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Original Article

Optimizing Fill Rate and Inventory Control in Peruvian Bakery SMEs through 5S and MRP Integration

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Abstract *- Nowadays, Small and Medium Enterprises (SMEs) are exposed to economic losses due to bad decisions, one of the main ones being the management of raw material inventories. This has consequences for the entire production and sales flow. Without the necessary material to produce, there are no products to sell, affecting the satisfaction of demand and, subsequently, the Fill Rate. Therefore, the motivation and objective of this research are to design an inventory management system and analyze the reasons and causes that decrease the fill rate of customers in SMEs in the bakery sector. To address this challenge, the objective is to raise the fill rate from 86% to an optimum of 94%, as indicated by the technical gap. The solutions are based on lean tools such as the 5S-Material Requirements Planning (MRP) methodology and demand forecasting methods. This proposed solution aims to improve the company's quantitative and qualitative indicators to make bakery industries more competitive in the changing and competitive market.*

Keywords *- Fill Rate, Warehouse Management, Inventory, Demand Forecast, 5S, MRP, Bakery Sector.*

1. Introduction

The bakery industry generates US$461 billion worldwide, and the market is 91% composed of artisanal or family bakeries, which are approximately 277,000 companies. The bakery sector in Peru has grown from 36.5% to 46.8% between 2007 and 2018. During the pandemic, this sector negatively impacted its production, reaching an index of 140.5 points, the lowest in recent years. Only recovering its production level in 2021 due to the state's economic reactivation by the state, reaching its highest point historically after 1 year and 2 months, with 206 points in the production index. The sectors with the highest participation in processed foods are bakery with 21%, dairy products with 20% and refrigerated products with 11%. [1] In Peru, only two out of every ten companies have an effective inventory management system or are in the process of changing it, and proper inventory management is essential to meet customer needs. [2] In the bakery industry, there are several problems, but the main one is the lack of inventory control of raw materials. [3]

The vast majority of SMEs in Peru and abroad have problems in the warehouse area, and 62.3% of small companies have inaccuracies in their inventories, which means that this is a very neglected area for SMEs. However, this is because warehouse management takes up a large amount of the total budget, making the management of this area inefficient. Not having it directly impacts efficiency, productivity and, above all, fill rate. [4, 5] Therefore, it is necessary to balance inventories since excess inventories are as costly as insufficient. [6] This leads customers to turn to the competition, making your company uncompetitive in a demanding and saturated market because a company that can satisfy its customers to a greater extent is more likely to survive. [7, 8] In other words, the consequences of not having an inventory of products have repercussions in the loss of sales and possible fines and the service provided to the customer will be affected. The organization of this article is structured as follows: The research starts with the detailed method, and what is already known in the literature is analyzed. Then, the contribution is explained. Then, the validation results are shown, and finally, conclusions and recommendations for the research are made.

The research gap identified in the article focuses on the lack of effective inventory management systems in Peruvian bakery SMEs, particularly regarding raw material control. The study points out that while inventory management is crucial for customer satisfaction and competitiveness, many small bakeries struggle with maintaining optimal stock levels, leading to a low fill rate and inefficient operations. This gap is

further emphasized by the limited implementation of structured inventory systems and continuous improvement tools, like 5S, MRP (Material Requirements Planning), and demand forecasting, within this sector and in a specific company.

2. Literature Survey

2.1. Fill Rate and Inventory Management

The bakery industry must have optimal inventory management for 3 reasons: the industry's products are perishable, it is a highly competitive and demand-sensitive sector, and it must take into consideration tools that correctly manage this area. [9] Otherwise, millions of tons of food are incinerated or dumped in open areas, causing large proportions of greenhouse gases and directly affecting people's and the environment's health. [10] Inventory management in the bakery sector is complex because it is an industry that produces many products with the same raw material in all its production lines. Inventory inaccuracy is a recurrent problem in manufacturing companies and can be translated within an organization as inefficient inventory management, low productivity, efficiency and, above all, low fill rate. [11] Other authors mention that the management and storage of materials is one of the objectives of any company to correctly manage its inventories. [12] Other marketing views maintain that increasing the fill rate makes you competitive since satisfying the customer will allow the company to survive in the market. [13,14] Therefore, it is necessary to balance inventories; excess or shortage of inventories is equally costly. But a shortage makes you lose confidence with customers. [15] Similarly, the fill rate requirement has been widely used in both theory and practice to measure inventory management performance. It is usually defined as a probabilistic constraint for demand to be satisfied with a high probability. By enforcing a fill rate requirement, companies can improve the Quality of Service (QOS). [16-18] In view of the above, the following authors show us some consequences that refer to a low fill rate and show us their point of view about the low fill rate. They mention that having a fill rate of almost 100% is an optimal and ideal objective and can be achieved if there is a fast and efficient supply chain to respond to demand and production instantaneously. However, the uncertainty and unpredictability of customers, suppliers and manufacturing systems make it a challenging goal. If product inventory is unavailable for some impatient customers, sales may be lost, and the level of customer service will suffer. Giving ideas on some consequences of having a low fill rate. [19]

2.2. 5S

Inventory accuracy is enhanced with continuous improvement tools. For that reason, it uses the 5s to improve operations within the warehouse. [20] Additionally, applying this tool contributes to reducing the search for materials in the inventory. The 5S methodology is responsible not only for promoting cleanliness and reducing waste in the inventory but also for reducing the search time for materials [21], which is an objective of the research. This tool aims to achieve an efficient and uniform operation in the workstations. [22] To complement the tool, VSM, line balancing and plant distribution concepts are used together with the 5s to have a much more global vision of the area, achieving favourable results in each application. Reduction of cycle time, inventory time, and non-value time by 34, 14 and 32%, respectively, reaching an inventory accuracy of 98.17%. However, more implementations of other Just in Time (JIT) based tools that will increase the benefits of 5s should be done. [23] This methodology also impacts safety policies, hygiene, material sorting, etc. Moreover, using this tool makes it easy to understand workers, as only conventional knowledge of the discipline and high commitment are required. However, understanding inventory management requires more time; workers must be trained and develop criteria to make decisions before less common situations occur. [24]

2.3. MRP

Identifying items within the inventory and determining the frequency of use and/or demand for subsequent implementation are regularly performed prior to the implementation of the MRP system. On the one hand, some authors focus on solving stock-outs and/or overstocks. [25,26]. On the other hand, other authors focus on reducing costs, shrinkage and irregularities within inventories. [27-29] MRP systems are now widely adopted to feed assembly lines due to their ability to control material flows. However, not only that, it is adaptable to almost any area of the company, from the production part to the administrative part; all this is because MRP works through simple and effective visual management of information. [30] Finally, it mainly mentioned 9 different implementation barriers that were identified in the MRP system, which are: lack of knowledge of the methodology, the confidentiality of data, complicated data collection, biased analysis, fear of product shortage, fear of failure of suppliers in delivery time, fear of a new implementation technique, the resistance of human resources, need for new investments. [31]

2.4. Forecasting Methods

Inventory management contributes to the improvement of efficiency and fill rate. Some companies prefer to ignore the variability of demand, either due to a lack of knowledge or a lack of forecasting tools. Forecasting is a decision support system that integrates a set of quantitative tools with managerial judgment and knowledge. [32] After the ABC classification of raw materials, the A classification PMs are assigned to the double exponential smoothing forecast, B to the simple exponential and C to the moving average system. However, Holt and Winters's forecasts should be used after the ABC analysis. However, one thing that these three authors agree on is the use of the Mean Squared Error (MSE), which is the one indicated for comparing different forecasts. [33] On the one hand, when it comes to the manufacturing sector,

production requires a solid and reliable plan because cost overruns can occur without it. To avoid this, one tool used is demand forecasting. Producers increasingly need forecasting and planning processes. [34-36] On the other hand, demand forecasts are important to always have material to produce and not to enter a critical state where the company's sales are harmed. [34].

2.5. Challenges for SMEs

Regarding the standardization and distribution within a raw material warehouse, some of the frequent problems are not distributing the raw material correctly, as well as delays in the warehouses, either by searching for materials or by the disorder that exists within the area. [35] In view of this, an inventory system based on the use of Unmanned Aerial Vehicles (UAV) for monitoring, surveillance and data collection in real-time is proposed. Similarly, entering industry 4.0, they make a proposal for the implementation of automated vehicles and the creation of a route planning algorithm in real-time mentioned implementations represent a challenge for bakery SMEs due to the cost of the systems and requirements, in addition to the maintenance of these and the complex algorithms. [36] On the other hand, there is an inventory gap in the stock movements within the area. In view of this, the implementation of a piezoresistive smart textile sensor is proposed, which is placed on a shelf and the item on top of the sensor to record the movements or weight of the stock from a smartphone. Similarly, the identification and recording of stock by means of Ultra-High Frequency (UHF)-Radio-Frequency Identification (RFID) antennas mounted on a robot that drives along designated routes, emitting signals and identifying the items. [37] The mentioned implementations do not represent a high cost for the bakery SMEs; however, both implementations present restrictions of use in these SMEs, the most important ones the presentation of the articles and the articles inside the warehouse, since the textile sensor presents a sensitivity of 0. 5 to 1.5 kg and the items in the warehouse exceed 9 kg or are at the limit with 500 g or lower weights. On the other hand, reflective objects such as aluminium foil in bakeries represent location errors of up to one meter in the signals of the UHF-RFID antennas. [38, 39]

3. Methodology

After the literature review, the main tools to solve the research problem were identified, based mainly on the success cases identified in the state of the art. This will allow for an increase in the fill rate in the bakery sector cluster.

3.1. Proposed Model

The proposed model integrates the tools of the lean philosophy to eliminate identified operational waste, the forecasting method to improve demand management and MRP to optimize the supply of materials required in the process; these techniques have been identified in the state-of-art through the success stories reviewed in the literature. Within the lean philosophy, the 5S tool for this work is to achieve correct warehouse management within the loss of products and contribute to improving the accuracy of inventory records, as this indicator is enhanced with tools of order and cleanliness.

The lack of supply reference and the high forecast error will be solved with the forecast method and MRP, and this will allow making supply decisions to cover future attention and thus avoid errors due to the attempt to guide the forecast by an empirical method or based on simple experience. The proposed model is shown in Figure 1.

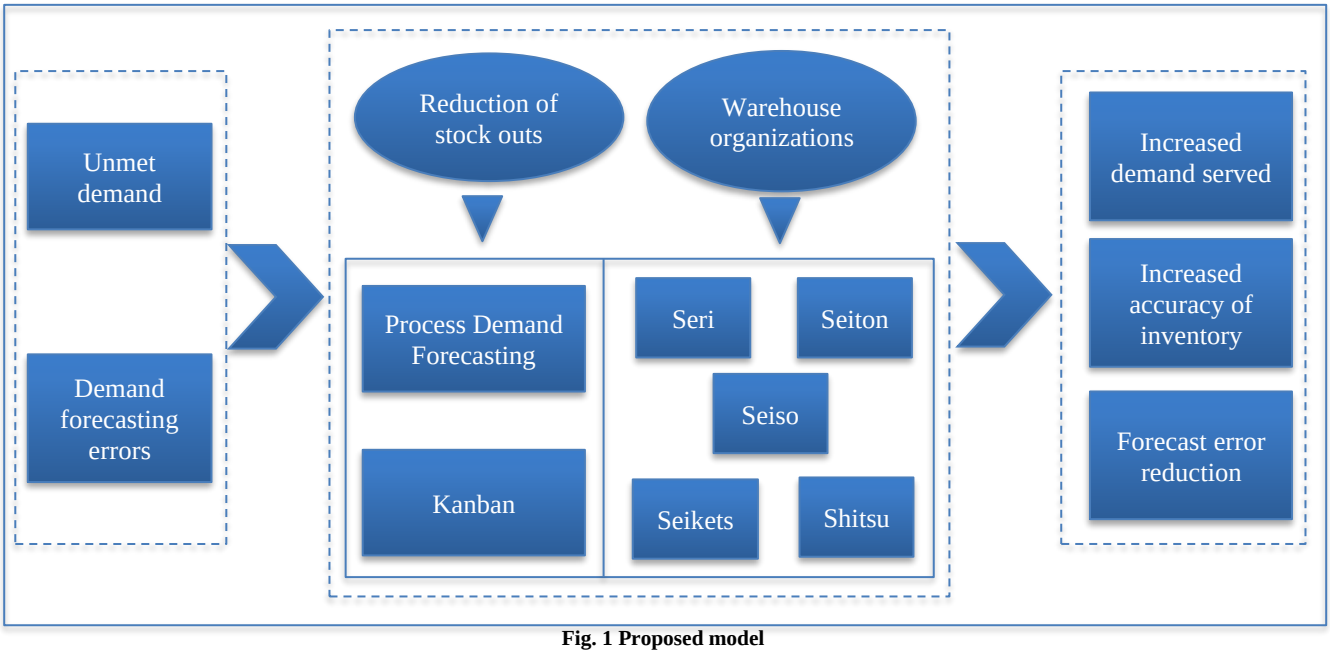

Fig. 1 Proposed model

3.2. Model Components

3.2.1. Reduction of Stock-Outs

The first component is the reduction of stock out, which seeks to prevent the lack of materials in the raw materials warehouse. This component can be achieved by having a demand forecast with a very low expected error, and that can help to know what will be required in the future; in the same way, the references in terms of inventory levels are important for this; in the same way, references in terms of inventory levels are important for this, not having a guide that mentions how much to supply and what actions to perform, there are no references to avoid stock depletion, seen in this way can be counted with the tools of forecasting method and MRP, this to ensure instructions, actions to be taken and methods within the supply stage.

3.2.2. Warehouse Organization

The organization of the warehouse is developed due to the loss of raw material in the organization warehouse, which is considered, within the Lean philosophy, the 5s tool since being linked to the loss of raw material due to the disorder in the warehouse, the mentioned tool is one of the main ones now of wanting to carry out the organization of a work area. Regarding team building, the principal authors of the methodology development will be the company's workers. The success of the 5S lies in how constant and disciplined you are over time. Since it is a continuous improvement tool, its application does not stop; constant changes and new learning exist. Therefore, the team in charge of its implementation must be committed and prepared. The main functions of the 5S team are indicated in Table 1.

Table 1. Functions of the 5S team

Responsible	Function
General Manager	Director
Chief Operating Officer	Supervisor
Warehouse workers and Operators	Collaborators

The training will be provided to the entire team so they know the tool in depth and its components.

3.2.3. 5s

- Seiri: A list of unnecessary items for the area is made, and these are assigned red cards depending on their frequency of use; actions will be taken for these items. The items should not be marked for more than two days and are temporarily stored in a space assigned by the supervisor for no more than 15 days. Finally, action is taken on the marked items.
- Seiton: According to the frequency of use of the elements necessary for the area, these will be ordered in such a way that those used at every moment must be closer to the workers.
- Seiso: With the use of a layout, the spaces where the raw materials will be stored are established, as well as the evacuation routes, signalling, etc. signalling the workers themselves are the ones who know their work area best. They will oversee cleaning their areas, as well as recognizing substandard acts and conditions that exist in their workspace since these are also key to promoting cleanliness.
- Seiketsu: To maintain what was achieved in the first 3S, it is necessary to raise new questions with respect to concerning being applied to create new mechanisms to maintain what has been achieved in terms of organization, order, and cleanliness.
- Shitsuke: Internal audits are conducted for each of the 'S' to verify whether the tool is maintained over time.

3.2.4. Demand Forecasting Implementation

The current forecast error presented in the case study is a 27.19% error. Within the implementation of this tool, I first determine the pattern that the 2 most important products in the company follow, both Ciabatta bread and Frances bread; in the first attempt, having the forecasted monthly demand vs. the actual demand, it was not possible to determine a clear pattern within the demand. Therefore, bimonthly data were taken, and a trend and seasonal pattern were determined for both pieces of bread.

Similarly, reviewing the literature and looking at the forecasting methods used in this bakery sector, it was observed that among the most popular methods are the Winters method and the double exponential smoothing method or Holt's method. Both methods are then developed for the two types of bread and compared according to the error obtained in the ECM or mean square error. For French bread, Winters' method is the minimum error found among the methods developed. Similarly, for Ciabatta bread, Winters' method is the minimum error found when comparing methods.

3.2.5. MRP Implementation

For the implementation of the MRP, the raw materials located in the warehouse that are necessary to produce Frances's bread and Ciabatta bread were identified, obtaining as raw materials dry yeast, fresh yeast, salt, flour, sugar, oil, lard and butter. For these raw materials, the average supply time 1 was identified, and knowing that the target fill rate is 94%, the optimum batch, EOQ, and safety stock of raw materials were calculated based on the previously determined forecast.

Thus, a minimum and maximum stock for each of the products is obtained. Likewise, EOQ is being used since it reinforces the control of the general costs of possession, which allows a better understanding of value generation in terms of payment and financing conditions.

4. Implementation and Results

4.1. Implementation process of the proposed model

Figure 2 shows the process required to implement the proposed improvement model.

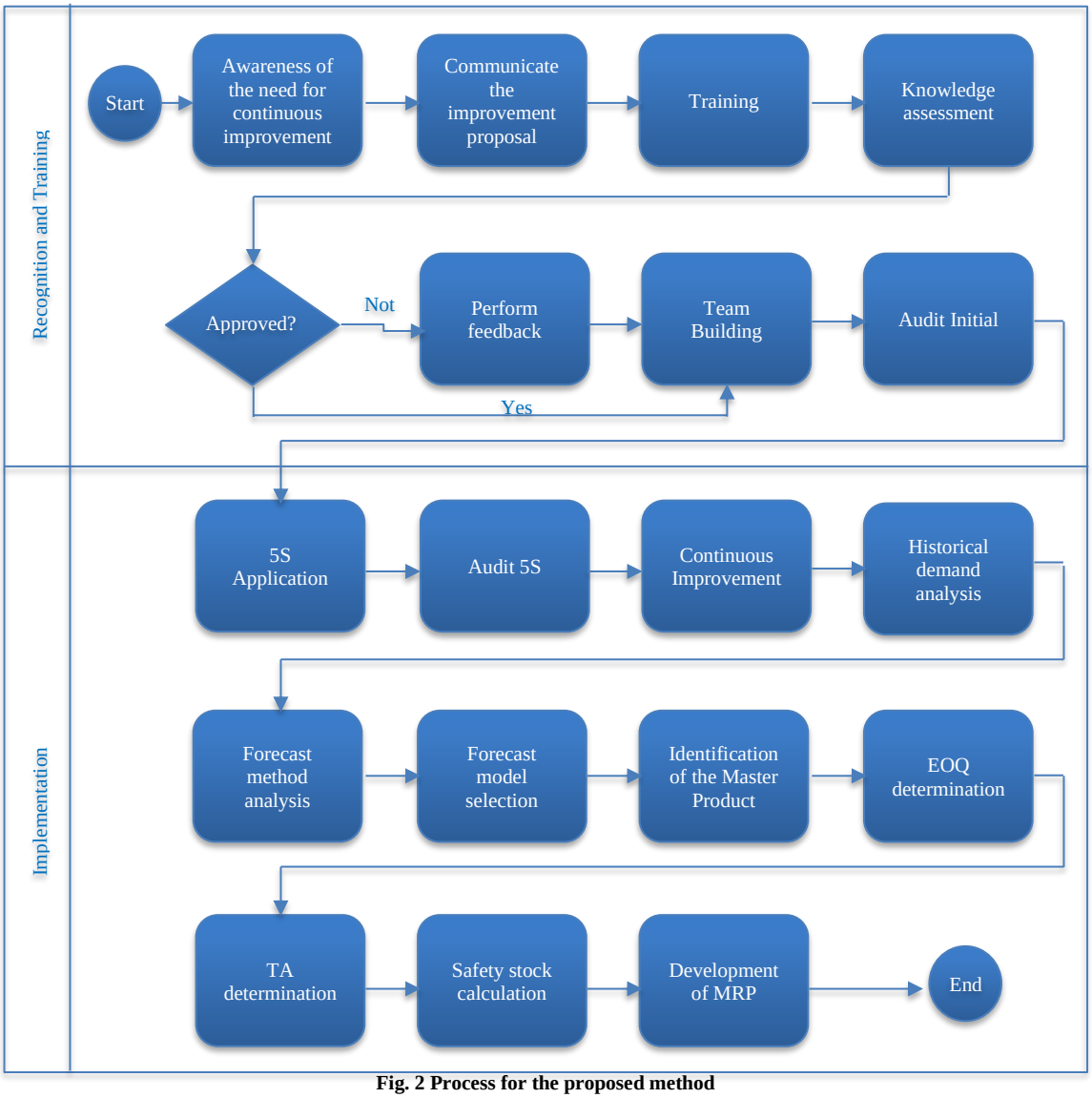

Fig. 2 Process for the proposed method

4.2. Model Indicators

The performance evaluation indicators are presented below:

- Fill rate indicator: Quantifies the performance in sales sold and the level at which they are served in the organization.
  Objective: Increase the Fill Rate by 8% in the French Bread and Ciabatta Bread lines.
- Forecast error: This indicator shows the confidence level in the chosen forecasting method versus actual demand.
  Objective: Decrease the forecast error by 22% in the French Bread and Ciabatta Bread lines.
- Stock-out: This indicator is defined as the inability to meet the required demand.
  Objective: Decrease stock out of stock by 9% in the French Bread and Ciabatta Bread lines.
- Accuracy records inventory: This indicator oversees measuring the concordance between what is recorded and the actual raw material.
  Objective: Increase inventory recording accuracy by 28% in French bread and Ciabatta bread lines.

5. Validation of Results and Discussion

For the validation of the proposed model, pilot plans were carried out to validate the improvements proposed in the model indicators: 8% according to the optimal fill rate, forecast errors should be reduced by 22% points, and stock-outs should be reduced from 14% to 5%.

Finally, inventory recording accuracy will increase from 67% to 95%, and all the results are given in Table 2.

Table 2. Expected results

Indicators	Current (%)	To be (%)	Objective (%)
Fill Rate	86	94	8
Forecast Error	27	5	22
Stock out	14	5	9
Accuracy Records Inventory	67	95	28

5.1. Validation Basis and Proposed Model

The validation of this research is based on the pilot plan of the three tools in the bakery 'La Ciabatta' to obtain real results and check the influence of these chosen tools in their impact on the Fill Rate. The pilot plan of the 5S methodology will be carried out according to the steps outlined, and at the end, a comparison of the results before and after the development of the tool will be made.

5.2. Validation of 5S

5.2.1. Before Implementation

The analysis of the current situation, according to criteria established from S1 to S5, yields a result of 8 points out of a possible 50. This indicates that there is a need for improvement in terms of classification, order and cleanliness so that these can be standardized in the long term and create continuous improvement over time. The results of the initial audit before the implementation of 5S are shown in Figure 3.

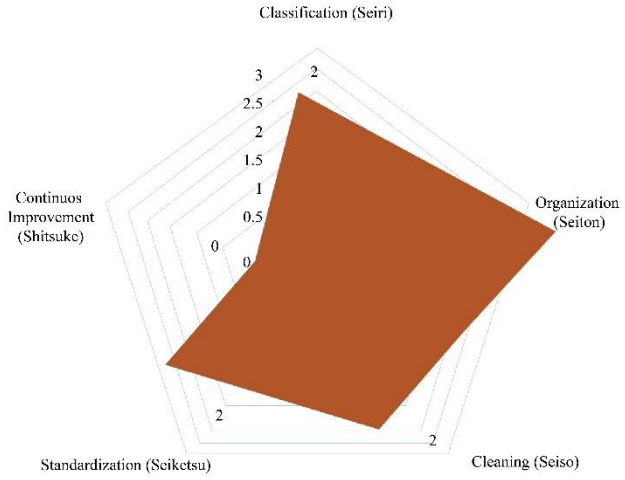

Fig. 3 5S Initial audit results

5.2.2. Pilot Results

The results after implementation improved concerning the first evaluation by 16%. A total of 37 points were obtained, representing 74%, 58 percentage points more than the initial assessment. It is worth mentioning that although there is a significant difference between the two evaluations, it is still necessary to create discipline to maintain the good practices of the methodology and continue improving over time and get closer and closer to 100%, as shown in Figure 4. The impact that the implementation of the 5s has had so far on the accuracy of inventory recording is 19% more than the initial one. Achieving an ARI of 86%. However, we know that the optimum is 95%. And for this, we will have to wait for the following months to continue evaluating the development of the tool.

5.3. Validation of Demand Forecasting

To enter the validation of the forecasting method, we must know that before implementing a suitable method, the method used was based on a forecast found empirically, i.e., the production manager found the demand by simple experience. Therefore, for the pilot plan, we used an automated form that was delivered to the company, and the results are shown in Table 3.

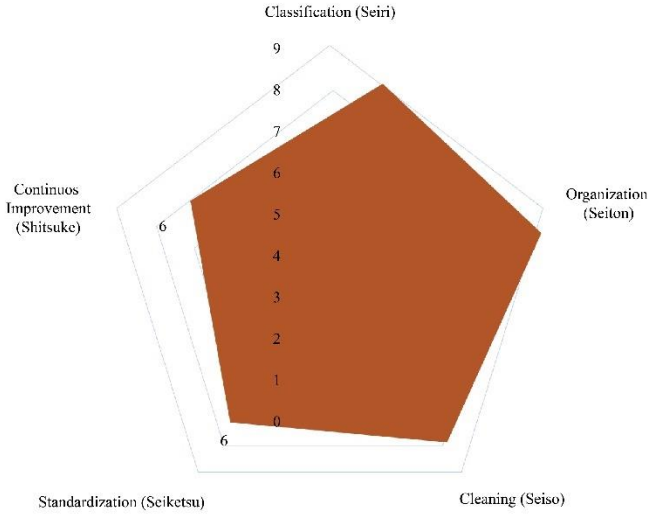

Fig. 4 5S Final audit results

5.4. Validation of MRP-EOQ

For this last part of the validation, knowing that one car of bread is equivalent to 400 loaves of Ciabatta or French bread is essential. Likewise, the raw material for each standard product must be identified. By identifying the inputs of these raw materials, we can know the EOQ and SS based on demand, as shown in Figure 5. With this calculated data, we can enter the corresponding data into the form to form the MRP in an automated way.

5.5. Economic Validation

The company will budget this project entirely, taking out of sight the loan it makes in specific projects.

To show the feasibility of this project, the Net Present Value (NPV), Internal Rate of Return (IRR), RCB, and Total Revenue (TR) will be used. The income and savings are reflected in Table 4.

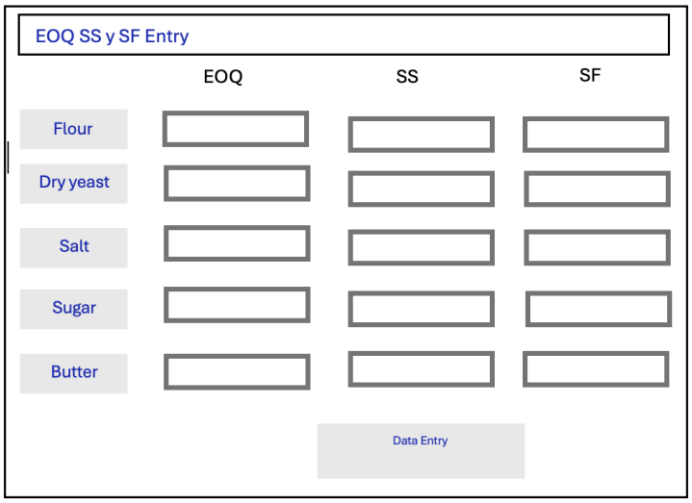

Fig. 5 French Bread and Ciabatta MRP form

Table 3. Results of Improved Demand Forecasting

Period	Demand	A	T	S	Forecast
	0			1	
1	24,388	24,388.00	0	1	
2	30,455	25,054.82	178.284	1.088	24,388.0
3	29,123	25,660.64	292.592	1.055	25,233.1
4	35,422	26,677.94	486.353	1.186	28,245.8
5	24,755	26,756.91	377.435	1.002	28,666.5
6	35,466	27,437.46	458.476	1.230	32,193.9
7	27,925	27,893.09	457.715	1.002	27,950.9
8	46,104	29,354.62	726.098	1.370	34,870.6
9	39,970	31,160.48	1014.789	1.117	30,129.8
10	43,095	32,097.35	993.949	1.359	44,066.3
11	43,716	33,756.40	1171.780	1.190	36,957.4
12	47,451	34,928.18	1171.780	1.359	47,451.0
13	41,644	35,978.92	1139.420	1.177	42,954.3
14	50,431	37,118.72	1139.519	1.359	50,426.4
15		34,053.30	15.269	0.694	**45,014.1**

Table 4. Economic validation

Indicators	Value
Penalty Savings	PEN 1,977.12
Total Profit	PEN 10,984.00
Revenues (Savings + Profit)	PEN 12,961.12
Initial Investment	PEN 6,565.50
Net Present Value	PEN 9,243.54
Internal Rate of Return	52.96%
Benefit-Cost Ratio	2.41
Payback Time	2.15

Table 5. Actual Vs. desired results

KPI	Results			To be Improved (%)
	Expected (%)	Actual (%)	No Desired (%)	
Fill Rate	94	89	86	5.00
Stock out	5	8.80	14	3.80
ARI	95	86	67	9.00
Forecasting error	5	9.50	27	4.50

5.6. Economic Results

Although we have not yet reached the desired level in any of the indicators, this is due to the short time that certain tools have been implemented. However, the improvement over what it was prior to using the tools is significant. This is how we see how using the right tools can give favorable results to a company, regardless of the industry. So, the actual and expected results are in Table 5.

6. Conclusion

A model is proposed to increase the fill rate of the bakery sector, and from the final observed results, the following conclusions have arrived:

- From the results it is concluded that due to the implementation of the 5S tool, MRP and forecasting methods, the Fill Rate increased to 92% within a period of 4 months in certain tools and others a little less.
- As the proposal is established and new improvement options are generated, the indicator will continue to increase. The results were achieved using the stock breakage and forecast error indicators.
- The opposite is the case of inventory registration accuracy, which, with the implementation of the 5S, increased but did not reach the desired level because this methodology is being strengthened over time. It is still too early to observe actual results.
- Using the 5S methodology over a period of 4 months improved the accuracy of inventory recording by 29%. However, this could increase over time. The development of the tool is still in the process of standardization and, subsequently, continuous improvement.
- The authors use the Fill Rate concept differently since no clear consensus establishes its idea. Many authors refer to it as a 'level of service'. When working with these concepts, it is vital to be clear when setting the route and objectives of the proposal.
- The order in this type of company, and even more in MSEs, often need to be considered, but it turns out to be one of the factors that may cause the product to be defective or a problem to occur during preparation.

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