LUMEN ET VIRTUS

Strategic packaging in the supply chain: Benefits and challenges

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ABSTRACT

The packaging must have the goodness of being strategic, a fundamental characteristic to be related to the proper maintenance of the good or product. The objective of the research is to analyze the economic effects that low-quality packaging has on the auto parts industry of the automotive industry in Guanajuato, Mexico, compared to packaging that has a good design and is constantly improving. 190 auto parts companies participated, there was a margin of error of 1.59% with a confidence level of 95%. Information was collected on pieces discarded due to poor packaging quality over a two-year period, 2022 and 2023. For the analysis, the statistical model of moving averages and dispersion measures under the standard deviation was used. The results were significant identifying inefficient packaging in the raw material and its economic impact on the organization. As well as well-designed packaging or packaging that undergoes continuous improvement, it implied significant cost reductions for the company.

Keywords: Strategic packaging, Auto parts, Automotive industry, Supply chain.

INTRODUCTION

Packaging is any product made with materials of any nature and that is used to contain, protect, handle, distribute and present goods, from raw materials to finished articles that have been made to later distribute them in the market for consumption. All disposable items used for this same purpose will also be considered packaging (Drupa, 2024; Redding, 2024).

The packaging must have the goodness of being strategic, a fundamental characteristic to be related to the proper maintenance of the good or product, which allows its properties to be preserved during each of the different stages of the supply chain, the design must facilitate handling, resist the effects of the pile-up and also tolerate the execution of the marking or labeling for its location, identification and routing (Ghosh, Roy, Khan, Mondal, Ezati, & Rhim, 2024; Long, Ceschin, Mansour, & Harrison, 2020).

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Some of the main characteristics of strategic packaging (Lora-Guzmán, Cardona-Arbelaez, & García-Cediel, 2023) are the following:

1) The raw material used must comply with the technical descriptions, maintaining quality to protect or shield the risks of contamination.
2) Packaging must be designed to allow for easy stacking while safeguarding products throughout the supply chain.
3) The packaging must respond to the demands of the products they seek to preserve and, in the same way, comply with the requirements of the authorities that regulate these provisions, whether they are phytosanitary, environmental, safety, among others.
4) On the materials with which the packaging is made, they must have those properties that can resist changes in temperature that they may suffer.

The supply chain is the biological tissue that connects suppliers, manufacturers, distributors, and consumers. From product design for sale, production to customer service, finance to strategy, virtually everyone touches the finished product or service, where packaging is no exception (Ciravegna, Pletto, & Pasini, 2024; Dominic, and Olsmats,. 2023; Metapack, 2023).

There are four elemental forces that are impacting packaging and posing challenges to it: the pressure to reduce the total cost of importing, the birth of new technological sensors, the blurring of product and packaging information, and short-term market lifestyles across industries. All these variables have a negative and significant influence on the strategic packaging that represents paradigms to be solved (Zhao, & Song, 2023).

The delivery of the product through strategic packaging, that is, its transfer from the time it is produced until it is in the hands of the customer, includes a wide range of operations that integrate its collection and transfer where the quality of the packaging due to its handling can be disrupted. The quality of the packaging in its delivery is given by the distance between the quality incorporated into the product after its manufacture and that which it maintains at the time of its transmission to the customer, taking care that it does not incorporate any rate of external defects that are questioned when they reach the customer's hands.

The quality of delivery, through strategic packaging, this function of several operations: the rate of internal defects that the organization does not correct; the efficiency of storage, packaging and delivery processes, which condition; the availability of the product at the time of its demand, which determines the speed of the service; and whether the specifications achieved in the manufactured product are maintained after delivery to the customer at the agreed point or after the end of the presentation of the service (Islam, S., Shakil, Hossain Sarker, Nayem, Akter, Sachcha, & Yasmin, 2024)

Therefore, many basic quality characteristics emerge when it comes to ensuring delivery quality, including the suitability of the product's distribution channel. It is convenient to appreciate the importance of packaging in this dimension of quality. A product may not achieve a high quality of conformity, deteriorate quickly due to improper packaging, break or damage the contents. It is equally necessary to balance the attention given to the virtual design of products and the tangible quality of the continents through which they reach the customer (Sarkar, Habib, Sarker, Rahman, Alam, Manik, Nayak, & Bhandari, 2024).

The influence that packaging has on product quality has been pointed out, although it is true, the constant search for optimization and improvement is a key factor in the success of companies and is essential when the objective is to achieve exceptional results in operational processes. Continuous improvement, applied with a focus on cost reduction, seeks to reduce costs by eliminating waste and optimizing the use of resources (Firdaus, Nursanti, & Achmadi, 2024; PR Newswire, 2021).

It is important to clarify that this should be carried out without the need to add something to the packaging, which represents money, but to work with what you have and explore all the ways that mean an approach to excellence. After this description, it is concluded that identifying areas of opportunity in existing packaging becomes a possibility where all levels of the company, from the operator who receives the component at its point of use to the plant manager who makes its daily trips, can collaborate to improve the indicators that are currently managed within the company. representing great opportunities aimed at continuous improvement (Basavegowda, & Baek, 2021; Panou, & Karabagias, 2023).

In order to design good packaging, appropriate to the functions it will have to carry out as an accompaniment to the product and capable of satisfying those who will have to deal with it – producer, transporter, distributor, consumer – it is very important to take into account not only the demands imposed by the content, but also those of the material, the conditions of storage and transport, of the behavior and culture of the customers, without leaving aside the conditions where the packaged merchandise will be safeguarded within the final facilities before its acquisition by the consumer (Li, 2023; MarketLine Company Profile: Crown Holdings Inc.,2023)

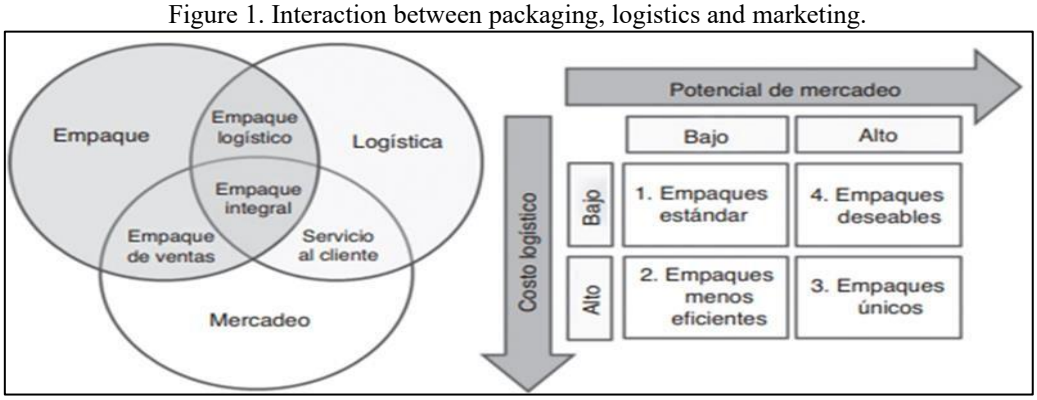
Understanding the role of packaging in logistics in a comprehensive, practical and methodological way is a prerequisite for making appropriate decisions considering the value chain, thus avoiding the inefficiency of the processes involved. The relevance of packaging is essential to give a sufficient advantage to the organization. Additionally, taking into account the elements that depend on the channel, location and socioeconomic status, such as product information and promotions, are important factors for the definition of packaging.

The purpose of packaging is to protect the goods in the course of their transport; during handling and when making preliminary, intermediate and terminal storage. Before any route planning

and hiring of carriers, an efficient packaging must be prepared that includes prior engineering, forgetting the misconception of putting together a "package" but of finding the functional value of the packaging on the basis of real technical requirements, respecting international requirements; such as weather conditions (humidity, heat, condensation, among others); the risks of manipulation or manoeuvres (blows, oscillations, spills, vibrations of vehicles on the roads due to potholes. Ditches, and a few others.), contact with dangerous goods. risk of theft, vandalism, storage time and its type (outdoors, in warehouses, and others) (Zou Shasha, Ibrahim, Abidin, & Ishak, 2023).

Given the multidisciplinary nature of packaging, it is necessary to define a comprehensive packaging that considers the impacts and benefits it can have in the areas of logistics and marketing as shown in Figure 1. The matrix on the right side highlights the existence of 4 types of packaging according to the level of impact they may have on logistics activities (logistics cost) and on marketing (marketing potential):standard packaging that generates both a lower logistics cost and a low marketing potential; desirable packaging (ideal situation) that implies a high marketing potential and a low logistics cost; less efficient packaging that generates a high logistics cost and a low marketing potential (anti-ideal situation); and unique packaging that produces benefits.

Figure 1. Interaction between packaging, logistics and marketing.



Source: Taken from Saghir (2024).

Taking into account the influence that packaging has on product quality, and the costs they represent for manufacturers, it is important to mention how investing in the continuous improvement method of packaging is a smart action (Firdaus, Nursanti, & Achmadi, 2024; PR Newswire, 2021). that brings profits that include:

a. More agility: Increased speed and efficiency of the packaging process, leading to increased productivity.
b. Lower costs: Continuous improvement reduces packaging process costs by improving process control and reducing waste.
c. Higher quality: Continuous improvement helps improve the quality of packaged products by improving accuracy and reducing defects.

d. Customer satisfaction: Increasing the efficiency of the packaging process leads to higher customer satisfaction. Process safety: through the identification and elimination of risks.

RESEARCH OBJECTIVE

To analyze the economic effects that low-quality packaging has on the auto parts industry in Guanajuato, Mexico, compared to packaging that is well designed and constantly improving. Therefore, the hypotheses proposed are as follows:

H1: Inefficient packaging in the raw material generates loss of raw materials, causing an economic impact on the organization.

H2: Packaging that is well designed or undergoing continuous improvement can mean significant cost reductions for the company.

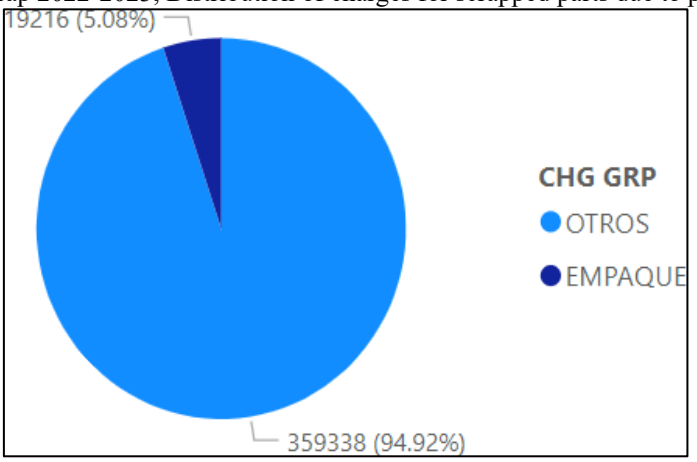
METHODOLOGY

Out of a universe of 200 auto parts companies in Guanajuato, 190 participated, which represented a margin of error of 1.59% with a confidence level of 95%. The general director of each company that collaborated in the investigation was contacted, disclosing the objective and confidentiality of the information. Information was collected on pieces discarded due to poor packaging quality over a two-year period, 2022 and 2023. The data was filtered to exclude waste generated by damage caused by the same plant. For the analysis, the statistical model of moving averages and dispersion measures under the standard deviation was used.

RESULTS

In hypothesis 1, the role played by a poor structure of a package in terms of economic impacts caused by the loss of raw material was established. For this study, an average of 19,216 pieces of various products were derived for each company, which were discarded due to their impact on quality. See Figure 2.

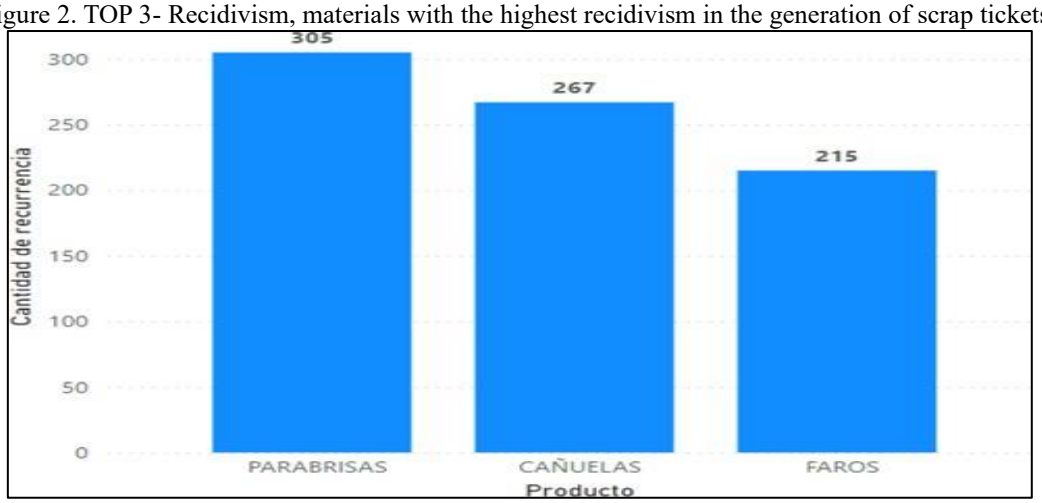
Figure 1. Scrap 2022-2023, Distribution of charges for scrapped parts due to poor quality.



Source: Authors.

All of these 19,216 pieces were distributed in 332-part numbers, some of which showed a high rate of recidivism. The recidivism of three was found significantly, which are illustrated in Figure 3, highlighting the products pipes, windshields and headlights with the greatest impact on the recurrence of scrap tickets. This indicator measures the occasions in which the impact on the quality of the part implied additional time for the plant personnel, in order to carry out a validation and request approval of disposition from the support teams that are quality and packaging. Therefore, this represented losses of time, human and monetary resources, on average for each company of $4,000,000.00 pesos considering only the three products commented on.

Figure 2. TOP 3- Recidivism, materials with the highest recidivism in the generation of scrap tickets.

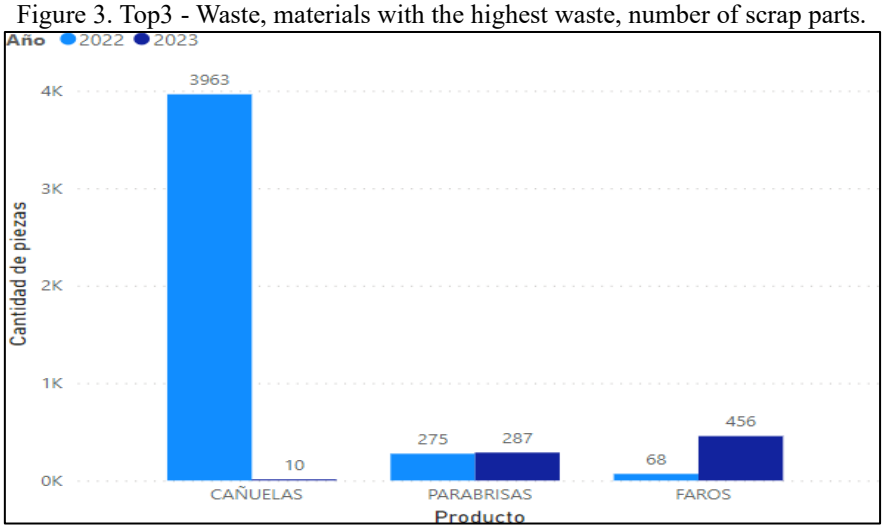


Source: Own elaboration

However, and continuing with the products that show a high recidivism rate in terms of the number of parts that do not meet the integrity and quality standards required to be entered into the production line, Figure 4 shows the data segregated by year. This made it possible to visualize the impact that inefficient packaging has on the company, causing additional times and processes that are not contemplated in the standard operations of operators. To ensure the clarity of the study, the

punctual monitoring of the products was segregated as follows: Case #1- Cañuelas, Case #2- Windshield, Case #3- Headlights.

Figure 3. Top3 - Waste, materials with the highest waste, number of scrap parts.



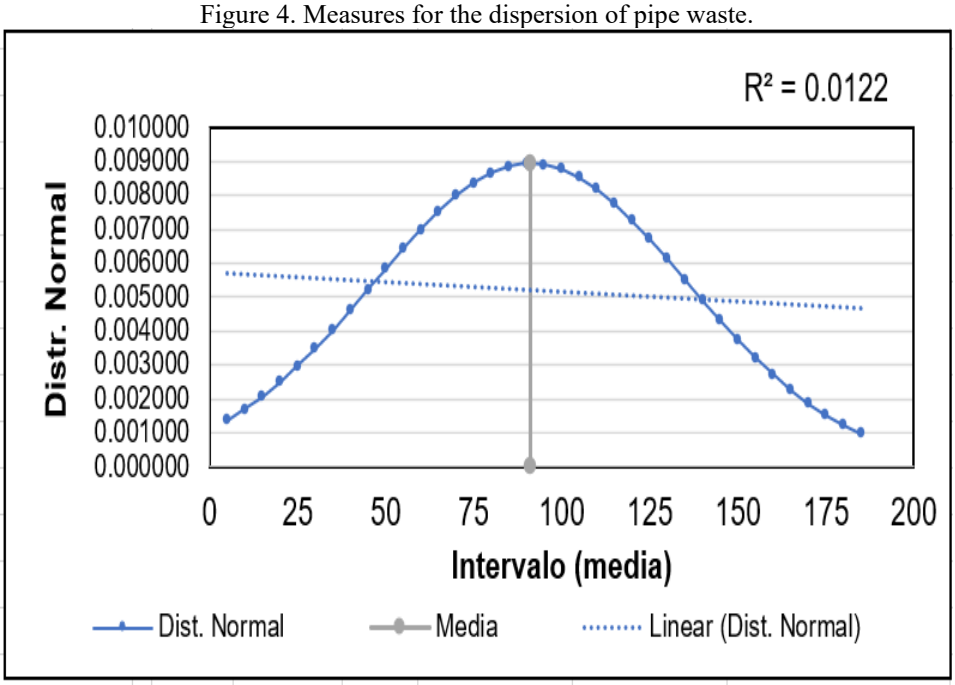
Source: Own elaboration.

Taking case #1, identified by the pipes, according to the unit cost of the piece, in 2022, the average waste for each participating company represented $700,000.00 pesos of loss. It is important to note that it was detected that in most companies this problem was already entrenched since 2021, with an average impact of $1,000,000.00 pesos. Although the companies had addressed the problem, the results did not lead to a significant reduction in waste.

For this specific case, an analysis of dispersion measures under the standard deviation was carried out in order to determine whether the period addressed in the study, represented in this exercise by the month, had a significant impact on the amount of material waste. This was based on the material's malleability and its susceptibility to changes in adverse weather conditions.

Figure 5 shows the graphical representation of this analysis, where the coefficient of determination $R^2 = 0.0122$ was calculated, indicating a very weak relationship between the variables, with only a 1.22% dependence between the independent and the dependent variables. Therefore, the damage cannot be attributed to the month in which it was generated. According to the observations of the first case, hypothesis 1 is confirmed, since the weight of the damage was attributed to inefficient packaging.

Figure 4. Measures for the dispersion of pipe waste.

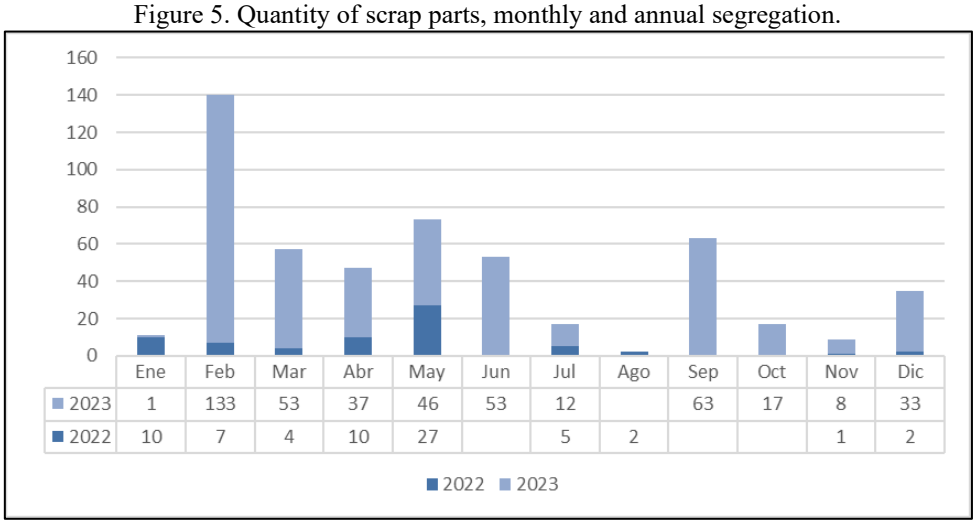


Source: Authors.

Case #2 showed that the material was extremely brittle and the amount of scrap behaved very similarly year after year, due to the influence of various external factors that affected the quality of the part. Since it was a windshield composed of glass, it goes through numerous processes before reaching the plant. The average monetary effect corresponding to a financial loss for each company was $250,000.00 pesos per year.

The graph in Figure 6 illustrates the number of discarded parts due to their low quality. This graph shows a significant increase in the month of June 2023, which indicated an increase in low-quality material. In response to this situation, we collaborated with the suppliers of the companies that converged to carry out maintenance on their containers and remove from the fleet those that did not meet the necessary requirements to guarantee the integrity of the material.

Figure 5. Quantity of scrap parts, monthly and annual segregation.



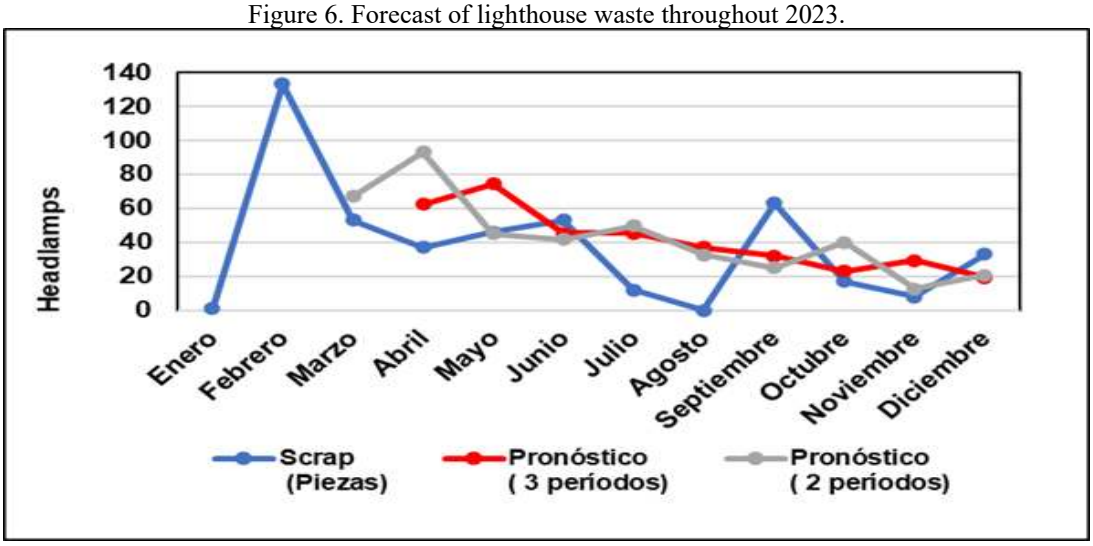
Source: Authors.

After taking these measurements, a notable decrease in the amount of waste was observed. However, the problem resurfaces in the months of September and December 2023, coinciding with the deterioration of the same containers. It is important to note, as mentioned above, that the material is highly susceptible to any type of manipulation.

Case #3, represented by the headlights, involved a waste with an average value of $2,000,000.00 pesos between both years. With regard to the quantities of discarded material, the segregation was distributed as follows: in 2022, an average of 68 pieces were discarded, while in 2023 the figure rose on average to 456, this last year being the one with the greatest impact due to the regular implementation of the container from February of the same year, Prior to this, its use was exclusive for pilot events.

Based on the history collected, the statistical model of moving averages was used to analyze the behavior of the variable throughout the months. Where hypothesis 1 was confirmed by the number of discarded pieces due to their low quality. According to the graph presented in Figure 7, the blue line reflects the average behavior of the waste of parts within each of the plants, while the gray line represents the forecast calculated based on the waste generated during the first two months. On the other hand, the red line considers on average the history of the first three months of waste within the plant for the generation of forecasts.

Figure 6. Forecast of lighthouse waste throughout 2023.



Source: Authors.

It was observed that at the beginning of the year with a packaging identified by hypothesis one, that is, an inefficient packaging, the waste was considerably high, and the forecast of lighthouses to be disposed of was excessive compared to the quantities actually disposed of.

In relation to hypothesis 2, based on case #1, it was detected that by providing the container with a strategic structure and increasing its resistance, the condition would be eliminated, which

would result in a significant reduction in waste. This was reflected on average in each company in only 10 pieces scrapped in 2023. Figure 8 shows the modifications that were implemented to ensure that the packaging maintained the quality and integrity of the part, for which different tests were carried out on the container:

a. Photograph 8.1 shows how the divider of each bed that made up the container was received, which was completely flat and lacked any type of reinforcement that would ensure the integrity of the four beds. Therefore, the first test was to implement a separator as seen in Figure 8.2, this consisted of the placement of two intermediate separators per bed, in order to provide greater resistance to the central part of the separator and prevent possible collapses.
b. After receiving the test, it was identified that, although there were no more collapses in the last bed, the material arrived poorly arranged, which resulted in deformations in the pieces. Feedback was provided to the suppliers of the participating companies, after the consultancy, the application of a second test was requested, under the creation of an arrangement standard that would guarantee a correct distribution of the pieces to avoid overweight and, consequently, deformations.
c. After receiving the test, it was observed that now the bed with findings was the first, where the corner of the container was not secured in place and, when experiencing any type of movement or manipulation, it moved from its position as shown in Figure 8.3, causing the loss of shape in the piece. Therefore, it was decided to carry out a third test on the suppliers where it installed a security mechanism in the corner of the container, thus guaranteeing its position regardless of the movements it could undergo.
d. Figure 8.4 shows the last test received and the current container standard, which, after some time since its implementation, has demonstrated what was stated in hypothesis 2.

Figures 8.1 to 8.4. Modifications made to weatherstrap packaging.



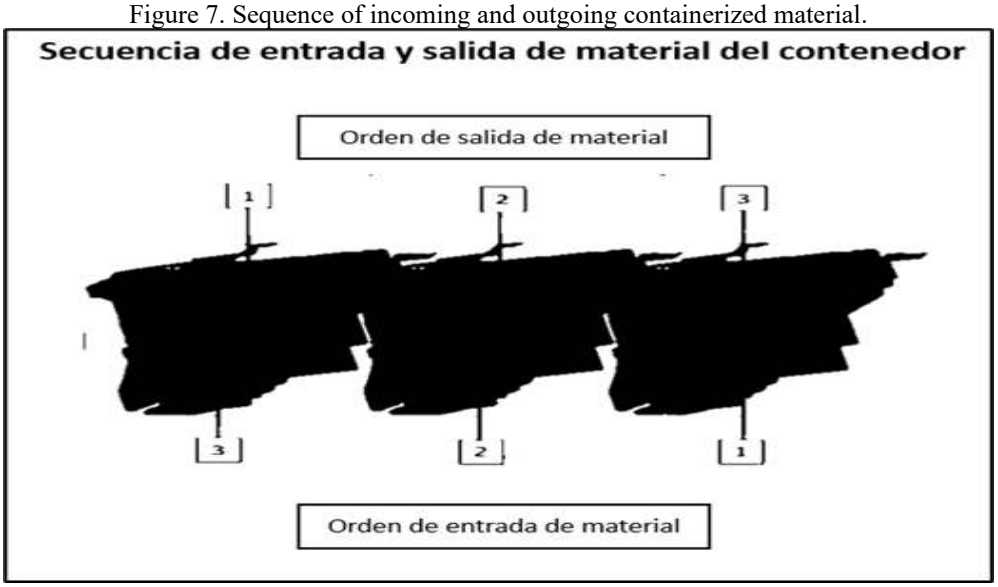
Source: Authors.

Finally, and based on case #3, after the analysis carried out on the headlight packaging, it was identified that, based on hypothesis two, the container required continuous improvements in terms of the standardization of its use with the equipment. This was necessary to meet operational needs and to work according to the established sequence for material entry and extraction, as shown in Figure 9, in order to reduce alterations in material quality.

Following the identification of this finding, it was reinforced and worked in collaboration with the participants' plant operators and suppliers to provide them with visual aids and the necessary indications in order to reduce waste and comply with the corresponding management standard. This effort resulted in a reduction of approximately 60% of headlight waste, represented on average by the participating companies for $400,000.00 pesos.

CONCLUSIONS

Figure 7. Sequence of incoming and outgoing containerized material.



Source: Authors.

The role of strategic packaging is critical in any business, regardless of the industry in which it operates. In this study, it has been possible to demonstrate the significant impact that this variable has on the financial and time management aspects of the company's processes. It is essential to consider the structure of the packaging as an aspect of utmost importance throughout the supply chain, in order to prevent negative impacts and make the most of its benefits. The analyses carried out demonstrated the economic impact suffered by the participating companies during the period evaluated. However, this situation is recurrent in various types of containers and products, which must be evaluated and corrected to mitigate future adverse repercussions on the company. Likewise, it is essential to make continuous improvements in those containers that do not generate negative effects, thus turning them into positive assets for the organization.

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