Improvement Proposal Applying SLP and 5S in the Confectionery Industry: Case of a SME in Peru

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Abstract

The objective of the present investigation was to propose a solution to the excessive generation of waste in a Peruvian SME dedicated to the production of sweet arare, combining both the Systematic Layout Planning (SLP) and the Lean Manufacturing 5S methodologies. The SLP methodology was used to optimize the distribution of the plant according to the production process and the 5S methodology proposed specific improvements at each of its stages. Through a simulation in the Arena software, it was validated that this solution reduces the proportion of waste produced to competitive levels in the industry, in addition to minimizing the material handling distance by 43.77% and the material transfer time by 8.75%.

Keywords
Confectionery, SLP, Lean Manufacturing, 5S, Candy industry

1. Introduction
According to the United Nations Industrial Development Organization or UNIDO (2022), the manufacturing sector plays a fundamental role as an engine of shared prosperity. To support this concept, the Economic Commission for Latin America and the Caribbean or ECLAC (2017) states that this sector is one of the essential sources of expansion of the global economy and generates large investments in research and technological development throughout the world. For example, in Peru the manufacturing industry became the lead contributor to the national GDP with an input of 2.1%, generated over one million direct jobs and more than 13 million soles in internal taxes (National Industry Society 2021). It is worth noting that this sector experienced a growth of 17.7%; in particular, the food industry presented growth of 7.4% and, in turn, the manufacturing branch of cocoa, chocolate, and confectionery products grew by 13.8% (SNI 2022). However, this growth is not free of difficulties, Gazdecki et al. (2021) point out that waste generation is one of the biggest problems in the food industry, due to its negative environmental, economic, and social consequences. This is because it leads to a great inefficiency in the use of raw materials, energy, and other resources, affecting the competitiveness of companies and therefore their stability in the short and long term.

In Peru, sweet arare is a newly introduced confectionery product primarily made from rice. An SME dedicated to its production faced a nearly 3% annual income loss (1695.66 soles) due to waste generation reaching 1.6% of its total production weight (500 grams per lot). This poses a problem for the expansion of its activities, as inefficiencies in its production process became evident and could further increase with a higher production volume. The main contributors to the elevated waste generation were found to be the unoptimized plant layout and general disorder in the production area, as the waste losses exclusively occurred during transfer between activities. Consequently, a solution proposal was developed by combining the use of the Systematic Layout Planning and 5S Lean Manufacturing methodologies to address each issue respectively. It should be noted that these tools were chosen for the low cost of their implementation, which makes them viable alternatives for strategic changes in SMEs in particular.

This scientific article is divided into 6 chapters: Introduction, Literature Review, Methods, Validation, Results, and Conclusions.

1.1 Objectives
The main objective of this article is to reduce the waste of an SME dedicated to the production of sweet arare down to 1.50% of its total production weight. Additionally, specific objectives were proposed to reduce the material handling distance by 30% and the material transfer time by 5%. To do so, a model based on the combination of Systematic Layout Planning (SLP) and the 5S Lean Manufacturing methodologies is presented, which will be applied exclusively to the production process of sweet a rare and the company workshop's layout. Thus, the contribution of this research is the strategic change in the company's activities at a minimal cost for a significant impact in its operations.

2. Literature Review
2.1 Waste in the Candy Industry
Waste in the candy industry is a widespread issue that can be triggered by different factors. An investigation in Russia by Kirushin et al. (2017) found that excessive waste was generated during the production of sugar cookies because of an inefficient layout, unoptimized production planning, and poor organization of tools and equipment. In the United Kingdom, Sibanda and Ramanathan (2018) determined that the lack of standardization in a company's chocolate production process led to poor quality, causing additional waste and losses. Ibarra et al. (2019) in Mexico found that that the lack of procedure guidelines caused excess waste in a lollipop factory. The difference in origin for waste across the industry highlights the importance of adapting the appropriate tools for specific applications.

2.2 Application of Systematic Layout Planning (SLP)
Long displacements with multiple crossings and turns during the production process can lead to higher handling costs, lower production capacity, and excess waste generation (Fauziah et al. 2017). In turn, the Systematic Layout Planning (SLP) methodology can be used to generate a new optimized layout that reduces the material handling distance based on the production process for a minimal cost and even generating significant savings (Haryanto et al. 2021). An efficient layout redesign considers the nature of both the labor and the laborer to create maximum synergy between them (Baccanti et al. 2021). The implementation of SLP by Ananda Esya et al. (2020) at a manufacturing company led to the reduction of the material handling distance by 68.72% and of the material handling costs by 44.7%. Likewise, Yang (2021) achieved a 65% material transfer time and 67% material handling distance reduction at an air equipment accessory manufacturer through the application of SLP.

2.3 Application of 5S
The 5S Lean Manufacturing methodology consists of 5 steps (Sort, Set in order, Shine, Standardize, and Sustain) focused on preventing dirtiness and disorder, and removing obstructive elements from the workplace (Verghese et al. 2018). Shahriar et al. (2022) also demonstrated its effectiveness at reducing motion and waiting time waste, by achieving up to 20.40% operation time reduction in a plastic bag manufacturing company through its implementation. Cristobal et al. (2020) implemented the 5S methodology in an alpaca wool workshop to obtain a 7% waste reduction, further proving its versatility and usefulness.

3. Methods
During the literature review process different investigations were analyzed and compared to better understand the use of the SLP and 5S methodologies to tackle waste generation. Two factors were identified as particularly relevant for the present article; Table 1 shows prior research and the tools used in each case to address said topics.

Table 1. Comparative Matrix.

Authors	**Relevant Factors**	
	Long and unoptimized material handling distance	Disorganized tools and resources
Adeodu, A., Kanakana-Katumba, M., & Rendani, M. (2021)		5S
Gazdecki, M., Gorynska-Goldmann, E., Kobus-Cisowska, J., Laba, S., Rejman, K., & Szczepanski, K. (2021)	Systematic Layout Planning	5S
Bouzon, M., Lista, A., Mostafa, S., Romero, D., & Tortorella, G. (2021)	Systematic Layout Planning	
Kirushin, S., Malafeev, A., & Vaskova, N. (2017)		5S
Llontop, J., Lora, A., Mamani, N., & Morales, C. (2020)		5S
Baccanti, F., Micheli, G., & Rampoldi, A. (2021)	Systematic Layout Planning	
Proposal	**Systematic Layout Planning**	**5S**

3.1 Proposed model
The proposed model was designed to address the root issues of the high waste generation in the sweet arare production process, taking the data collected from the company as an input to generate a tangible reduction in said indicator as an output. The SLP and 5S methodologies are included in the model to achieve this result.

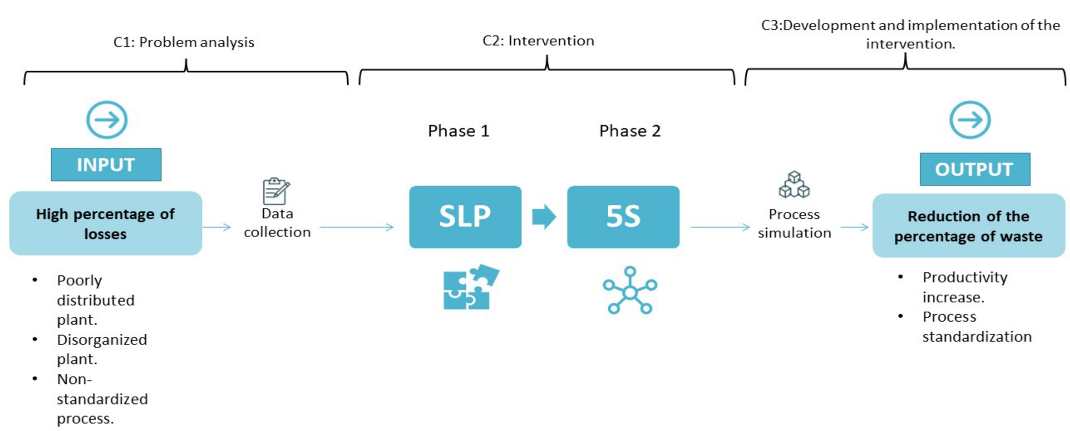

Figure 1. Proposed model.

This model consists of 3 main components, starting with the problem analysis of the base situation. The next component consists of the application of both the SLP and 5S methodologies to address the root issues of the high waste generation. The final component of the model is the development and validation of the solution proposal through simulation software to determine the final situation. This model provides a first reach into the application of different engineering tools for optimizing the production of sweet arare, a newly introduced product in Latin America.

3.1.1 Component 1 - Problem Analysis
This component consists of the identification of the root causes for the high waste generation during the sweet arare production process. The diagnosis was carried out through interviews with the company workers, measurements in

the workplace during production, and the collection of photographic evidence. The first root cause found was the inefficient plant layout, which generated a long material handling distance and several crossings and sharp turns to occur during production. The second root cause found was the lack of organization for tools, equipment, and resources, which in turn generated additional motion, wasted time, and a higher propensity to spill the product during production. These root causes were initially discovered with an Ishikawa Diagram, and their importance was tallied through a Pareto chart.

3.1.2 Component 2 - Intervention

The second component consists of the combined application of the SLP and 5S methodologies. SLP (Systematic Layout Planning) assists in the redesign of a manufacturing plant while reducing the total distance traveled through the production process and the probability of waste losses during transfer (Bouzon et al. 2021). The 5S methodology increases efficiency by standardizing the production process and removing unnecessary elements from the workshop (Adeoudu et al. 2021). Each tool was employed in a separate phase to ensure that the organization efforts from the 5S implementation would be focused on the new plant layout to avoid redundancy and achieve better synergy.

3.1.3 Component 3 - Development and implementation of the intervention

The third component consists of the validation of the end result of the solution proposal implementation. Research done by Gazdecki et al. (2021) established a 1.5% waste loss over the total production weight to be an industry-wide competitive indicator for grain products. A sustainable reduction in waste over total production leads to increased productivity, and the standardization of the new process conditions and operations leads to consistency in these results. Similarly, a reduction in material handling distance and material transfer time is expected due to the removal of obstructive elements and the generation of a new workflow route through the workshop.

3.2 Indicators

The following indicators were deemed appropriate to measure the effectiveness of the solution proposal. Their descriptions and formulas are detailed below:

Waste over Total Production Weight: To measure whether the amount of generated waste during the production process was within an acceptable value a comparison with the total production was required. As the final product is distributed in a 130-gram presentation, weight was chosen as the variable for the comparison. The total weight is calculated in relation to the weight of one sweet arare production lot.

$$Waste\ over\ Total\ Production\ Weight = \frac{Total\ waste\ weight\ in\ kg}{Total\ production\ weight\ in\ kg}$$

Material Handling Distance: As the key aim of the SLP implementation is the optimization of the workflow through the workshop layout, it becomes necessary to measure the total distance traveled in between production stages.

$$Material\ Handling\ Distance = \sum Distance\ traveled\ inbetween\ production\ stages\ in\ m$$

Material Transfer Time: As the optimization of the plant layout and the organization of tools, equipment, and resources is aimed at reducing inefficiency during the production process, the time between the start of activities in one stage of production and the end in another is an effective way to determine if the new distribution is effective.

$$Material\ Transfer\ Time = \sum Time\ taken\ between\ production\ stages\ in\ seconds$$

4. Validation

For the validation of the solution proposal, a comparison between the initial situation and the implementation was required. Firstly, the initial workshop layout and the corresponding workflow were examined, considering the different areas in which production activities take place. In this situation, the material handling distance was calculated to be 48.036 meters, and the material transfer time was 165.66 seconds.

Order	Area
1	Raw material storage and weighing area
2	Laundry
3	Cooking area
4	Kneading area
5	Multipurpose table 1
6	Drying cabin
7	Multipurpose table 2
8	Frying area
9	Multipurpose table 3
10	Packaging area
11	Storage and weighing area for finished products

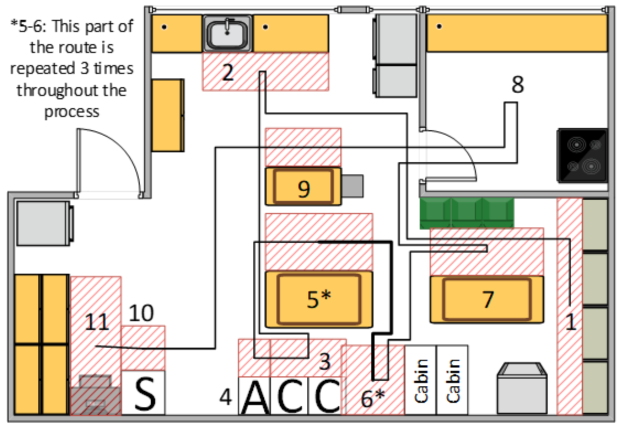

Figure 2. Initial workshop layout and areas.

Considering the initial scenario and the way the different areas were related to each other, the implementation of SLP called for the creation of a relational table where the closeness between areas was assessed based on criteria such as urgency, accident prevention, and possible effects of humidity and heat on elements in workshop.

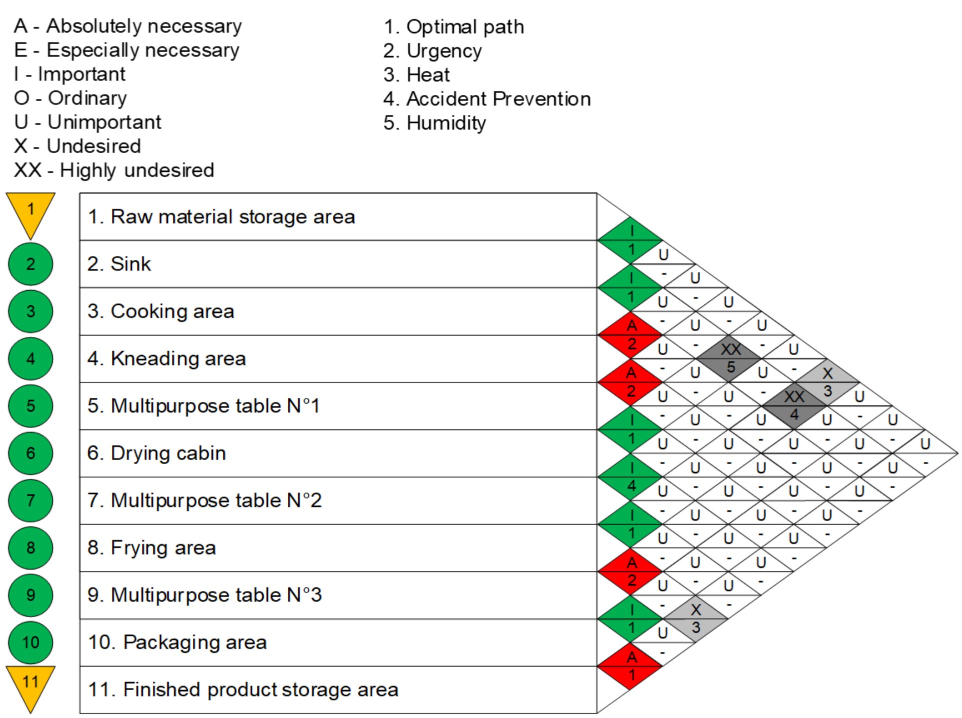

Figure 3. Relational table according to chosen criteria.

With this information, a new layout was designed to take advantage of the available space while reducing the distance traveled during the production process. The proposed layout has a material handling distance of only 27.011 meters.

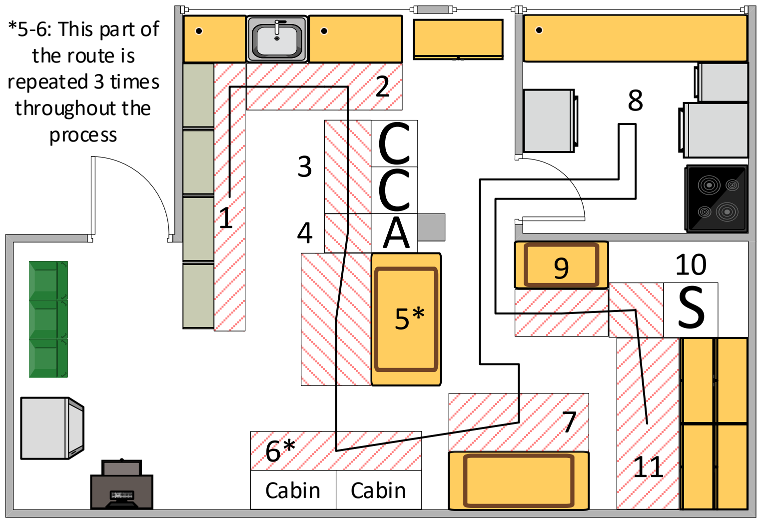

Figure 4. Proposed workshop layout

For accurate results, the material handling distance was calculated based on the distance traveled in the initial workshop layout and the proposed layout between areas or stages. The same areas were kept in both instances, but their distribution throughout the workshop varies based on the criteria from the relational table.

Table 2. Distance traveled by production process stage for each layout

Stage	Distance traveled in the initial layout (m)	Distance traveled in the proposed layout (m)
Area 1 to 2	8,549	2,940
Area 2 to 3	5,319	1,033
Area 3 to 4	860	850
Area 4 to 5	2,868	1,117
Area 5 to 6	10,893	5,070
Area 6 to 7	3,603	2,378
Area 7 to 8	5,542	6,118
Area 8 to 9	3,911	5,086
Area 9 to 10	5,740	951
Area 10 to 11	751	1,468
Total	**48.036**	**27.011**

The next phase of the solution proposal was the implementation of the 5S methodology. During the first component of the proposal, several foreign elements, such as a children's bicycle, were documented as being stored in the workshop. All elements that did not contribute to the sweet arare production process nor served any purpose in the workspace were set for removal (1S, Sort). All remaining elements would be required to have a designated space in the workshop (2S, Set in order) and then any potential contamination sources would have to be eliminated (3S, Shine). Afterwards, all procedures would be standardized to ensure that all workers know how to properly accomplish their duties (4S, Standardize), and finally, checklists and routines would be implemented to keep the changes stable in the long term (5S, Sustain).

Figure 5. Foreign elements and clutter in the workshop in the initial scenario.

The changes pushed by the proposal aim to deal with the lack of order in the workshop in its initial state, and instead optimize the space and time spent in it to reduce the possibility of waste loss and to increase productivity.

Figure 6. Agglomeration in the workshop's storage area in the initial scenario.

With the initial situation's condition properly assessed and the proposal changes already established, a simulation in the Arena software was used to validate the differences between each scenario and whether any substantial improvements were achieved. The simulation includes all production related activities and their time requirements based on statistical data obtained from multiple measurements made during the production process. The simulation starts from the moment the raw materials are taken from their storage area and ends when the finished product is placed in storage. For each iteration of the simulation, the average production in one month is processed, for a total of 30 iterations, and the intervention of the workers is accounted for whenever needed.

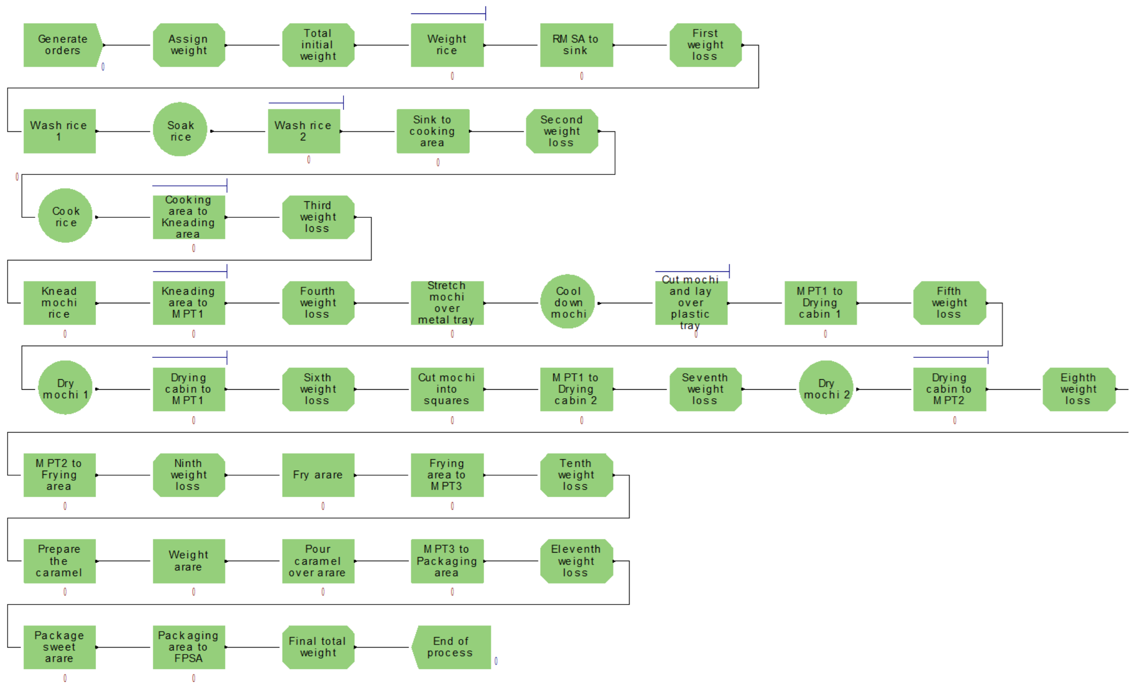

Figure 7. Simulated arare production process

Since the waste losses occur exclusively during transfer, these had to be accounted for in the simulation model, with the value changing based on the implementation of the solution proposal. Similarly, the time between each activity and the total production time were also improved by the implementation of the proposal.

5. Results and Discussion

After the simulation finished running, the main indicators were tallied to determine the effectiveness of the solution proposal. The following table contains the results from both the initial scenario and the scenario according to the solution proposal:

Table 3. Main indicators before and after the implementation of the solution proposal

Stage	Initial scenario	Scenario according to proposed solution
Number of orders served	64	64
Percentage of losses on total weight	1.6%	1.5%
Total cycle time (hours)	124.16	124.14
Total travel time (seconds)	165.66	151.15
Distance traveled (m)	48,036	27,011

As can be seen, the number of orders served remains constant, but the percentage of losses over the total weight decreases due to the proposed improvements. The total cycle time remains constant because the time spent in motion between activities constitutes a minimal fraction of the total duration of the production process, while stages that do not require human intervention, such as soaking and drying, last several days. The total travel time is analog to the material transfer time indicator and presents a significant improvement, since a reduction of 8.75% was achieved compared to the initial scenario, and the distance traveled is analog to the material handling distance indicator and presented the greatest improvement between scenarios, as it was reduced by 43.77% compared to the initial situation.

As the company's activities and product variety increase so will the importance of material handling distance as the workers will have to manage multiple production processes simultaneously, causing the distance traveled from one area to another to greatly affect their timely response capacity. Considering that timing is one of the most important factors in food production, any delays could lead to potentially losing entire production lots.

It should be noted that, if the methodologies employed in this investigation are to be used in another confectionery business, a prior analysis of the case must be carried out and their viability must be determined in relation to the root cause of the issue. In the case of Ibarra et al. (2019) for example, it was determined that Lean Six Sigma and DMAIC were a better fit, leading to a 36.51% decrease in losses. While in both investigations the issue at hand is excessive waste loss, in their case, the analyzed company was much larger in size and production volume with the root cause of their problems being lax production standards rather than an ineffective layout. The choice of tools to address the issue of waste loss is not a constant for all instances, but prior investigations can be used as a referenced when similar situations arise even across different industrial sectors.

6. Conclusions

The present investigation concludes that reducing the waste generation in an SME through the application of the SLP and 5S methodologies is possible, achieving the main objective of reaching a level of 1.5% waste over total production weight. Additionally, both specific objectives were surpassed, reducing the material handling distance by 43.77% (with an original objective of a 30% reduction) and the material transfer time by 8.75% (with an original objective of a 5% reduction). Furthermore, this implies that the 2.46% income loss would be reduced to only 2.29%. The reduction in income loss implies that more impressive results can be achieved in the future as the company grows over time and its operations increase both in complexity and scale.

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