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Improving Warehouse Management Processes to Ensure On-Time Delivery of Paprika-Based Products

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Abstract–

On-time deliveries are considered a strategic factor for the market positioning of companies. Such is the case of the company under study where only 76.5% of orders arrive on time, compared to 90.2% of companies in the same sector in Colombia. The causes of the problem are an inadequate management of the raw material warehouse processes, causes such as the lack of organization of the physical space that lengthen the preparation of orders, inefficient inventory control processes at the entrance and inside the warehouse and inadequate handling. These have caused losses of raw materials due to pyrolysis, shortages, and delays in production and therefore the rescheduling of the delivery date of orders. In order to improve these processes, we implemented the 5S and a redesign of the warehouse, simple sampling, ABC analysis, cyclic counting and EOQ model. As a result, an increase in orders delivered on time of 12.53% and an economic impact of $ 399,599 in a period of 5 years excluding implementation costs and a net cash flow in the first year of $ 9,810.

Keywords — On-time deliveries, warehouse management, warehouse design, paprika, raw materials

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I. Introduction

According to the World Bank and the Turku School of Economics in the logistics performance survey conducted among clients of private sector companies and individuals in the international logistics sector, where respondents rated how often shipments reached the consignee within the time scheduled or expected from 1 (almost never) to 5 (almost always). Peru obtained a score of 3.45, ranking below countries such as Chile 3.80, Brazil 3.51 and the United States 4.08, the latter being the best positioned in the region [1]. In Peru, according to the latest National Survey of Companies published in 2017, only 38.3% of companies nationwide have a functional area of Logistics and purchases/storage and detailed that 23.5% considered delivery time a relevant factor for market positioning [2]. In the case of the company, being a company in the food production sector such as paprika pepper, postharvest factors that cause loss of quality and properties during storage must be taken into account [3]. Storage losses in developing countries such as Peru are between 20 and 50%, generating problems for the final consumer, such as unplanned deliveries and low quality [4]. The origin of these losses in warehouses can be considered of 5 types: environmental conditions, infrastructure, processing, treatment and handling methods. Environmental factors include temperature, humidity, and sun exposure, among others [5].

In order to improve storage processes, the following previous efforts have been made. A storage system called block stacking reduced spoilage losses by 55% [6]. An automated retrieval system helped reduce setup time by 5% and controlled stock with 95% confidence [7]. The V-shaped design increased collection efficiency by 25% [8]. Likewise, the impact of 5S was evaluated after being implemented in a case study of the food industry, after clearing, ordering, cleaning and standardizing the storage, reception and preparation areas, work time decreased by 12%. and product returns in 89.2% [9]. Given the rescheduling of delivery dates caused by shortages, the lack of a warehouse control and management policy, and constant losses [10], the use of cycle counting was proposed, reaching an inventory accuracy of 99.95%. and reducing losses by 12% in the first quarter of execution. The contribution of the article is aimed at implementing a proposal to improve preparation times, reduce the percentage of pyrolyzed paprika and improve the flow of information within the raw material warehouse, having as its central axis the design of the warehouse layout, incorporating tools and techniques. such as 5S, simple sampling, cycle count, EOQ method, ABC analysis and Good Storage Practices for food products. The objective of the case study is to provide a guide to improve warehouse management processes and increase on-time deliveries.

II. State of the Art

The state of the art is made up of 4 typologies where we classify and analyze the proposed solutions used to address our issues.

A. *Warehouse, inventory and production optimization models*

The authors [11] [12] in this typology present linear and nonlinear programming with the objective of creating a storage model that considers shelf life and variable supply demand, in order to reduce storage costs and counteract variations in supply and demand; after implementation, a reduction of 8% in stock-outs and 1.7% less deteriorated raw material is obtained. Results below expectations because the authors mentioned that they did not take into account variables such as ABC classification, warehouse design, etc., in order to reduce the cost of storage and counteract variations in supply and demand.

In another case study, the preparation and physical distribution times, which were not addressed by previous authors [13], generate quality and stock out problems, time losses, low productivity, and stock confusion. Therefore, the approach of material flow simulations to plan and validate control strategies [14]. The use of simulation in material flow analysis ultimately helps in material flow evaluation and planning [15]. Within the area of inbound logistics, a discrete event simulation system was developed to understand and compare the effects of changes in delivery windows, inventory management policies [16]. In the case of warehousing, loading, and unloading systems were simulated to minimize the dwell time of any truck at the dock [17]. As a result, a 36% increase in productivity and a 75% reduction in waiting points were observed.

B. *Techniques and tools to improve productivity in warehouses*

The application of Lean Manufacturing techniques in warehouses has proven to be useful for the elimination of waste, reduction of unproductive times and optimization of activities and processes. Authors such as [18], [19] [20] faced with problems such as excess waste in the warehouse and orders delivered out of time due to excess time, personnel movements and increase of defective products, this motivated the authors to implement tools such as VSM, Kanban and 5S. The 5S helps the sustainability of the company through the classification, ordering, standardization, and maintenance of new processes after the implementation of the VSM and in conjunction with the Kaban method, the elimination of defective products. In this way, these authors were able to increase orders delivered on time by 25 and 26%.

Another factor to take into account is the human factor and how labor time in activities such as order picking is getting longer and more tedious [21]. Picker-to-parts systems where human operators walk or travel through the warehouse and pick the requested items account for 65% of warehouse operating costs [22]. Therefore, the authors proposed the integration of the VSM ABC classification and warehouse design, to identify the activities that do not generate value and the warehouse design classification of products with ABC method and thus managed to reduce the preparation times by 22.38%.

C. *Production and warehouse management and control systems*

Faced with the difficulties of order picking, control of warehouse processes caused by factors such as layout, storage allocation, routing, and order batching policies, lead to inefficient warehouse management and control. The proposed solutions involve new Layout and 5S designs in conjunction with mathematical models or simulation software. The objective is to evaluate more quickly and objectively various warehouse scenarios and configurations, space allocation and picking routes. The authors [23] [24] applied a warehouse design, linear programming, and ABC analysis for 2 important points within the warehouse firstly the ergonomic and economical optimization of the layout for item allocation and secondly to improve the efficiency of stock handling. The efficiency of warehouse processes is improved by reducing travel time and cost in replenishment and order picking [25].

Evaluating the operational and strategic issues, 5 planning and decision problems are identified: distribution design, storage allocation, zoning (the division of the warehouse into other zones), batching (the accumulation of smaller orders into larger lots) and finally the routing through the storage area [26].

For them both authors [24] [25] in the search to solve their 2 most important points within the warehouse plan a U-shaped storage design which obtains the following results. Reduction in ergonomic stress and the total travel time is reduced between 33% and 50% compared to the rest of the solutions proposed to date.

D. *Methodologies to improve storage processe*

Within the warehouse it is crucial to control processes such as quality measurement, inventory control, tracking and traceability. As was the case of a Peruvian food company that had returns of 2.1% of the total shipped, the problem was inefficient warehouse management and cross-contamination, the authors [36] faced with this and in search of increasing shelf life and eliminating cross-contamination. The authors applied tools such as value mapping (VSM), Pareto, Ishikawa KPI's to perform an initial analysis and based on this apply the 5S methodology, SPC tool and HACCP system. The results of the pilot implementation were very satisfactory, with an 89.2% reduction in returns compared to the previous year.

Regarding the process of inventory control, tracking and traceability, the authors [28] [29] [30] proposed the implementation of systems to optimize the inventory management process in a real context of preceding food products to minimize the total cost of inventory management, the most widely used strategy being the EOQ. Within the food industry, the analysis starts from determining an optimal configuration of reordering policies that cannot overlook shelf-life constraints [30]. This policy was applied to an Italian food processing company obtaining results such as 38% savings in maintenance costs, improving the service level with up to 99% effectiveness and reducing spoilage losses by 18%.

Finally, other strategies for control and follow-up are cyclic counting by ABC classification and simple sampling. The cyclic counting model by ABC analysis is a very efficient tool; its application improves the effectiveness of physical inventory counting and consequently the reduction of shortages, improving the profitability of companies [31]. This tool applied in the logistic sector distributor of perishable PM managed to maintain inventory control with an accuracy of 99.95%, reducing inventory losses by 13.59%. In relation to the simple sampling by attributes, it is performed by taking a lot size N, qualifying it according to its tributes in conforming or nonconforming elements. The lot is accepted or rejected according to the acceptance-rejection criteria, i.e., the maximum number of nonconforming elements allowed in the sample, all determined according to an acceptable quality level (AQL) [32].

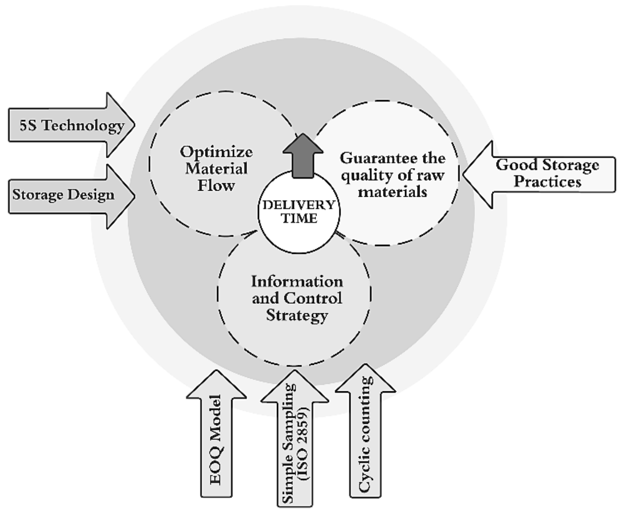

Fig. 1 Conceptual model

III. CONTRIBUTE.

According to the problem of orders delivered out of time and the causes identified in the warehouse which motivate the problem, the following solution model is considered.

A. *Conceptual model*

According to the author [33], a professor at the University of Tokyo who, in the search for efficient and sustainable warehouse management, proposed 3 components which are linked as follows: 1st component to optimize the flow of materials, 2nd component to guarantee the quality of raw materials and finally the information and control strategy.

1) *Optimize material Flow*

The first component to be implemented is based on the following techniques.

Storage design and 5S: The warehouse design follows the design of the authors [26] [34] who propose a U-shaped design and taking into account the considerations involved in the storage of paprika, what is sought is the reallocation of spaces for an existing structure, improve the flow of materials and reduce the time and preparation of orders. As for the 5S technique, it will be applied in order to order the spaces pre and post implementation of the warehouse design, create a culture of cleanliness and standardize the new preparation processes [35] [36].

2) *Guarantee the quality of raw material*

This component seeks to improve environmental conditions to guarantee quality and eliminate pyrolysis and reduce reclassifications:

Good Storage Practices: The set of rules and laws oriented to guarantee the quality and maintain the characteristics of food products, related to the first component in the warehouse design, are applied.

3) *Information and control strategy*.

The third component to be implemented is based on the following techniques.

Cycle counting technique to reduce losses and variations in inventory, which will be complemented by an ABC analysis using a time-of-arrival valuation criterion.

EOQ model: the application of this model is aimed at managing purchases responsibly, saving maintenance costs and controlling the inventory position below the limit and reducing pyrolysis losses.

Simple Sampling (ISO 2859): technique that follows a system of acceptance by attributes, this sampling is determined by lot size, inspection level and an acceptable quality level (AQL). Applied for characteristic control processes.

B. *Implementation of the system*

The implementation will be divided into 2 stages, the first stage is the implementation of warehouse design and 5S, following the guidelines of the good storage practices, the second stage consists of the implementation of the information and control strategy component which is constituted by the techniques of cyclic counting, EOQ model and simple sampling. The steps to be followed are summarized in Figure 3 below.

1) *Stage I.*

Warehouse design and 5S: The implementation follows the steps of the author [37] classified according to a six-sigma approach and is developed as follows. Define, the minimum requirements for infrastructure, order, stowage, and environmental requirements are considered according to the storage guide for primary agricultural foodstuffs and NTP 011.051.2010 (revised 2020). Measure, 5-star diagrams are made for the processes of reception, location, storage, order preparation and dispatch, the objective is to evaluate the ASIS

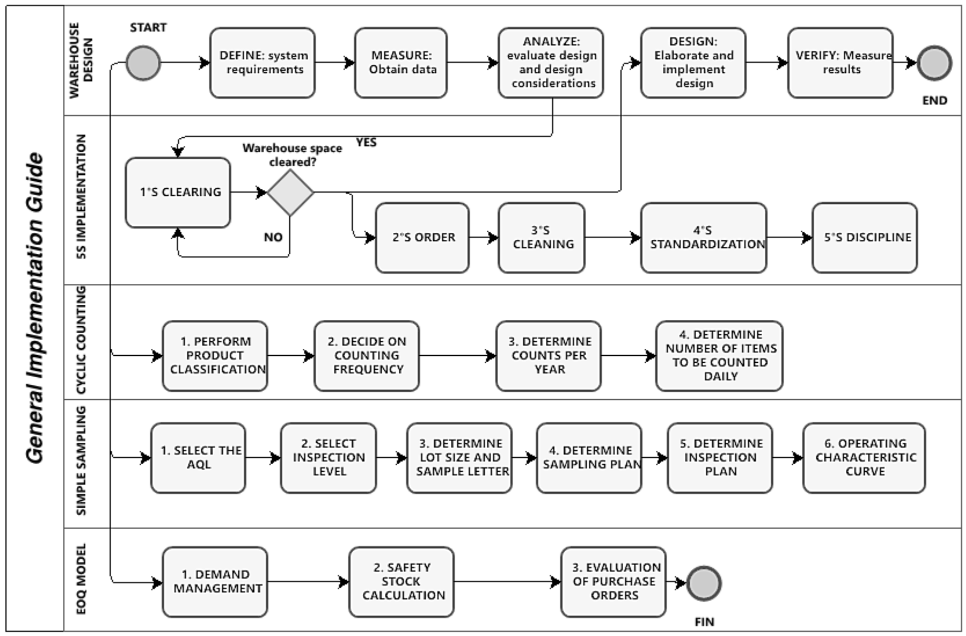

Fig. 2 Design of the proposed solution model.

of the warehouse prior to the construction of the new design. Analyze, the selected design is U-shaped with 4 levels, composed of 40 blocks and each block will be able to store 2 pallets and each pallet 8 bags. Design, the height will be 8.34 m by a length of 10.82 m and a width of 7.21 and an aisle of 4.81 m will be able to store 80 pallets (See Fig. 3). Since 232 pallets are required per month, the storage area will consist of 3 equal areas. To verify, a time study will be carried out to measure the new order picking time and a WTP.

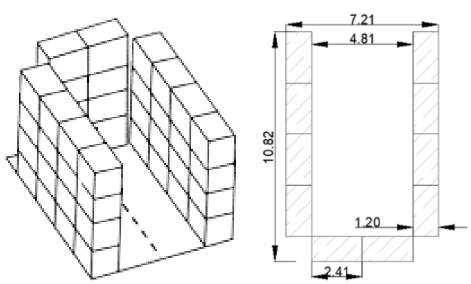

Fig. 3 U-shaped warehouse design.

As for the 5S that in the initial audit, it was found that tidiness (57%) and cleanliness (67%) are below the average of the others, therefore these should be given higher priority.

1S° Clear: Sorting and selection activities were carried out in the warehouse with the help of registers and the red card to label and classify the items.

2S° Sort: On the U-shaped layout, the circulation aisles, preparation areas were painted, and to identify the batches, pallet labeling with a pallet code was to identify the batches, pallet labeling was implemented with a bar code in accordance with the GS-128 standard.

3°S Cleaning: A cleaning register and inspection and review procedures were created, and cleaning shifts and work groups were assigned.

4°S Standardize: Standard operation sheets are developed for receiving, picking, cleaning and temperature taking activities in the warehouse.

5°S Discipline: An improvement record was drawn up to show the results obtained and provide evidence of significant improvements in the PM warehouse.

2) Stage II

Simple sampling: It is developed in 6 steps and following NTP-ISO-2859-1 (2018), in first step is to select the quality level of acceptable (AQL) the most used are 0%, 2.5% and 4%. Second step is to select the inspection level which for this study is level II. Step three is to determine the letter according to the lot size and level. Step four select plan type, the selected plan is the simple plan, since we will be governed by a certain number of defective items to accept or reject the lot. In the fifth step in the sampling plan table with the help of the AQL and letter mentioned above, the number for the acceptance criteria and rejection criteria is obtained. Finally, we construct the operating characteristic curve that will allow us to measure the reliability of our sampling plan.

EOQ Model: The implementation of the EOQ model is developed in 3 steps:

Demand Management: In order to know the future demand and to be able to calculate the EOQ, forecasting models are used, which will be subjected to forecast error indicators to select the one that best fits the behavior of our data. It is recommended to use sales data for at least 3 years.

Safety stock calculation: To avoid problems of stock-outs and taking into account that delivery time is variable, the safety stock and replenishment point are calculated in order to avoid stock-outs, improving the service level, the safety stock calculated for a variable provisioning time is 16.35 tons and the replenishment point is 55.42 tons.

Evaluation of purchase orders: This is done through the application of the EOQ model, requiring data such as annual demand, cost of ordering, maintenance rate and unit cost of the product. The optimal purchase lot of 41.03 tons would allow us to maintain the optimal inventory capacity and minimize total storage costs.

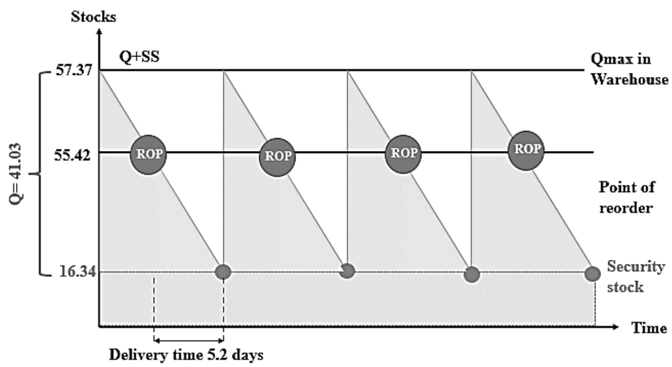

Fig. 4 Graphical representation of the EOQ model.

Cyclic counting: It was developed in the following 5 steps. The first step is an ABC classification of products using the criterion of time in stock because only one type of raw material is used. The second step is to choose the counting frequency for the ABC category, according to the literature, the 4-2-1 criterion was followed, higher frequency for A and so on. The third step is to multiply the number of items per lot of each classification by the counting frequency and obtain the total counts per year. The fourth step divides these counts by the total number of days to be worked during the year to obtain the number of items to be counted daily. Finally, count each category daily the corresponding number of times.

C. *Performance indicators*

To measure the final situation and compare the final vs. initial situation, the following indicators were selected See Tables 1 of the book [38].

TABLE I
INDICATORS

Indicator	Formula
Level of compliance dispatch	$\frac{\text{[No. of shipments completed on time]}}{\text{[Total number of dispatches required]}}$
Inventory aging	$\frac{\text{[Pyrolyzed paprika units]}}{\text{[Paprika units in inventory]}}$
Inventory Accuracy	$\frac{\text{[Value difference (\$)]}}{\text{[Total value of inventory]}}$
Warehouse capacity used	$\frac{\text{[Capacity Used]}}{\text{[Maximum warehouse capacity]}}$

V. VALIDATION

The selected validation method is by means of simulation, success cases and pilot of the simple sample, the chosen simulator is the Arena Simulation software since it allows the user the process of elaboration, validation, and experimentation of the model in a graphic environment. The systems to be analyzed are:

A. *Graphic representation diagrams of the system*

- Inventory system with reorder point.

This system simulates the EOQ model with a fixed replacement point, the input variables are lead time, quantity to buy, safety stock and demand. The output variables are the final stock and whether or not raw material shortages occurred.

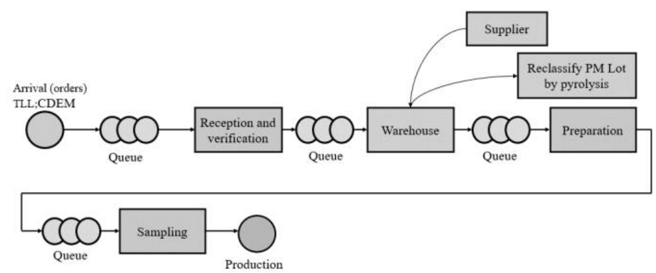

Fig. 5 Representation of the inventory system with repeat point.

- Picking and order preparation times.

This system simulates the preparation times of raw material for production within the new warehouse design. The input variables are the number of production orders and the collection time of the 3 stevedores. The output variable will be the total average preparation time for each order.

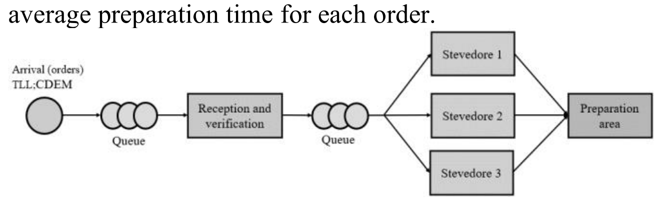

Fig. 6 Representation of raw material order picking system.

- Raw material bag reception process.

This system is the representation of the new reception process where a sample is made based on the lot size. Once the sampling number is selected, it is weighed, to verify, separate and correct the weight of the bags that enter.

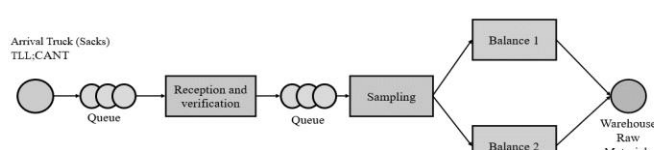

Fig. 7 Representation of the system of taking weight for sampling.

The simulation process consists of collecting the input data for each entity of the system, the data treatment is performed to adjust them according to a distribution with the help of the Input Analyzer ensures a safety level of 95%, then the model is built in Arena and calculates the number of replicas, finally the output is obtained and analyzes multiple scenarios and the results obtained.

B. *Evaluation of results*

Inventory system with reorder point.

The purpose of this simulation system is to reduce the amount of reclassified PM and to reduce the warehouse capacity used. The results obtained were:

TABLE II
ANALYSIS OF RESULTS AND SCENARIOS

Concept	Pessimistic	Moderate	Optimistic
Product Shortage (Tons)	0.0	1.2	0.1
Stock on Hand (Tons)	225.1	62.3	97.3
Time in the System (Minutes)	88.0	87.4	92.4
Reclassified Raw Materials (Tons)	23.1	0.0	0.0

Picking and order preparation times.

The aim of this simulation system is to measure the preparation time of 180 orders which should not exceed the standard time of 96.92 min in a moderate scenario. 164 of the 180 orders were delivered in less than 96.92 min.

TABLE III
ANALYSIS OF RESULTS AND SCENARIOS

Concept	Pessimistic	Moderate	Optimistic
Time in System (Minutes)	99.97	86.83	74.75
Operator 1	93.70%	79.63%	81.77%
Operator 2	93.49%	79.55%	82.45%
Operator 3	-	80.19%	73.48%

Raw material bag reception process.

With the implementation of the pilot, the aim was to analyze that the weight with which the bags enter the warehouse is within the range of 38.5 and 45 kilos and to calculate the probability of acceptance. Batches 4, 5, 8, 9 and 11 are rejected (see Table IV) and will have to be weighed in their entirety, the batches entered in the pilot month have a reliability level of 92.84%.

TABLE IV
SIMPLE SAMPLING RESULTS

Lot	Lot size (quantity of Sacks)	Sample size	Compliant	Observed	Probability of acceptance
001	452	50	47	3	89.46%
002	569	80	76	4	78.51%
003	378	50	49	1	99.40%
004	427	50	45	5	65.10%
005	475	50	43	7	27.59%
006	384	50	48	2	96.43%
007	428	50	47	3	89.46%
008	416	50	44	6	51.19%
009	625	80	73	7	27.59%
010	350	50	49	1	99.98%
011	439	50	43	7	27.59%
012	543	80	77	3	96.43%
013	602	80	78	2	96.43%
014	345	50	47	3	89.46%

Performance indicators:

The results obtained from the simulation are measured with the indicators (See Table V), which show the percentage reduction in the causes of the reasons.

TABLE III
ANALYSIS OF INDICATORS AS IS VS TO BE

Indicator	Initial situation	expected situation	Obtained result
Level of compliance dispatch	75.4%	95%	91.11%
Inventory aging	8.7%	3.5%	1%
Inventory Accuracy	14.1%	2%	7.16%
Warehouse capacity used	119%	90%	28.4%

The reduction of the causes of the problem generates that the reasons for the problem are reduced increasing the orders delivered on time (See Table VI).

TABLE IVI
RESULT OF REDUCTION OF ORDERS DELIVERED AFTER THE DUE DATE

Reasons for late deliveries	Order	Reduction	Deliveries on time	Difference
Raw material reclassification	25	88%	18	7
Production Delays	20	65%	13	7
Delays due to raw material shortages	9	88.9%	8	1

Orders delivered on time were initially 76.5% but have now increased to 89.03%.

C. *Economic impact*

The economic impact assessment is carried out to measure the viability of this research project, for which we will use the following financial indicators: NPV, IRR, CBR and DRP.

1. *The positive flows of the project.*

Positive cash flows for the 5-year duration of the project are as follows.

TABLE VI
EXPECTED POST-IMPLEMENTATION SAVINGS

Savings	Quantity	Unit amount	Total amount
Savings on overtime pay	5943 hours	$ 1.85	$ 10,996
Saving of pyrolyzed paprika	160 ton	$ 952.35	$ 181,812
Penalty payment savings	43 orders	$ 579.73	$. 99,449
Savings on extra-customary payments	43 orders	$ 340.67	$. 107,341

It is expected that after and during implementation, savings distributed over the 5 years of the project will amount to $ 399,599, not including implementation costs. In the first year, subtracting the costs involved in the implementation, the net cash flow will be $ 9,810.

In addition, it is necessary to calculate the financial indicators with the help of a net cash flow for 5 years, which is the duration of the project, and the following financial indicators were calculated.

TABLE VII
FINANCIAL INDICATORS

Financial Indicator	Value
NPV	56,940
IRR	61.3%
CBR	2.73
DRP	3.08

The NPV >0 indicates that the project is viable.

The interest rate of return is 61.3%, which indicates that the project is profitable.

The benefit-cost ratio (CBR) = 2.73 indicates that the benefits outweigh the costs.

With the discounted recovery period is 3.08 years or 28 months or 828 days.

V. CONCLUSIONS

The problem identified was late deliveries due to production delays, stock-outs of raw materials, and reclassification of raw materials caused by inefficient management of certain warehouse processes such as reception, storage, control, and preparation.

The expected results after the simulation, validation through success cases and pilot plan within 5 years is the increase of on-time orders by 12.58%, which would go from 76.5% to 89.03%. In addition, an improvement in preparation times from 96.92 min to 86.83 min is expected, increasing the level of order fulfillment from warehouse to production from 75.4% to 91.11% and a reduction of pyrolyzed paprika of 7.7%.

In addition, it is expected to save $399,599 of the costs involved in late deliveries, a recovery of 69.33% of the total costs, which are distributed over the 5-year duration of the project.

For an initial investment of $32,986 and for a projected term of 5 years after calculating the financial indicators, the following NPV greater than 0 was obtained, which makes the project viable, an IRR of 61.3%, a benefit-cost ratio of 2.73, which indicates that the benefits are greater than the expenses and finally the payback period of the investment is 3.08 years or 28 months. In addition, in the first year a net cash flow of $9,809 is expected, discounting the costs involved.

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