN SMEs OF BAKING: AN EMPIRICAL INVESTIGATION IN PERU

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Proposal of production model based on Lean and Continuous Improvement to improve the productivity in SMEs of baking: An empirical investigation in Peru

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ABSTRACT

In Peru, the food industry represents 16.52% of GDP and bread is one of the foods that generated the highest consumption; however, despite the demand, bakery SMEs have a negative performance. Poor process management and methods are used affecting its productivity. Faced with this problem, SMEs in Europe are using the Lean Manufacturing methodology to optimize their processes. That is why this article proposes as a contribution the Lean-Deming Model, which includes tools such as Poka Yoke, Work Standardization, 5S and Deming Cycle. To validate this contribution, the model was developed in a bakery SME in Lima, Peru in its "pan frances" production line. A simulation of the improvements in the Arena Software was carried out, with which positive results were obtained. Searching tools times decreased by 10.34% and labor productivity improved by 23.91%, thus improving overall process productivity.

CCS CONCEPTS

• **Lean Manufacturing**; • **Applied computing**; • **Baking Industry**;

KEYWORDS

Poka Yoke, 5s, Work Standardization, Deming Cycle, SMEs

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1 INTRODUCTION

SMEs in Latin America and Europe account for 30% and 60% of GDP respectively, the main reason for this difference is the existence of a productivity gap between the two sectors [1]. In Peru, the food industry represents 16.52% of the Gross Domestic Product [2], and food consumption in the home increased by 6.4%, with bread and cereals accounting for 11.8% [3]. Despite the increase in demand, productivity in the Peruvian bakery industry is below the average productivity of SMEs, which is 1.7 [4].

The Peruvian bakery industry has had a negative performance, with the main difficulties being the lack of training in methods and tools to improve their processes and inefficient quality control [5]. In addition, 65% of bakeries in Lima remain informal businesses, mainly due to their lack of focus on process organization [4]. This problem has also been identified in research in other countries. In Colombia, bakeries have high levels of informality, low value added and low productivity [1] and in Brazil, bakery SMEs need to overcome the challenge of the economic crisis and the increase in operating costs, the latter generated by wastage, raw components, energy and other resources [6]. In response, it was identified that European SMEs in this sector show good results after the implementation of Lean Manufacturing [1]. However, the application of this methodology is at a primary level. A 2013 study conducted in Malaysia concludes that food industries are at an initial level of implementation [7] and, despite the years, in 2019 in Colombia, a study points out that Lean Manufacturing implementation is at an early stage [1]. In this situation, it is necessary to involve the concept of continuous improvement with the Deming Cycle tool for a correct implementation of Lean Manufacturing.

In this context, a case study was developed that covers some of the most important causes of inefficient productivity in the sector: increased time allocated to activities and inadequate process and space management. To develop the solution, a combination of Lean and Continuous Improvement methodologies were applied to the production processes: 5s, Poka Yoke, Work Standardization and Deming Cycle. In conclusion, this article offers a model to improve the productivity of the "pan frances" production process of an SME through the implementation of the 5s, Poka Yoke, Work Standardization and Deming Cycle tools. The main topics addressed are:

Table 1: Comparative matrix

Author	Ref	Cleaniness of the work area	Tool organization	Standardization of activities	Implementation plan management	Ingredient usage management
Viteri et al. (2016)	[20]	5s	-	-	-	-
Junior & Broday, (2019)	[9]	-	5s	-	Deming Cycle	-
Vinayagasundaram & Velmurugan, (2018)	[21]	-	-	-	-	Poka Yoke
Realyvásquez et al. (2019)	[22]	-	-	Work Standardization	-	-
Best options		5s	5s	Work Standardization	Deming Cycle	Poka Yoke

Introduction, state of the art, proposed model, validation, discussion, conclusion and references.

2 STATE OF THE ART

2.1 The Deming Cycle applied to process improvement

The Deming cycle consists of five phases (Plan, Do, Check and Act) and is a continuous improvement process applied in Total Quality Management [8]. This is a highly effective methodology for continuous improvement and is one of the tools to be used as a management method by companies in different industries to solve problems of loss reduction or elimination [9]. For example, this methodology was used to analyze the problem and identify a possible solution to optimize the process in a distribution center [10]. A case study that applied the Deming Cycle in a garment SME in Peru resulted in a reduction of reprocesses from 27.6% to 20.4% [11].

2.2 Poka Yoke

The main objective of its implementation is to eliminate or avoid errors, whether they are of human or automated origin. The defect is prevented by stopping the line or machine when the root cause of the defect is activated or detected [12]. The error can occur in work of any kind, e.g., malfunction, not performed according to protocol, use of incorrect tools, missing parts, defects during assembly, use of incorrect components or inaccurate measurement [13]. These Poka-Yoke systems have been used in a variety of contexts, such as construction, health care, and information technology [14]. Furthermore, with the simple thought that no mistakes can be made, with Poka-Yoke what we do is create a system in the process to prevent us from making mistakes. Basically, it can perform 2 functions: alerting or correcting [15].

2.3 Efficiency through Lean Manufacturing

Raising both productivity and efficiency requires directing efforts to the area of quality and continuous improvement [16]. This is made possible, with greater ease, by the implementation of Lean Manufacturing; therefore, Lean enables the creation of more effective, innovative, and efficient companies [17]. This methodology allows efficient use of resources in such a way that it consumes less space, less H-H and fewer raw materials than a mass production system with a comparable production level and therefore, it will achieve cost reduction and quality improvement [18] [6]. There are many cases that prove this Lean-Efficiency relationship; for example, a case study that implemented Lean in the production of bread cakes was able to improve its efficiency from 81% to 92% [19]. Another case, of a company in the same industry, managed to increase its efficiency from 74% to 83% [4].

3 PROPOSED MODEL

Thanks to the literature review, the optimal tools to solve the problems affecting the sector were identified. Table 1 shows the comparative matrix.

Figure 1 plots the proposed model integrating the tools identified to improve productivity.

3.1 Model Components

The model has 4 phases.

3.1.1 Phase 1 Plan. Phase 1 consists of activities to successfully carry out the implementation. The commitment of the bakery owner is vital to implement the proposal; the owner must be able to recognize the importance of each stage and guarantee his participation in some of them. This phase begins with the collection of data on the initial state of the process, preparation of the VSM, root cause analysis and the establishment of objectives and indicators. Subsequently, the owner must be responsible for communicating and disseminating the importance of the tools to be used to the operators and the master baker.

3.1.2 Phase 2 Do. As a first step, the 5S is implemented. (1) Unnec- essary elements were classified, and it was decided to group them into obsolete elements and unserviceable elements, whose action plan is to transfer and eliminate, respectively. (2) The remaining items are arranged according to frequency of use; a tool board and delimiting tapes are used. (3) The workshop is then cleaned; schedules and necessary tools are established. A cleaning map was implemented. (4) The previous steps are then standardized through documentation and visual control. (5) Finally, discipline is encour- aged through 5S Policies and a 5S Panel. The second stage consists of implementing the Poka Yoke. (6) First the possible failure is de- scribed in detail. (7) The most common times and places where they

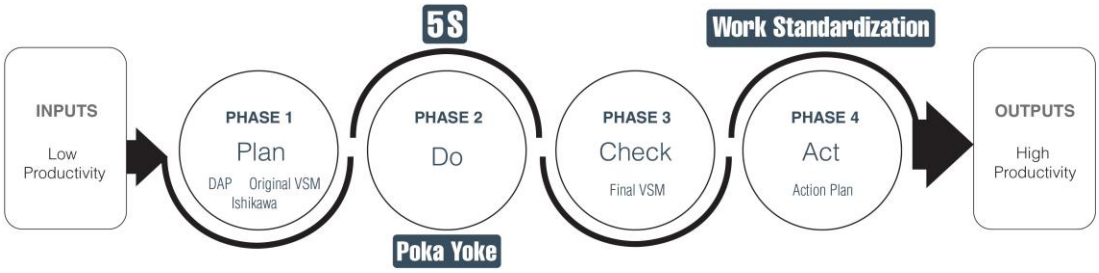

Figure 1: Lean-Deming model

Table 2: Table of indicators

Indicator	Algorithm	Use	Tool
Search time tools	$\frac{Total\ time\ of\ activity\ that\ use\ tools \times n^{\circ}\ ope}{Total\ batches}$	Calculate the time duration of activities using tools.	5S
Productivity MO	$\frac{Produced\ batches}{Man\ Hours}$	Calculate the number of batches produced per man hour.	Poka Yoke, 5S and Work Standardiza-tion
5S compliance level	Survey	Identify the % of compliance with the activities established for the 5S.	5S

occur should then be identified. (8) Next, the causes that led to this problem are determined. (9) Finally, it will identify what solution can be provided and create a device or technique that can prevent or solve the identified errors.

3.1.3 Phase 3 Check. As a first step, a data collection plan is prepared, which will be carried out by the owner of the company. The plan consists of an evaluation through observations and internal audits. With this information, the final VSM is made, and the initial indicators are measured in order to compare what was obtained in phase 1 with what was obtained in the present phase. A "check list" will be implemented as a support for better control.

3.1.4 Phase 4 Act. By analyzing the results of the previous phase, the fulfillment of the objectives is verified. If the objectives are not met, a brief analysis of the implementation is carried out to identify the main reasons for non-compliance and, based on these results, corrective actions are taken. On the other hand, if the objective was met, the work standardization is applied, and standardized procedure formats are created.

3.2 Validation

3.2.1 As-Is Process. When evaluating the company under study, a deficient productivity in its french bread production line was observed. Figure 2 illustrates the initial diagnosis: problem, impact, causes, root causes and their representativeness (%). In addition, the right side of the graph shows the tools to use for each cause.

3.2.2 Validation design and Comparison with the Initial Diagnosis. The model was developed for the entire "pan frances" production process, from the weighing activity to the storage of the loaves. In order to validate the model it was necessary to go through 4 phases, first we started with the information gathering stage with the help of the bakery staff during the months of June and August. With this information, tools such as DAP, VSM and Ishikawa diagram were used to identify the main cause of the problem. The data from this first phase were entered into the Arena software to compare the improvements obtained. In the second phase, the 5S and Poka Yoke tools were used to organize the workspace and control activity times; these tools generate an improvement in the processes [4]. A warning Poka Yoke was used for the mixing and stirring activities and a physical Poka Yoke was used to enhance the weighing activity of the ingredients. The first Poka Yoke included a Time Sheet which indicates the relationship between the weight of the dough and the time of use of the machine. Also, a color was assigned by weight. Then a timer was used, which is marked with the colors indicated on the time sheet, so the operators do not make a mistake when setting the time. The second Poka Yoke consisted of a picking cart with “divisions” according to the ingredients to be used. In the next phase, information was collected, the 5S Check List format was completed, and the indicators were calculated and compared. In the last phase, the Standard Work was implemented with the objective of standardizing the improvements made.

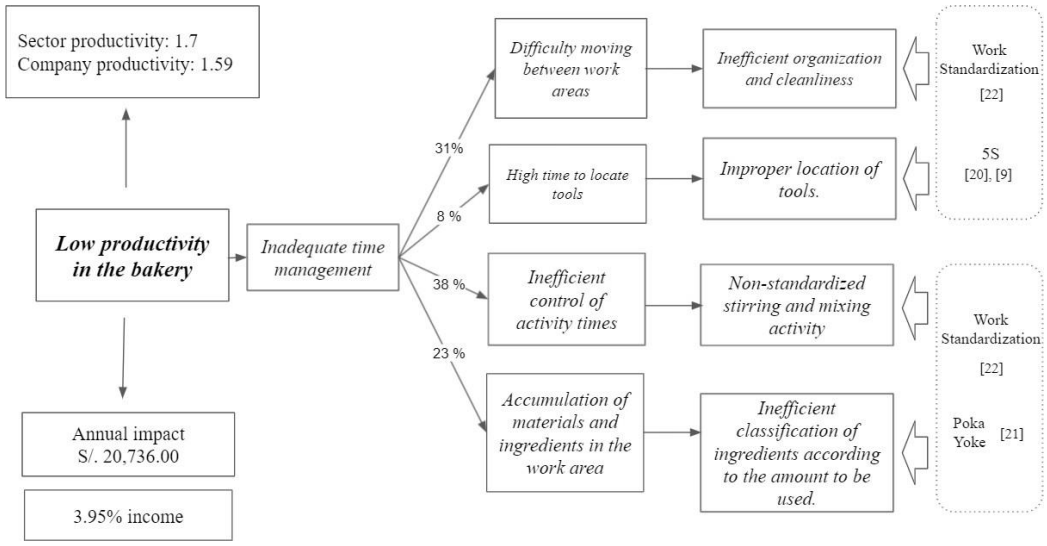

Figure 2: Problem Tree

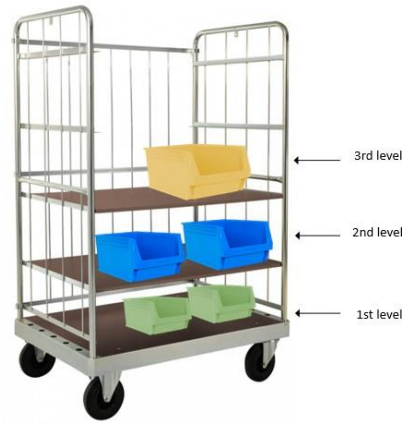

Figure 3: Picking cart example

3.2.3 Simulation and results. Two scenarios were performed and compared. Scenario 1 represents the process in its initial state considering the delays due to the causes already presented. Scenario 2 is the result of the application of the proposed model. Both models have the same structure; the changes are presented in the timing of each activity of the process.

The simulation started with a sample of 30 observations; from this, the optimal number of observations was determined in order to have greater reliability. These observations were entered into the Input Analyzer to obtain the distributions for each activity. Subsequently, the number of replicates of the system was determined in order to have a confidence level of 95% and an error of less than or equal to 1 minute. This resulted in a total of 100 and 137 replicates for the current system and for the improved system, respectively.

After running the model in Arena, the results are displayed in Category Overview. In the real scenario (initial) the process time is 321.40 minutes and there are 4 finished batches and 3 in the second rest; while with the improvements applied in the simulation the time is reduced to 315.46 minutes and there are 5 finished batches and 3 in the second rest. Achieving a 1.85% reduction in production time and an increase of 1 production batch.

Previous research obtained similar positive results when applying these engineering tools. Table 3 shows the indicators taking into account both simulation scenarios and compares them with previous studies to evaluate the results obtained.

Regarding the 5S compliance level indicator, this indicator could not be found with the simulation, therefore results obtained in other articles were compared to analyze a possible result. A study achieved a 5S implementation level of 82% [23]; on the other hand, other study after 3 months of application of the 5S achieved a result of 79% [24]. Considering that the present investigation, unlike the two articles mentioned above, was carried out by applying the Deming cycle method, it is expected that the verification and action steps can contribute to achieving a minimum compliance level of 82%.

4 DISCUSSION

The initial situation of the company under study is described as a messy workshop without a cleaning plan that allows a pleasant work environment, as the absence of activities standardized and time control for the production process. The proposed tools positively affected the Production System. The 5S will improve the order of machines, tools, utensils, and the workshop in general. The Poka Yoke managed to improve time control in kneading and kneading activities. It also improved the method of weighing ingredients, reducing its time. Finally, the work standardization aims to help maintain the proposed improvements through instructions and formats.

The proposed model with the objective of improving productivity in bakery mypes can be applied to different sectors; however, the

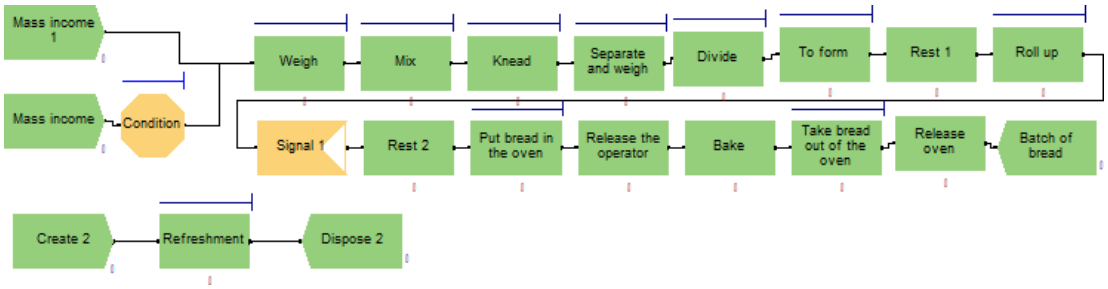

Figure 4: Process Simulation Model

Table 3: Comparison of indicators

Indicator	As-Is	To-Be	Variation	Objective	Reference of the objective
Search Time tools	59.627 min	53.464 min	10.34%	33%	[23]
MO Productivity	0.45 lot/hh	0.57 lot/hh	23.91%	13%	[4]
5S Compliance level	0%	82%	82%	82%	[23]

sector that would benefit the most would be those that have a low level of knowledge in process management or those that guide their processes in an empirical way, as is the case of bakeries [5]. Because the proposed model applies simple tools and steps, but with a significant impact on production. Therefore, the contribution of this research is a basis for a preliminary guide applicable to emerging mypes.

The results of the application of this model are shown in Table 3. It is observed that the best indicator with the highest positive variation is the MO Productivity, obtaining an improvement of 23.91%, achieving the results of previous research [4], one of the causes is the reduction of time of the activities thanks to Poka Yoke, Work Standardization and 5S. As shown, this third tool manages to reduce tool search times by 10.34% thanks to the tool board, the formats and visual posters; Since, as mentioned in other articles, the lack of visual signals increases the time when it is required to locate elements [10]. Finally, the last indicator achieved the objective of 82%, which shows that the bakery personnel understood the importance of the tool and are trying to apply the proposed measures.

5 CONCLUSIONS

The implementation of the 5S, Poka Yoke and Work Standardization tools under the framework of the Deming Cycle in a bakery SME achieved positive results. Through the simulation, the increase of MO productivity by 23.91% and thus improve production is verified. This optimization of resources (hours men) is translated in a greater productivity [17]. In conclusion, it was possible to demonstrate the objective of this article, the productivity increase.

The tools presented depend on significant operator participation; therefore, worker participation should be encouraged during implementation. Thanks to the development of the contribution, it was identified that some key factors for success in SMEs are leadership and the correct management of the implementations, since constant supervision is necessary.

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