Industrial Engineering and Applications
L.-C. Tang (Ed.)

doi:10.3233/ATDE230092

Production Model Based on Lean Tools and SLP to Increase Labor Productivity in Companies in the Food Industry

Valeria Huarcaya-Melendez [a,1] and Alexander Platero-Mamani [b]
[a] *Universidad de Lima*
[b] *Universidad de Lima*
ORCID ID: Valeria Huarcaya-Melendez https://orcid.org/0000-0003-1557-507X, Alexander Platero-Mamani https://orcid.org/0000-0003-4851-8047

Abstract. The Peruvian food industry plays a crucial role in the country's economy, but it faces a major challenge in the form of low labor productivity. This problem not only hinders the industry's growth but also negatively impacts company profits. This study proposes a model for improvement using SLP and Lean tools to address the underlying causes of low labor productivity in a Peruvian food industry company. The objective of this research is to enhance labor productivity and achieve or surpass industry standards by proving the effectiveness of the proposed model. In this manner, the SLP is implemented to mitigate the lack of order in storage, the 5S to address the inappropriate location of tools and the Poka Yoke to reduce the generation of waste. To validate the model, a pilot test was conducted for the 5S and Poka Yoke, while the Arena Simulator software was used for the SLP. The results were positive, showing a labor productivity of 25.02 Kg/ Sol, a 3.19% reduction in standard time per box of cinnamon that went through the processes of cleaning and packaging, a reduction of waste of 54.17%, a 55.02% reduction in cleaning time for cinnamon and an overall reduction in standard time of 5.35%.

Keywords. Labor productivity, 5S, Poka Yoke, Lean Manufacturing, SLP.

1. Introduction

In Peru, the food industry represents an important part of the economy; however, there is a factor that negatively affects its competitiveness: low labor productivity. Indeed, the country is in the lowest group of the ranking worldwide, occupying position 113 out of 185 countries based on this indicator [1]. The present investigation has as object of study a company that sells mainly nuts and has a labor productivity of 17.79 kg/sol; while the average indicator for the sector is approximately 19.2 kg/sol. This represents a technical gap of 1.41 kg/sol. In other words, the company belongs to the group that reduces the average value of labor productivity in the food industry. Consequently, the objective of this research is to propose an effective model to achieve an increase in labor productivity in order to match or exceed the market standard.

[1] Valeria Huarcaya-Melendez[a], and Alexander Platero-Mamani[b], 20180916@aloe.ulima.edu.pe[a] and 20183074@aloe.ulima.edu.pe[b]

Among the main causes of the problem in the sector are the low level of production, high labor costs, poor facilities management, tools in poor condition or not well located, outdated technology, and the work environment. Among these, the main reason of the problem in this company is the low level of production, identifying that, some of its causes are a high percentage of waste and defectives, production stoppages due to lack of operators in the workstation and lost time in internal transfer. Through a bibliographical review, success stories related to the mitigation of the aforementioned causes were found. One of these involves the use of Poka Yoke, a technique to avoid errors, which resulted in a reduction of production defects in a MYPE that achieved an improvement in the elimination of defectives of 60% in its G2 line and 66.66% in its G1 and FD lines [2]. Likewise, in a manufacturing compan, the SLP is used, a tool that optimizes processes through the strategic location of areas, to redesign the production process and achieves economic savings of 44.7% [3]. Also, the 5S management technique, which promotes order, organization and cleanliness, was used in the welding area of a company in Indonesia, resulting in a reduction in the search time for equipment and merchandise by 18.75% [4].

The present investigation uses the DMAIC approach as a framework, since it is a structured method to solve problems with long-term solutions and has been successfully applied in projects to reduce errors in production and decrease the rate of their appearance [5]. Specifically, the Poka Yoke is recommended to reduce the percentage of defectives generated in production; the SLP to reduce the internal transfer time and 5S to improve the location of tools.

A model based on SLP and the Lean 5S and Poka Yoke tools is proposed. This article is divided in four sections: Material and Methods, Results, Discussion and Conclusions.

2. Material and Methods

2.1. Bibliographic Review

A comparative matrix is presented with the causes of low labor productivity and the adequate tools to apply according to reviewed articles.

Table 1. Comparative Research Matrix

Indicator	Waste generation	Downtime due to tool search Scenario	Management of internal transfer time in the production area
Silva-Campusano, D., & Vega-Romero, D. (2022)		5S	5S
Kulińska, E., Masłowski, D., Dendera-Gruszka, M., & Zbyrad, A. (2020)	Poka Yoke		
Sunardi, Esya, J. A., & Santoso, B. (2020)		SLP	SLP
CONTRIBUTION	**Systematic Layout Planning and Lean Tools: 5S and Poka Yoke**		

2.1.1. Productivity Management in the Food Industry

Among the most common problems in the sector are high productive times, high percentage of waste and returns, order and inadequate distribution in the workplace, among others. Given this, in the cases reviewed, solutions such as the use of Lean and Data Science tools stand out.

Regarding Lean tools, one of their success stories occurred in a food processing company in Denmark, where preparation times were reduced by 34% and the production capacity of the main production line increased by 11%. [6]. Additionally, in a manufacturing company in Brazil, the influence of Lean tools such as 5S and the Kaizen philosophy caused reduction in the percentage of defectives by 40% [7].

On the other hand, the effectiveness of Data Science was evidenced in plant distribution and occupational health and safety scenarios. At an Indonesian comfort food company it resulted in increased material flow efficiency by 39.6% [8]. In addition, it allowed an increase in labor productivity of 2% through the prevention of occupational diseases, which also increased the company's income by 8% [9].

2.1.2. Lean Manufacturing

The methodology aims to optimize the use of resources in production by eliminating waste [10]. Likewise, this is a system of continuous improvement in production and delivery of products and services, distinctively of the waste involved in the supply chain [11]. Its techniques and tools are implemented to increase productivity and reduce delivery time in order to achieve greater customer satisfaction and the generation of value with less use of resources [12]. It was recognized that this methodology could be used successfully for various purposes, such as waste reduction, improvement of facility layout, ergonomics, among others.

One of the most distinctive benefits of Lean Manufacturing is the reduction of defects. In a paper manufacturing company, the Lean Six Sigma tool was used to reduce waste in the production line. The implementation of the proposal achieved an increase in productivity from 23% to 40% through the use of Kaizen and work standardization. This is due to the reduction of idle time from 32.6% to 11%, excess personnel from 33% to 16%, and labor inventory savings through TPM, work standardization, inventory management, and Six Sigma methodologies such as 5S, DMAIC AND DMADV. It is worth mentioning that the article highlights the effectiveness of Lean Six Sigma in improving metrics such as quality, response capacity, total response time, among others.

Another success story occurred in an Indonesian company, specifically in the welding area, where the implementation of the 5S tool minimized the use of space by 11.20%. In addition, the search time for equipment and merchandise was reduced by 18.75%. Therefore, the workshop process became more efficient. [13].

Likewise, in a manufacturing company in Latin America, the use of Lean Manufacturing and ergonomic tools made possible to reduce the exposure of workers to musculoskeletal disorders (MSD) by 67.27% and reduce the absenteeism rate by 52.85% [14].

In summary, Lean Manufacturing is a methodology that can be used to mitigate various problems, in various industries and through different tools that can complement each other.

2.1.3. Systematic Layout Planning

Systematic Layout Planning is a systematic and organized layout design method. This method is used to design the best alternate layout and minimize the time of material transfer that occurs on the production floor. [15]. Also, the method uses quantitative inputs, such as the distance and frequency of movement of the material, and qualitative inputs, such as the degree of relationship of the activities in the analysis stages, so that the analysis is performed better [16]. In addition, the SLP method entails detailed procedures to organize designs based on the process sequence, build block diagrams and, ultimately, make detailed designs of each plant [16].

A successful case of the application of the method was carried out in a hard disk manufacturing company, in the brushing area. As a result, it was possible to reduce the material handling costs of the production process flow equivalent to savings in the company's material handling costs from IDR 5,377,415 per month to IDR 2,971,717; which represents a saving of 44.7% [17]

Additionally, in the production plant of a company in Surabaya, the material handling distance was reduced thanks to the application of SLP. The total material handling distance for the design had a total distance of 508.6 meters and decreased to a total distance of 324.8 meters [15].

2.2. Proposed Model

2.2.1. Component 1: Define

Systematic For the "define" component, the objective is to identify possible problems to be solved to improve the performance of the company. For this, a data collection of the food industry is carried out through the literature review.

2.2.2. Component 2: Measure

The purpose is to gather documented information from the company and determine the current real situation. To achieve this, a block diagram that explains the sequence of the process is used, as well as the Systematic Interrogation Technique to interview the senior management of the company and employees in order to obtain more detailed data related to possible errors in the staff tasks. To validate the information gathered, a series of quantitative data from 2021 was also collected.

2.2.3. Component 3: Analyze

For the "Analyze" component, the objective is to identify the root causes of the problems found in the organization. Once the data of the company was contrasted with the average data of the sector, the problem to be attacked was determined as well as the economic impact. Subsequently, the root causes were searched using a Pareto Diagram where the most likely causes of the problem were selected. Once the two main problems were defined, their causes were established using the Problem Tree. This resulted in root causes as lack of operators in the operation (45%), human error in manual processes (27%), lack of order in the warehouse (8%) were obtained; bad location of tools (5%); accumulation of orders (9%) and lack of clarity in processes (6%).

2.2.4. Component 4: Improve

2.2.4.1. 5S

To evaluate the 5S, a pilot of approximately 3 days was made in which around 50 cinnamon samples that went through the cleaning and packaging area were evaluated. This were the processes that took place in the area allowed for the pilot by the company.

As a result, a standard average time of 77.96 minutes per box was obtained. The data showed that the first product processed in the day had a longer standard time since the operator took a few extra minutes to search for tools.

The steps to follow next started with the determination of the proper location for the tools and the optimal structure of the area. In order to comply with these changes, visual controls will be carried out to maintain the correct location of the elements, a checklist for cleaning compliance and activities to promote the self-discipline of workers

2.2.4.2. SLP

Its use consists of four stages. First of all, the location of the area is decided. In this case, it is mandatory to adapt to the location already chosen by the company. Subsequently, the general distribution plan is studied to redistribute optimally all the spaces. Afterwards, the detailed distribution plan is made, where the location of the equipment, finished products, among others, are specified. Finally, in the installation, the improvement plan is carried out. The initial information was obtained through visits to the company's warehouse and the Arena Simulator was used to measure the improvements resulting from the redistribution of the plant were identified.

First, data from the current situation was collected. This was done at the level of all the products in the plant, since the redistribution of Areas affects all areas of the warehouse. From a significant sample of around 30 boxes, it was decided to evaluate 50 inputs to the system. It is worth mentioning that not all boxes go through the same flow, and this result will depend on both the types of product and their condition. A standard average time of 48.22 minutes/box was identified. Next, we detail the statistical distributions of each part of the process obtained thanks to the Arena Input Analyzer plugin

Table 2. Simulation Inputs

Process	Distribution
Arrival to cleaning	Uniform(0.91; 1.22)
Cleaning to straining	Normal(0.375;0.0189)
Straining to packaging	Normal(0.176;0.0208)
Arrival to straining	Uniform(1.27; 1.46)
Arrival to packaging	Normal(1.64;0.0615)
Cleaning to packaging	Triangular(0.52;0.583;0.61)
Packaging to Storage	Uniform(1; 1.34)
Cleaning	Uniform(70.6; 74)
Straining	Normal(3.06;0.854)
Packaging	Uniform(0.44; 0.57)

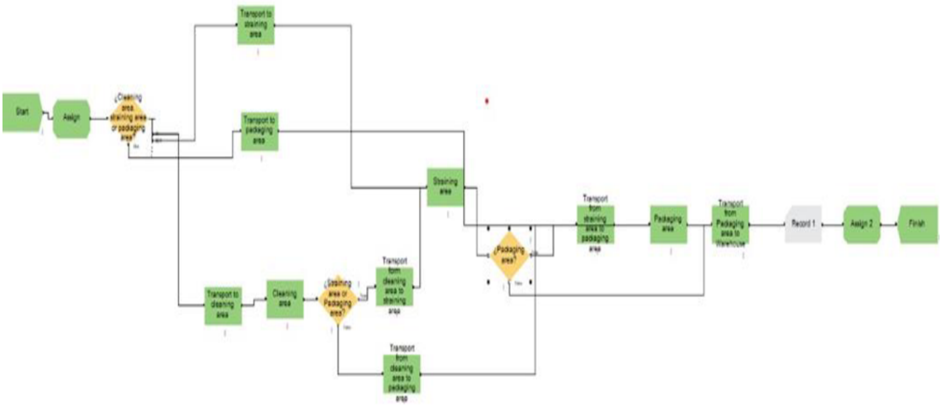

Figure 1. Simulation model.

2.2.4.3. Poka Yoke

In order to avoid the generation of waste, the Poka Yoke tool will be applied in the cleaning process of the production area. A detailed analysis of commonly used techniques and tools will be carried out. Likewise, consulting sessions will be carried out with those suppliers whose products present higher levels of fragility that make them prone to damage from inputs. In this way, the best technique will be established to prevent errors and a control system.

Initially, a cleaning time of 20.83 seconds was determined for every 120 grams of cinnamon, with the longest time involved being 2.89 minutes/kilogram. Likewise, it was identified that from the entire sample of 50 observations, equivalent to 6kg of cinnamon, there are 85.8 grams of loss, which represents, 1.44%.

2.2.5. Component 5: Control

Once the proposed solutions have been correctly simulated, the same values of the indicators established prior to the implementation of the solution tools will be revalued. These data will then be analyzed by means of a comparison of values. If the established productivity objective is not reached, all the steps of the present study will be repeated

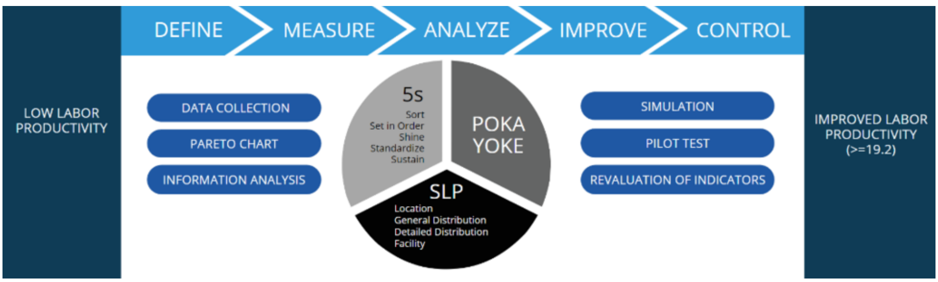

Figure 2. Management model.

3. Results

3.1. Indicators Definition

The indicators presented below will be used to evaluate and validate the impact of the applied solutions.

3.1.1. Labor Productivity (Kg/soles)

This indicator measures the effectiveness with which the labor input is being used to produce final products per month. The higher the value, the more optimal the management of the resource and the ability of the business to offer products to its customers are considered. The aim is to increase labor productivity up to 19.2 kg/soles.

(Kg produced per month / monthly labor cost)

3.1.2. Standard time from Cleaning to Packaging (min/cinnamon box)

This indicator refers to the total processing time of a box of cinnamon that goes through the Cleaning and Packaging processes.

(Transport time Warehouse to cleaned + Cleaning time + Transport time Cleaned to packaging + Packaging time + Packaging time to warehouse)

3.1.3. Percentage of Waste (%)

This indicator refers to the fraction of products with defects for the month within the total number of products produced in a period. It seeks to reduce the percentage to 1%.

(Grams of waste / Grams of products produced) x100

3.1.4. Cleaning Time (minutes / kg cinnamon)

This indicator refers to the total cleaning time of 1 kg of cinnamon. This indicator was measured in a practical way for each stick of cinnamon and the conversion to kilograms was made later.

(Total cleaning time/kg of cinnamon processed)

3.1.5. Standard Average Time (minutes / box)

This indicator refers to the average total processing time for a box of any product treated in the warehouse. The indicator includes both transformation and transportation between areas of the establishment.

(Total processing time/boxes processed)

3.2. Indicators Report

Table 3. Indicators Report

Indicator	Unit	Current Scenario	Target Value	Enhanced Scenario
Labor productivity	Kg/soles	17.8	19.2	25.02
Standard time per box of cinnamon cleaned to packed	Minutes/box	77.96	75.50	75.48

Indicator	Unit	Current Scenario	Target Value	Enhanced Scenario
Waste percentage	%	1.44	0.1	0.66
Cleaning time per kg of cinnamon	Minutes/kg	2.89	2	1.3
Standard average time per box	Minutes/box	48.22	46.5	45.64

4. Discussion

4.1. Proposed Improvement

For 5S, several measures were implemented. It began with the cleaning of the selected workstation. Efforts were joined with the company's work force to sweep the floor of the area indicated and the disposal of waste that was in the area. Next, the permitted areas were organized and unnecessary objects were eliminated by labeling them with different colored stickers that specify whether or not they should be removed from the workplace. In addition, the areas were delimited both for the location of tools and for piles of products. In this way, it is specified what space is intended for a determined task and it is ensured that the routes where the employees walk and the transport of products happens are constantly clear and without obstacles. Also, to reduce tool search time, a toolbox was provided with a specific code, clearly labeled both on the tool and its corresponding box, and with the name of the tool specified on the box. In this way, at the end of its use, it is known where to return each object. This container was located at the entrance of the area where the tools are used. In this case, the tools for cinnamon transformation were assembled. Among these is the brush, the bag sealer in which the supplies are delivered, a simple scissors and tape.

For the analysis of the effectiveness of the Poka Yoke model, initially, 50 observations of the time it took an operator to clean 2 sticks of cinnamon equivalent to 120 grams prior to the implementation of the model were measured with the help of a digital chronometer. On average, an operator takes 20.82 seconds to clean 120 grams of cinnamon and the input with the longest cleaning time is 2.89 min/kg. In addition, with the help of a scale, the defectives generated by these 50 observations equivalent to 6 kg of cinnamon were weighed, with a loss of 1.44% equivalent to 85.8 grams. Using the model, on average, an operator takes 9.33 seconds to clean 120 grams of cinnamon; therefore, the processing capacity for the cinnamon with the proposed model is 1.30 min/kg of cinnamon. Therefore, thanks to the tool, the processing capacity of cinnamon (23% of all the kilograms that enter the cleaning process) improved from 2.89 min/kg to 1.3 min/kg; that is, an improvement of 55%. Likewise, the average defective percentage per 25 kg of Cinnamon, after the implementation of the model, is 0.66%., a decrease of 54%.

Finally, in the SLP the Arena Simulator was used to exemplify the flow that a product can follow in the warehouse with the proposed optimized distribution, which resulted in a standard average time of 45.64 minutes per box, which represents a reduction in delivery time. 5.35% attributed to decreased transportation time.

4.2. Achieved Improvement

The final results were the following.

Table 4. Indicators Variation

Indicator	Unit	Current Scenario	Enhanced Scenario	Variation
Labor productivity	Kg/soles	17.8	25.02	+40.58%
Standard time per box of cinnamon cleaned to packed	Minutes/box	77.96	75.48	-3.19%
Waste percentage	%	1.44	0.66	-54.17%
Cleaning time per kg of cinnamon	Minutes/kg	2.89	1.3	-55.02%
Standard average time per box	Minutes/box	48.22	45.64	-5-35%

5. Conclusions

The effectiveness of Lean and SLP tools is verified to increase labor productivity in a company in the food industry. This indicator increased by 40.58% reaching 25.02 kg/Sol as a result. Every tool used had a positive result in order to achieve the mentioned value. Accordingly, it is concluded that Poka Yoke is useful to reduce waste and standard time, achieving a decrease of 54.17% of waste, which represents a 0.66% loss, and a reduction of standard times per kilogram of the cleaning process, up to 1.3 min/kg with a decrease of 55.02%. The 5S manages to reduce standard process times, in this case cleaning and packaging, up to 7.48 min/kg with a 3.19% decrease, highlighting its impact on tool search time. The SLP has the capacity to reduce the standard average time of the products in the warehouse up to 45 minutes per box, representing a decrease of 5.35%.

The results found and the evidence collected from the bibliographic review allow us to conclude that Lean and SLP tools are effective for improving labor productivity, helping to increase profitability and ultimately contribute to the overall growth of the industry.

It is important to note that this model is a general proposal and should be adapted and validated by the company before implementation. Also, other factors such as employee's training, communication and involvement should be considered to ensure the success of the model.

References

[1] International Labour Organization. Statistics on labour productivity. 2022 Jan.

[2] Kumar R, Dwivedi RK, Dubey SK, Singh AP. Influence and Application of Poka-Yoke Technique in Automobile Manufacturing System. IOP Conference Series: Materials Science and Engineering. 2021 Mar;1136(1):012028, doi: 10.1088/1757-899X/1136/1/012028

[3] Haryanto AT, Hisjam M, Yew WK. Redesign of Facilities Layout Using Systematic Layout Planning (SLP) on Manufacturing Company: A Case Study. IOP Conference Series: Materials Science and Engineering. 2021 Mar;1096(1):012026, doi: 10.1088/1757-899X/1096/1/012026

[4] Rizkya I, Syahputri K, Sari RM, Fadhilah N. 5S Implementation in Welding Workshop – a Lean Tool in Waste Minimization. IOP Conference Series: Material Science and Engineering. 2019 Jul;505(1):012018, doi: 10.1088/1757-899X/505/1/012018

[5] Sodhi HS, Singh D, Singh BJ. A conceptual examination of Lean, Six Sigma and Lean Six Sigma models for managing waste in manufacturing SMEs. World Journal of Science, Technology and Sustainable Development. 2020 Jan;17(1):20-32, doi: 10.1108/WJSTSD-10-2019-0073

[6] Maalouf MM, Zaduminska M. A case study of VSM and SMED in the food processing industry. Management and Production Engineering Review. 2019 Jul;10(1):60-68, doi: 10.24425/MPER.2019.129569

[7] Hussain Z. Optimizing Productivity by eliminating and managing rejection frequency using 5S and Kaizen Practices: Case Study. Independent Journal of Management & Production. 2019 Dec;10(6):1952-1970, doi: 10.14807/ijmp.v10i6.943

[8] Putri NT, Dona LS. Application of lean manufacturing concept for redesigning facilities layout in Indonesian home-food industry: A case study. The TQM Journal. 2019 Sep;31(5):815-830, doi: 10.1108/TQM-02-2019-0033

[9] Orlova EV. Innovation in Company Labor Productivity Management: Data Science Methods Application. Applied System Innovation. 2021 Sep;4(3):68, doi: 10.3390/asi4030068

[10] Guia Espinoza R, Rios Del Castillo P. Lean – BPM Integrated model to improve productivity in SMEs in the aquaculture sector: A research in Perú. 11th Industrial Technology and Management Conference; 2022 Jul 18-22, doi: 10.18687/LACCEI2022.1.1.81

[11] Rahmanasari D, Sutopo W, Rohani JM. Implementation of Lean Manufacturing Process to Reduce Waste: A Case Study. IOP Conference Series: Materials Science and Engineering. 2021 Mar;1096(1):012006, doi: 10.1088/1757-899X/1096/1/012006

[12] Ashraf RB, Rashid M, Rashid AR. Implementation of 5S Methodology in a Food & Beverage Industry: A Case Study. International Research Journal of Engineering and Technology (IRJET). 2017 Mar;4(3):1791-1796 , doi: https://www.irjet.net/archives/V4/i3/IRJET-V4I3411.pdf

[13] Rizkya I, Syahputri K, Sari RM, Fadhilah N. 5S Implementation in Welding Workshop – a Lean Tool in Waste Minimization. IOP Conference Series: Material Science and Engineering. 2019 Jul;505(1):012018, doi: 10.1088/1757-899X/505/1/012018

[14] Aquino D, Rodríguez E, Quiroz J. Ergonomic Redesign Model to reduce musculoskeletal disorders in a cluster of SMEs in the clothing accessories sector. 20th LACCEI International Multi-Conference for Engineering; 2022 Jul l8-22, doi: http://dx.doi.org/10.18687/LACCEI2022.1.1.51

[15] Sunardi, Esya JA, Santoso B. Redesign of The Production Facility Layout by Using Systematic Layout Planning Method at Cahaya Bintang Mas Company Surabaya. Journal of Physics: Conference Series. 2020 Jul;1569:0322007, doi: 10.1088/1742-6596/1569/3/032007

[16] Gozali L, Widodo L, Nasution S, Lim N. Planning the New Factory Layout of PT Hartekprima Listrindo using Systematic Layout Planing (SLP) Method. IOP Conference Series: Materials Science and Engineering. 2020 Apr;847(1), doi: 10.1088/1757-899X/847/1/012001

[17] Haryanto AT, Hisjam M, Yew WK. Redesign of Facilities Layout Using Systematic Layout Planning (SLP) on Manufacturing Company: A Case Study. IOP Conference Series: Materials Science and Engineering. 2021 Mar;1096(1):012026, doi: 10.1088/1757-899X/1096/1/012026

[18] Kulińska E, Masłowski D, Dendera-Gruszka M, Zbyrad A. Analysis of solutions dedicated to non-conformity prevention. European Research Studies. 2020 Jun;23(3), 434-445, doi: 10.35808/ersj/1648

[19] Silva-Campusano D, Vega-Romero D. Improvement Proposal Applying Standardized Work and 5'S to Reduce the Rate of Returned Orders of a Poultry Company Under the PDCA Cycle. 7th North American International Conference on Industrial Engineering; 2022 Jun 12-14, doi: https://ieomsociety.org/proceedings/2022orlando/190.pdf